Gema WIRALODRA

Editor-in-Chief: Yudhi Mahmud

Publisher: Universitas Wiralodra

Conservation status of flora and fauna in the nickel mining area of PT Hengjaya Mineralindo

Muchtazar[a], Harry Cahyono[b], Virgo Lelono[c], Firda Lestari[d]
[a]PT Hengjaya Mineralindo, Indonesia, muchtazar@hengjaya.co.id
[b]PT Hengjaya Mineralindo, Indonesia, harry.cahyono@hengjaya.co.id
[c]PT Hengjaya Mineralindo, Indonesia, virgo.lelono@hengjaya.co.id
[d]PT Hengjaya Mineralindo, Indonesia, firda.lestari@hengjaya.co.id

Conservation status of flora and fauna in the nickel mining area of PT Hengjaya Mineralindo

Muchtazar[a], Harry Cahyono[b*], Virgo Lelono[c], Firda Lestari[d]
[a]PT Hengjaya Mineralindo, Indonesia, muchtazar@hengjaya.co.id
[b]PT Hengjaya Mineralindo, Indonesia, harry.cahyono@hengjaya.co.id
[c]PT Hengjaya Mineralindo, Indonesia, virgo.lelono@hengjaya.co.id
[d]PT Hengjaya Mineralindo, Indonesia, firda.lestari@hengjaya.co.id

*Correspondence: harry.cahyono@hengjaya.co.id

Abstract
Indonesia is an archipelagic country with a high level of biodiversity from the sea to the mountains. Likewise, the island of Sulawesi has a variety of endemic flora and fauna with an extraordinary level of endemicity. This rich flora and fauna face various threats that cause ecosystem degradation. This research is intended to review the level of flora and fauna status in the Sulawesi region, especially in the PT Hengjaya Mineralindo mining area in Bungku Pesisir and Bahodopi District, Central Sulawesi. Based on observations in areas with code HA WD 06, HA Pit Central, HA Arboretum 1 and HA Arboretum 2 areas, it was found that some flora and fauna were categorized as being in conservation status by Minister of Environment and Forestry Regulation No. P 106 Concerning Protected Plants and Animals, International Union for Conservation of Nature (IUCN), and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Thus, the company will always strive to encourage ecological succession to achieve ecosystem stability in the future through sustainable practices.
Keywords: Biodiversity, Conservation Status, PT HM, Sustainable Efforts

1. Introduction

Sulawesi is the largest and most biogeographically important island in Indonesia, located in the biogeographical subregion of Wallacea, which is a unique area because it is a transitional area between the Asian and Australian continents that has a biological diversity with a fairly high level of endemicity (Pitopang & Ihsan, 2014). This level of endemicity is caused by the island's isolation, which occurred in ancient times and allowed the evolution of various species of native flora and fauna. This condition needs special attention for all stakeholder elements to avoid future population decline and extinction of flora and fauna. This is because the composition and structure of flora and fauna will influence the stability of an ecosystem community (Guimaraes Jr, 2020). Reduced flora and fauna can be used as a bioindicator of environmental disturbances (Stoll et al., 2022), increasing disaster status (Ahmed & Fakhruddin, 2018), reducing conservation value (Hamzah, N, & Ardiansyah, 2023) and threatening the stability of ecosystem services on which humans depend (McCann, 2000).

Exploitation of flora and fauna, illegal logging, conversion of forest areas into other areas, hunting and illegal trade are some factors that have caused the current threat to biodiversity (Malik et al, 2020). Only tolerant species survive the long-distance negative effects on biodiversity (Li, et al., 2010). Nickel mining is an extractive activity that can positively and negatively impact the environment. These natural resource extraction activities can affect natural ecosystems, including the surrounding land, vegetation, and fauna. Therefore, it is important to map the biodiversity of flora and fauna in the operational area of PT Hengjaya Mineralindo (PT HM) so that the company can mitigate impacts and plan future environmental management. Moreover, this is related to the environmental crisis which has become a serious problem for the international community, so various conventions and agreements regarding environmental preservation schemes and biodiversity conservation must continue to be

Original Article

promoted (Prasetyo et al, 2019). Because biodiversity has important values seen from various aspects, such as the value of existence, services, heritage, choice, consumption, production, and social culture (Ministry of Environment and Forestry of Indonesia, 2014).

The main objective of this research is to identify and map the status of biodiversity in PT HM's operational areas by Minister of Environment and Forestry Regulation No.P 106 concerning Protected Plants and Animals, International Union for Conservation of Nature (IUCN) 2021, and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) 2019. Apart from that, this research can also provide an overview of the collaboration that can be carried out by various parties in maintaining biodiversity in the region. Through an in-depth understanding of this issue, it is hoped that appropriate action can be taken to balance the development of mining areas and the preservation of the environment and biodiversity in PT HM's operational areas.

2. Method

This research uses a descriptive qualitative approach to review the conservation status of biodiversity in mammals, avifauna, herpetofauna, and insects. Data collection activities for research on flora and fauna biodiversity conservation were carried out for 3 months in 2022. These included various stages of activities, starting from team preparation and activity design, monitoring and evaluating flora and fauna, data analysis, and final report. The tools and materials used during the monitoring process were camera trap, mist net, binocular-monocular, photo camera, global position system, insect net, grab stick, headlamp, hop rope, survey tape, phi-band, measuring stick, meter, lithium battery, and other tools. Each data has been monitored, plotted, and analyzed for the status concerning Minister of Environment and Forestry Regulation No.PP 106 concerning Protected Plants and Animals, International Union for Conservation of Nature (IUCN) 2021, and Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) 2019. Data was presented descriptively, supported by tables, graphs, and pictures relevant to monitoring conditions in the field. This research activity was in the PT HM Nickel Mining area, which is administratively located in Morowali Regency, Central Sulawesi Province. The scope and stages of activities to determine the diversity and status of flora and fauna at the study location can be reviewed in Table 1.

Table 1.

Scope and Activity Stages

Scope of Activities	Activity Stages
Inventory and identification of the status of flora and fauna diversity	1. Analysis of work maps and road networks 2. Land cover analysis 3. Construction of survey transects that intersect the road network or parallel 4. Installation of observation tools 5. Inventory and identify tree status through height measurements and tree marking through vegetation plots and exploration methods 6. Inventory and identification of terrestrial and arboreal mammal groups directly in frequently visited areas or indirectly, for example, through animal track signs 7. Inventory and identification of avifauna groups in the morning and evening 8. Inventory and identification of amphibian groups 9. Inventory and identification of groups of butterflies and dragonflies 10. Analysis the biodiversity status

3. Results and Discussion

Based on research on the status of flora and fauna in the PT HM mining area, the results will be described based on two focuses, namely types of flora (trees and undergrowth) and fauna (mammal groups, avifauna groups, herpetofauna groups, and insect groups).

Vegetation Conservation Status (Trees and Undergrowth)

From the results of observations of vegetation at all study locations in natural forest areas in the PT Hengjaya Mineralindo nickel mining concession, which was carried out at 4 locations, namely HA WD 06, HA Pit Central, HA Arboretum 1, and HA Arboretum 2. The identification results recorded that as many as 94 tree species were distributed at the vegetation study location of PT Hengjaya Mineralindodari. The number of tree species, if the status is analyzed, is based on the national protection status, which refers to the Minister of Environment Regulation (PerMenLHK) No P 106 of 2018 concerning Protected Plants and Animals; there are no tree-level plant species that have the status protected. Meanwhile, for the international extinction threat level status of the IUCN, 2 tree species have been recorded as being vulnerable to extinction (Vulnerable, VU), namely Agathis dammara and Diospyros celebica. Meanwhile, 1 type is included in the dependency conservation (CD) category, namely the Koompassia excelsa type. The rest have low-risk status (Least Concern, LC), namely 11 types including Actinodaphne glabra, Bouea oppositiveolia, Cinnamomum javanicum, Dacryodes rostrata, Garcinia dulcis, Knema elmeri, Macaranga lowii, Myristica maxima, Pterospermum javanicum, Santiria tomentosa, and Syzygium tawahense. Meanwhile, for the results of the status analysis referring to CITES, which is the status of flora and fauna in international trade, no plants in the tree category were found that were included in the CITES Appendix category

Figure 1.
Ebony Diospyros Celebica which has a stem diameter > 100cm)

Figure 2.
Agathis Dammara found in the study plot.

Not only data on tree vegetation status, researchers have also made observations on types of understory plants (herbs, epiphytic lianas and palms) which are food for forest wildlife. This plant is essential to review because it is closely related to the level of biodiversity and its relationship to local ecological conditions as well as its relevance to the distribution of wild animals. In this way, based on the findings, 27 types of understory plants have been identified. If we refer to the status of each of these plants, based on the Minister of Environment and Forestry (MenLHK) Regulation No. P. 106 of 2018 concerning Protected Plant and Animal Types in the PT Hengjaya Mineralindo concession found no understory plant species with protected status. Meanwhile, for conservation status based on IUCN at the vegetation study

Original Article

location, of the 27 types of understory plants identified, only three types of plants have IUCN conservation status in the Least Concern category (low risk of threat), including the types Dicranopteris linearis, Leea indica, and Pandanus tectorius. Apart from that, for conservation status based on CITES data, no species are listed in the appendix status.

Fauna Conservation Status

The fauna groups discussed in this research are mammals, avifauna (birds), herpetofauna (reptiles and amphibians), and insects (order Lepidoptera and order Odonata).

Mammal Group

Identification of mammalian status is carried out by direct and indirect observation. Direct observation is animals that are encountered directly, either with the help of a camera as a documentation tool or with the help of binoculars. Meanwhile, indirect observation is by installing camera traps, identifying sounds, footprints, information from employees and other signs of presence. Camera traps are installed at potential locations indicated by the presence of footprints found, food trees, animal paths, or locations directly identified by animals. Camera traps are installed at monitoring locations for 30 – 60 days. The camera traps are installed in potential locations ranging from natural forests to new roads (HRM/Hauling Road Mining). The aim is to determine the distribution of mammal groups in the PT HM area. In general, the results of mammal identification in the PT HM area can be seen in Table 2.

Table 2.

Mammal identification results in the PT HM area

No	Family	Species name		Conservation Status		
		Scientific name	Local Name	P106	IUCN	CITES
1	Bovidae	*Bubalus depressicornis*	Anoa	D	EN	I
2	Cercopithecidae	*Macaca ochreata*	Butung Monkey	D	VU	II
3	Pupilae	*Rattus hoffmanni*	Mouse	-		-
4	Sciuridae	*Rubrisciurus rubriventer*	Big Squirrel	-	VU	-
5	Suidae	*Sus celebensis*	Wild boar	-	NT	-
6	Suidae	*Babyrousa celebensis*	Hog deer	-	VU	I
7	Viverridae	*Viverra tangalunga*	Tenggalung, Malaya	-	LC	-
8	Viverridae	*Macrogalidia musschenbroekii*	Sulawesi civet	D	VU	-

Information:

D=protected, T=not protected LC=least concern (low risk), NT=Near Threatened (almost threatened), VU=Vulnerable (vulnerable), EN=Endangered (endangered), I= Appendix I (list of all plant species and wild animals that are prohibited in all forms of international trade), II= Appendix II (list of wild plant and animal species that may be threatened with extinction if trade continues without regulation) and III= Appendix III (list of protected plant and animal species in the country certain within the boundaries of its habitat area)

Based on the data in the table above, it can be seen that based on Minister of Environment and Forestry Regulation No. P 106, 3 types of mammals are recorded as protected, namely the Anoa (Bubalus depressions), the Sulawesi civet (Macrogalidia musschenbroekii), and the Butung monkey (Macaca ochrea). Of the three, what is interesting is, if you look at the record of Anoa footprints found in natural forests, it is known that along the footprints found there are plants that are thought to be traces of Anoa eating in the form of fractures on plant shoots. Generally, the part of the plant eaten by these mammals is mostly leaves (79%), and a small part is fruit. The plants in question include black wood (Diospyros celebica), forest breadfruit (Artocarpus sp.), and various types of fig trees.

Original Article

Figure 3.
Anoa footprints (Bubalus depressicornis)
which was found in the natural forest
around HRM PT HM

Figure 4.
Anoa (Bubalus depressicornis)
adult male

Inseparable from the existence of the Anoa (Bubalus depressicornis), this mammal is also the only mammal that is included in the endangered or endangered (EN) category based on the IUCN category. Apart from that, in this IUCN category there are 4 types of mammals that are categorized as vulnerable to threats (VU), namely the Butung Monkey (Macaca ochreata), the Large Squirrel (Rubrisciurus rubriventer), the Deer Pig (Babyrousa celebensis), and the Sulawesi Civet (Macrogalidia musschenbroekii). When talking about Butung Monkeys, in general this type of mammalia is endemic to Sulawesi and only gives birth to 1 child per mother. They live in tall trees, especially trees which are their food source. Based on observations in the PT HM area, the Butung Monkey's habitat is often found in areas bordering gardens, settlements and other mines. Apart from that, for other mammals that are included in the IUCN category, it is mapped that there is 1 other type of mammal that cannot be identified to species level so its conservation status cannot be known and a record of 1 type of mammal that is in the low risk category for threats (LC) is obtained.). Apart from that, if you refer to CITES data, you can find 2 types of mammals that are included in the appendix I category and 1 type that is included in the appendix II category.

Avifauna Group (Birds)

Observations on the conservation status of bird species in the PT HM area have been carried out using direct encounter methods, camera traps and installing bird nets. Observation locations include post-mining reclamation areas and natural forests. In general, the land cover conditions at the observation location range from lowland forest to lower mountain forest, which makes the area very potential as a habitat for various types of birds. Meanwhile, the geographic location of the location is included in the Wallacea zoogeographic region or transitional region which has the highest level of endemicity in the world. The forest area in the PT HM area is still relatively good and spacious so that it will allow for the presence of various types of birds.

Based on the results of the researchers' analysis, firstly, the bird diversity index in the PT HM area is in a fairly high category. Meanwhile, if viewed based on location, the bird diversity index in the post-mining reclamation area is in the medium category. This is influenced by the condition of post-mining reclamation areas which tend to remain open, especially in young reclamation areas. Post-mining reclamation areas are also close to natural forests, so many birds prefer forest areas. Vegetation structure and food availability in the habitat are the main factors that influence species diversity in natural forests. On the other hand, variations in vegetation

Original Article

cover can also influence the presence of bird species. Relatively small nickel mining activities are also a factor that influences the diversity of bird species, so if land clearing becomes more widespread, it will affect the quality of natural forests as bird habitats and, in the long term, will affect the composition and distribution of wildlife.

Secondly, it has been mapped that 12 types of birds are protected nationally. For the threat of extinction status, it is known that there are 37 species of birds in the low-risk category for extinction (Least Concern, LC), there are two species that are vulnerable (Vulnerable, VU) to the threat of extinction, two species of birds are approaching the threat of extinction (Near Threatened, NT) and two species critically endangered (CR) birds. Of the total bird species found, there were also ten bird species included in the CITES Appendix II list. A list of bird species and their conservation status can be seen in Table 3 below.

Table 3.

Results of several avifauna identification in the PT HM area

No	Family	Species name		Conservation Status		
		Latin name	Indonesian name	P106	IUCN	CITES
1	Accipitridae	*Spilornis rufipectus*	Sulawesi snake-eagle	D	LC	II
2	Accipitridae	*Icthyophaga humilis*	Little Fish-Eagle	D	NT	II
3	Accipitridae	*Accipiter soloensis*	Eagle- Chinese Falcon	D	LC	II
4	Accipitridae	*Indus haliasture*	Bull eagle	D	LC	II
5	Accipitridae	*Varnis celebensis*	Sikep-Sulawesi honey	D	LC	II
6	Bucerotidae	*Rhyticeros cassidix*	Julang Sulawesi	D	VU	II
7	Bucerotidae	*Penelopides exarhatus*	Kangkareng Sulawesi	D	VU	II
8	Campephagidae	*Lalage leucopygialis*	Cotton Sulawesi	Q	LC	-
9	Columbidae	*Turacoena manadensis*	Sulawesi black dove	Q	LC	-
10	Columbidae	*Ducula aenea*	Pergam green	Q	NT	-
11	Coraciidae	*Coracias temminckii*	Sulawesi lampshades	Q	LC	-
12	Corvidae	*Corvus enca*	Forest crow	Q	LC	-
13	Corvidae	*Corvus unicolor*	Crow proud	D	CR	-
14	Cuculidae	*Phaenicophaeus calyorhynchus*	Kadalan Sulawesi	Q	LC	-
15	Dicaeidae	*Dicaeum celebicum*	Gray-pelvic chili	Q	LC	-
16	Dicruridae	*Dicrurus hottentottus*	Srigunting tufts of hair	Q	LC	-
17	Nectariniidae	*Antreptes malacensis*	Brown-throated Sunbird	Q	LC	-
18	Oriolidae	*Oriolus chinensis*	Black-rumped oriole	Q	LC	-
19	Phylloscopidae	*Phylloscopus poliocephalus*	Cikrak Sulawesi	Q	LC	-
20	Psittacidae	*Loriculus stigmatus*	Serindit Sulawesi	D	LC	II
21	Psittacidae	*Prioniturus platurus*	Kring-kring hills	D	LC	II
22	Psittacidae	*Loriculus exilis*	Red-billed serindit	D	LC	II
23	Pycnonotidae	*Pycnonotus aurigaster*	Cucak Kutilang	Q	LC	-
24	Rhipiduridae	*Rhipidura teysmanni*	Sulawesi fan	Q	LC	-
25	Sturnidae	*Streptocitta albicollis*	Bilbong priest	Q	LC	-
26	Zosteropidae	*Zosterops atrifrons*	Forehead-black glasses	Q	LC	-

Information:
D=protected, T=not protected LC=least concern (low risk), NE= Not Evaluated (not yet evaluated), NT=Near Threatened (almost threatened), VU=Vulnerable (vulnerable), EN=Endangered (critical), I = Appendix I (list of all wild plant and animal species prohibited in all forms of international trade), II= Appendix II (list of wild plant and animal species that may be threatened with extinction if trade continues without regulation) and III= Appendix III (list wild plant and animal species protected in a particular country within the boundaries of their habitat area)

Original Article
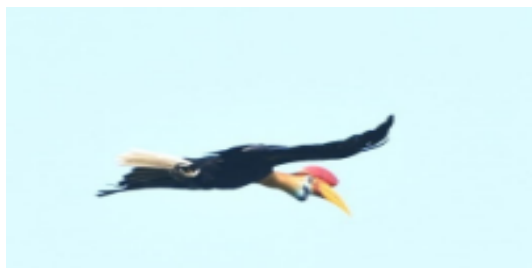
Figure 5.
Julang Sulawesi (Rhyticeros Cassidix)

Figure 6.
Kring-Kring Bukit (Prioniturus Platurus)

Herpetofauna Group (Reptiles and Amphibians)

From the results of the identification carried out by researchers, the number of herpetofauna species found at the monitoring location was 21, consisting of 10 types of amphibians and 11 types of reptiles. In general, the diversity of herpetofauna species is in the medium category, with the distribution of individuals in each species relatively even, and there is no dominant species. Species diversity can change rapidly (increase or decrease), considering that the presence of herpetofauna in a location is influenced by humidity and rainfall. Herpetofauna groups are usually easier to find in the rainy season than during the dry season. However, an essential factor in the existence of herpetofauna is changes in natural vegetation cover. Changes in vegetation cover will impact changes in microclimate, environmental quality, and food sources. For aquatic environments, amphibian groups can be used as aquatic bio-indicators.

In addition, it is known that not all types of herpetofauna are not protected. For the threat of extinction status, it is known that there is one species in the data deficient category (Data Deficient, DD), 17 species at low risk of extinction threat (Least Concern, LC), one species in the vulnerable to extinction category (Vulnereable, VU) and one species in the threatened (Endangered, EN). Meanwhile, one other type has not yet been evaluated. Apart from that, CITES data shows that no herpetofauna species are included in the appendix list.

Insect Groups (Lepidoptera and Odonata)

Based on the mapping results, the number of butterfly species identified in the PT HM nickel mining business area consists of 23 species, most of which belong to the Nymphalidae family. The most butterfly species found were in prospective conservation area (HK) forests, with 12 species. Meanwhile, other locations were found in almost the exact numbers, namely six types in the Central Pit Forest (HPC) and five types in the WD6 Forest (HWD6) and post-mining reclamation area (KRPT). The differences in types between HK natural forests and post-mining reclamation areas are generally quite significant. The number of species was also relatively small at the HWD6 and HPC locations. This occurred because the time duration and coverage of the survey area were narrower compared to the HK location. Apart from the type of butterfly, the number of dragonflies identified in the PT HM nickel mining business area comprises 22 types belonging to 6 families. The family with the most types is Libellulidae, included in the Sub-Order Anisoptera or true Dragonflies. From the number of butterflies and dragonflies found, it is known that no butterflies are nationally protected according to Minister of Environment and Forestry Regulation No. P.106 of 2018 concerning protected plants and animals. None of the butterflies found have vulnerable or endangered status according to the IUCN Redlist, and none of the species are included in the CITES Appendix list.

Figure 7.
Endemic Butterflies Faunis Menado

Figure 8.
Striped Tengger Dragonfly (Agrionoptera Insignis)

In general, flora and fauna were successfully identified by researchers at PT Hengjaya Mineralindo mining area, which is very diverse in type and status. Based on the status identification of biodiversity of flora and fauna with referring to the Minister of Environment and Forestry Regulation No.P 106 concerning Protected Plants and Animals, the International Union for Conservation of Nature (IUCN) 2021, and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) 2019, it was known that there are several flora and fauna status is protected, near threatened, vulnerable, orun precarious in its existence. The status shows variations in conditions that can be the basis for stakeholders in determining the strategy to protect the ecosystem resilience adequately and appropriately. Therefore, this issue is essential to understand regarding the relation to ecosystem sustainability balance in terms of flora and fauna. There is a balanced population of flora and fauna ecosystem resilience, one of which plays a role in mitigating climate change by contributing to long-term carbon sequestration in several biomes.

The existence of protected and endangered flora and fauna has become a fundamental change, which needs to be a concern for the company. If we look broadly, the main factors directly driving the loss of biodiversity throughout the world are natural change and habitat destruction, which has increased rapidly in the 20th century (Agarwal, 2015). This condition occurs faster than ever before in the history of life, and it is predicted that there are no signs that the process will slow down. However, the strategic steps need to be planned and implemented inclusively between stakeholders to keep the population of flora and fauna in balance in natural ecosystems and ensure that habitat destruction by humans does not continue exploiting natural resources. Based on the monitoring, no signs of poaching were found, but monitoring the forest area is necessary for both the threat of poaching and predators. This is because there is logging activity around the PT Hengjaya Mineralindo mine. This mitigation needs to be socialized to local communities, employees, and other companies about policies and strategic steps in conservation programs. This is due to human activity becoming one of the main factors in posing risks to the sustainability of biodiversity (Mehta, 2023; U.S and Agarwal, 2015).

4. Conclusion

Based on the results of monitoring biodiversity in the PT HM area), it can be concluded that in the post-mining reclamation area, insert types have been planted and natural vegetation, both trees and undergrowth, has grown, so that the composition of the vegetation is increasingly diverse. However, wild animals have not yet used the post-mining reclamation area as an alternative habitat because the condition of the vegetation in the forest area is still relatively good and extensive. Mammal diversity is in the medium category. The presence of mammals in the PT HM area is influenced by its vegetation cover. However, mammals are rarely found

Original Article

in post-mining reclamation areas because the vegetation cover is still relatively open, and the vegetation composition tends to be homogeneous. The diversity of bird species at the monitoring location is in the high category, and there is no dominant species. The presence of various types of birds can be an indicator of ecosystem balance because critical species are found, namely from the Accipitridae and Bucerotidae families. Herpetofauna diversity is in the medium category. However, the environmental conditions are still in good condition, including humidity, vegetation cover, and the quality of the water environment. These conditions can support life for various types of herpetofauna. Insect diversity in the PT HM area is medium to high. Large forest areas and good environmental quality are essential to maintaining insect diversity around mining operational areas.

5. References

Ahmed F, F. A. (2018). Tinjauan pencemaran lingkungan akibat hidrokarbon minyak bumi dan biodegradasinya. *Sumber Daya Sci Nat Intl J Lingkungan*, 11(3), 1-7. https://doi.org/10.19080/IJESNR.2018.11.555811

CITES. (2019). Checklist of CITES Species Appendices I, II, and III. Retrieved from Checklistcites.org.Website

Guimares, J. (2020). Struktur Jaringan Ekologi Lintas Tingkat Organisasi. *Annual Review of Ecology, Evolution, and Systematics, 51*, 433-460. https://doi.org/10.1146/annurev-ecolsys-012220-120819

Hamzah, A. S., N, N., and Ardiansyah, A. (2023). Status, Diversity, and Feeding Guilds of Aviifauna in the Mining Area. *IOP Conference Series: Earth and Environmental Science*. https://doi.org/10.1088/1755-1315/1277/1/012036

IUCN. (2021). Retrieved from The IUCN Red List of Threatened Species: www.iucnredlist.org.Website

Li, j.-T., Duan, H.-N., Li, S.-P., Kuang, J.-L., Zeng, Y., and Shu, W.-S. (2010). Cadmium pollution triggers a positive biodiversity–productivity relationship: evidence from a laboratory microcosm experiment. *Journal of Applied Ecology*, 890-898.

Malik, A. A., Prayudha, J., Anggreany, R., Sari, M. W., and Walid, A. (2020). Keanekaragaman Hayati Flora dan Fauna di Kawasan Taman Nasional Bukit Barisan Selatan (TNBBS) Resort Merpas Bintuhan Kabupaten Kaur. *Jurnal Ilmiah Pendidikan Sains, 1*(1). https://doi.org/10.33369/diksains.v.lil.14702

McCann, K. S. (2000). The diversity-stability debate. *Nature, 405*(6783), 228-233. https://doi.org/10.1038/35012234

Mehta, V. (2023). Biodiversity of Flora and Fauna in India: A Comprehensive Review. *International Journal of Research in Humanities and Social Sciences, 11*(10), 32-36.

Ministry of Environment and Forestry of Indonesia. (2014). The Fifth National Report of Indonesia to the Convention on Biological Diversity. Deputy Minister of Environmental Degradation Control and Climate Change Ministry of Environment and Forestry.

Pitopang, R., and Ihsan, M. (2014). Biodiversitas Tumbuhan di Cagar Alam Morowali Sulawesi Tengah Indonesia. *Online Jurnal of Natural Science, 3*(3), 287-296.

Prastyo, E., Ibrahim, P. A., and Armis, H. R. (2019). Konservasi Keanekaragaman Hayati Flora dan Fauna Pada Site Plant PT Polytama Propindo. *Jurnal Rekayasa, Teknologi, dan Sains, 3*(2), 72-76. doi:10.33024/jrets.v3i2.1909

Republic of Indonesia. (2018). Regulation of Environment and Forestry of the Republic of Indonesia Number P. 106/MENLHK/SETJEN/KUM.1/12/2018 concerning Amendments to the Regulation of the Minister of Environment and Forestry Number P.20/MENLHKSETJEN?KUM.1/6/2018 Concerning Types of PrA.

Original Article

Stoll, E., Roppsind, A., Maharaj, G., Velasco, S., and Caughlin, T. (2022). Mendeteksi dampak penambangan emas terhadap keanekaragaman hayati serangga di wilayah pertambangan tropis dengan citra SmallSat. *Remote Sensing in Ecology and Conservation, 8*(3), 379-390. https://doi.org/10.1002/rse2.250

U.S., R., and N.K., A. (2015). Biodiversity: Concept, Threats and Conservation. *Environment Conservation Journal, 16*, 19-28. https://doi.org/10.36953/ECJ.2015.16303