

Biodiversity and Forest Loss in Sulawesi, the Laboratory of Evolution —What Are the Risks of Woody Biomass (Pellet) Production?—

1. Sulawesi: A “Living Laboratory of Evolution”

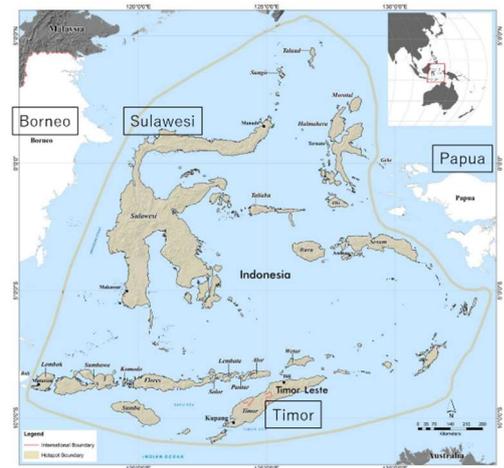
Indonesia’s Globally Significant Biodiversity

Indonesia possesses the world’s third-largest area of tropical forest, following Brazil and the Democratic Republic of the Congo. Across more than 17,000 islands, the country contains 55 distinct ecosystems. It ranks among the most biodiverse nations globally in terms of total species richness and levels of endemism (species found nowhere else) ¹. Indonesia has the highest number of mammal species in the world. Of these, 37% are endemic, while 24% are classified as threatened with extinction².

The Uniqueness of Sulawesi’s Biodiversity

Located in central Indonesia, Sulawesi hosts a biota that differs markedly from both the Asian continental islands (such as Borneo and Sumatra) and the Australasian islands (including Papua).

Due to prolonged geographic isolation over a long geological time, Sulawesi’s species have undergone independent evolutionary trajectories. As a result, the island is designated as **one of the world’s biodiversity “hotspots,” recognized for its exceptional conservation value.**



Map: Wallacea Biodiversity Hotspot Map (c) CEPF

Sulawesi contains **six active hybrid zones, where species differentiation continues to occur at high frequency. Alongside the Galápagos Islands, Sulawesi is often described by researchers as a “living laboratory of evolution,”** holding extraordinary significance for evolutionary biology.

The map shows Sulawesi with thick black lines indicating hybrid zones between various Macaque species: *M. heckii*, *M. nigrescens*, *M. tonkeana west*, *M. tonkeana east*, *M. ochreata*, *M. maura*, and *M. brunnescens*. A scale bar indicates 100 km.

What Is a Hybrid Zone? — Sites of Ongoing Evolution

A hybrid zone is **an area where closely related species interbreed, generating genetic diversity and increasing the potential for the emergence of new species.**

Macaques (relatives of the Japanese macaque) and tarsiers, introduced below, have diversified into multiple species across these hybrid zone boundaries. Similar patterns of divergence and hybridization are also observed in toads, rats, and draco (flying lizards).

(Thick lines in the left figure indicate hybrid zones. Source: Presentation by Dr. Jatna Supriatna.)

¹ “Countries ranked by species count / biodiversity share” in “World Rainforests” <https://worldrainforests.com/03-biodiversity-share-by-country.htm>

² “Indonesia” in “BioDB” <https://biodb.com/region/indonesia/>

2. Representative Endemic Species of Sulawesi

Unlike Sumatra and Borneo, Sulawesi does not have large mammals that are iconic of rainforests such as orangutans, elephants, and rhinoceroses. Instead, Sulawesi harbors numerous distinctive endemic species rarely found elsewhere. While other Indonesian islands host only one or two species of tarsier or macaque, Sulawesi supports approximately ten species of each group.

Industrial Energy Plantations in Gorontalo Province and Habitats of Key Endemic Species — All Listed as Threatened Species

- What is Industrial Energy Plantations (HTE)?—Areas where permissions are given to harvest natural tropical forests to be converted into fast-growing tree plantations for the production of wood pellets.
- Two pellet mills are currently operating in Gorontalo Province:
 - **PT. Gorontalo Panel Lestari (GPL)**, located in Northern Gorontalo (operational from March 2025)
 - HTE concession area: approx. 74,000 hectares
 - **PT. Biomasa Jaya Abadi (BJA)**, located in Southwestern Gorontalo (operational since 2020)
 - HTE concession area: approx. 30,000 hectares
- **Total HTE area:** approx. 100,000 hectares
(Equivalent to roughly half the area of Tokyo Metropolis)

Concessions of both mills



BJA's concessions



GPL's concessions



- **Sulawesi Babirusa (*Babirusa celebensis*)**
An endemic wild pig distinguished by upward-curving canine teeth that pierce through the skin.
- **Lowland Anoa (*Bubalus depressicornis*)** and **Mountain Anoa (*Bubalus quarlesi*)**
Small wild bovines endemic to Sulawesi that inhabit forested areas near water sources.
- **Maleo (*Macrocephalon maleo*)**
An endemic bird with a unique reproductive strategy: eggs are incubated in sandy beaches, lakeshores, and riverbanks using geothermal and solar heat.

- **Macaques (*Macaca* spp.)**
Eight genetically and morphologically distinct species occur on Sulawesi; all are classified as endangered or critically endangered.
- **Tarsiers (*Tarsius* spp.)**
Currently estimated at 12–16 species (with some taxonomic uncertainty).

3. Impacts of Forest Loss on Hybrid Zones and Wildlife Populations

Forest loss, degradation, and fragmentation lead to population isolation and reduction in population size. These processes decrease genetic diversity and increase extinction risk. Species that depend strongly on forest structures — such as tarsiers, which rely on tree cavities and inter-tree connectivity — are particularly vulnerable to the loss of natural forests.

Between 2000 and 2017, Sulawesi lost approximately 11% of its forest cover (over 2 million hectares). Gorontalo Province experienced a similar forest loss of approximately 11% (around 135,000 hectares) during the same period.

Forest clearing within or near hybrid zones disrupts the very processes that generate genetic diversity, thereby increasing long-term extinction risks for multiple species.

Forest loss continues around Sulawesi’s six hybrid zones. Within a 50-kilometer radius of these zones, approximately 540,000 hectares of forest—equivalent to 2.7 times the area of Tokyo—have been lost. None of these hybrid zones are currently designated as protected areas, raising concerns about the continued loss of forest.

4. Disaster Risk Associated with Large-Scale Deforestation

In November 2025, massive floods and landslides struck North Sumatra, which have been attributed to years of ongoing deforestation and land conversion in upstream river basins in the regions. The Indonesian government acknowledged this connection, cracking down on illegal activities and revoking some permits of operation³.

Sulawesi’s soils are predominantly limestone-based with shallow topsoil layers. Gorontalo Province is characterized by its mountainous terrain. Large-scale deforestation in such landscapes may increase risks of soil erosion, flooding, and landslides. Expansion of forest clearing in Sulawesi, including Gorontalo, raises concerns that similar disaster scenarios to those observed in Sumatra could occur.

³<https://news.mongabay.com/2025/12/sumatras-natural-disaster-wasnt-natural-how-deforestation-turned-a-rare-cyclone-catastrophic/>
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