

The Vegetation of Sulawesi

I. Coarse filter analysis

performed as part of the
Ecoregional Conservation Assessment

sponsored by
The Nature Conservancy
and
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Foreword

This project greatly exceeded my expectations, in the amount of thought, time and energy consumed, the gigabytes of data compiled and analyzed, and the continued fascination and fulfillment that studying the island of Sulawesi has provided me. Sulawesi is a Rorschach test of the conservationist's mind. Its environmental complexity, biological heterogeneity, and cultural history allow one to see and highlight what one chooses. Many fanciful descriptions of its shape have been inspired by its wild geological history. Its unique biota and critical biogeographic position at the crossroads between two ancient continents places it on nearly everyone's list of biodiversity hotspots and critical conservation areas. And yet, we know so little about Sulawesi's natural ecosystems. It is one of the most poorly studied islands in Indonesia. Its continued political unrest makes 'the heart of Sulawesi' a dangerous place to visit. Its young and jagged topography tests the hurried field biologist. Hopefully, this report will help create a framework within which an effective conservation and research plan can be developed.

Many people have contributed to this report. John Harting played a critical role at all phases, particularly in providing his expertise with GIS software, preparation of data for analysis, performing some of the analyses, and support and companionship during the one month field survey. Marcy Summers has provided guidance, a level-head, and sound advice throughout. Paul Kessler, National Herbarium of the Netherlands, kindly provided the collection database for Sulawesi. Agus Salim did a lot of the groundwork to compile and organize the data. Oyong joined us for the last half of the field trip and helped smooth our interactions and logistics. The people working for the Nature Conservancy offices in Bogor and Jakarta were helpful throughout. Numerous Indonesians, from the Wana in Morowali to the local government officials across the island, assisted us with their kindness, generosity, knowledge, curiosity, and patience.

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The Vegetation of Sulawesi: Coarse filter analysis

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SUMMARY

The vegetation on the island of Sulawesi is poorly known and even less understood. Present plant communities are the product of several interacting biogeographic processes. Sulawesi is a relatively young and large oceanic island sitting just to the east of Wallace's Line. Separated from Borneo by the narrow, deep Makassar Strait, the plant communities on Sulawesi are surprisingly different, given the close geographic proximity of the two islands. Local communities are composed of a roughly equal mixture of Asian and Australian plants, with a number of ecological dominants from Borneo only represented by divergent and rare taxa. Lying at the crossroads between two ancient landmasses, separate in time by tens of millions of years, the island flora of Sulawesi is unique and compelling.

An additional factor is the crazy shape of the island. With its four peninsulas and relatively small core, no spot is over 100 kilometers from the coast. This geographical constraint means that most local populations are small. Soil types differ markedly across the island, among young volcanic and old clay soils, rich alluvial plains and nutrient poor ultramafics. These soil types are concentrated on different parts of the island and the geographic distribution of many plants species are determined largely by soils. These factors mean that populations of specialist plants are not widely distributed across the island and, once extinct locally, would have few sources from which to reinvade. Rainfall can be more seasonal on Sulawesi, with several areas that experience substantial dry periods. This increased seasonality probably further reduces historical population sizes of many groups as the instability of the climate would drive sensitive species to local extinction.

In absolute numbers, total plant species diversity and endemism are roughly equivalent to other major Indonesian islands, given equal land area. The complex biogeographic setting of the island and increased apparent seasonality discussed above should generally reduce overall species diversity, so if Sulawesi contains a comparable amount of diversity to Borneo, this is surprising. The island of Borneo, with its close biogeographic connections to Java, Sumatra, and Indochina, much larger size, and large "heart", should be expected to have a higher proportional level of diversity and even endemism. Additionally, current estimates of species diversity on Sulawesi are low due to the low collection rate and lack of taxonomic focus. Most botanists who have visited the island report that a substantial amount of morphological diversity is waiting to be described. Within the stone oaks, this is certainly the case.

In terms of human impact on the island, soil fertility and the accessibility of a site has an obvious effect on forest condition. Sites with agriculturally productive soils have largely been converted. Little over 3% of forests on rich alluvial soils remain intact while over half of ultramafic and karst formations, generally unsuitable for agriculture, have good forest cover. Mangroves and wetlands are critically threatened with less than 5% and 1% intact, respectively. Site accessibility, as determined by elevation, also has a strong effect on forest cover. Just over 20% of lowland areas remain in good forest condition while 70% remains in areas above 1500 meters elevation. Fortunately, except for the lowland areas with rich to intermediate soils, roughly half of the mainland is forested, with little or no obvious signs of disturbance. The smaller island archipelagos, on the other hand, have little forest cover.

The biogeographic regions recognized in this ECA vary widely in their degree of disturbance and overall composition of forest classes. Southwest Sulawesi only has 4%

forest cover¹ while Central North Sulawesi, of equal size, has 50% forest cover (the highest of any region). Lowland and upland areas in West Central Sulawesi, the largest region, are more heavily disturbed than the general pattern across the island, probably due to the development of upland agricultural practices by the Torajans. Eastern North Sulawesi, one of the smaller mainland regions, has substantially less than average forest cover with only 13% total cover while Luwuk-Morowali has substantially more than average forest cover with 45% in good to old-growth condition. Of the island groups, the Sangihe Talaud group is the most intact (41% forest cover) while the Sula group is the most heavily damaged (3% forest cover). In general, the islands possess far less forest cover than the mainland. This is probably due to high degrees of natural disturbance in addition to the increased accessibility from the coastline.

East Central Sulawesi (ECS) and Luwuk-Morowali (LM) are unusual in having a roughly equal mixture of intermediate (27 and 28%), limestone (29 and 20%) and ultramafic (37 and 41%) soils, most of which is in the lowlands (78 and 66%, respectively by bioregion). In ECS, only 14% of the lowland intermediate habitat has good forest cover while the lowland ultramafic habitat is still half intact. In comparison, roughly a quarter (22%) of lowland intermediate habitat in LM is still under good cover. ECS also contains the greatest amount of karst formation on the island, which is concentrated in a single area south of Lake Towuti. Southwest Sulawesi has the distinction of possessing the largest amount of lowland alluvium habitat but less than 0.2% of this forest remains in good condition (>370,000 ha total land of this forest class but only 411 hectares of good forest still remain).

Lowland forest on intermediate soils comprises almost half of the entire island's land area but less than a quarter of this area (21%) has forest cover. Upland forest (850-1500 meters elevation) on intermediate soils is in quite good condition, with 50% cover. The distribution of these intermediate soils and the condition of the forest cover is certainly not equal among the biogeographic regions. West Central Sulawesi has a large amount of lowland intermediate habitat, of which only 14% has good forest cover, while Central North Sulawesi (CNS) has by far the greatest amount of lowland intermediate habitat in good condition (>640,000 hectares).

Overall, the vegetation of Sulawesi remains in fairly good condition, given the island's lack of an interior and the increased seasonality. Large areas of old-growth forest have been identified which could serve as "cores" or "sources" for biodiversity. These areas are largely contiguous, threading throughout the various biogeographic regions. The continued protection and geographic integrity of these areas is essential, particularly by focusing on those old-growth areas most vulnerable to disturbance and conversion. Another major focus should be the rehabilitation, preservation, and management of remnant fragments of lowland forests, on both alluvial and intermediate soils. Local communities and government officials can directly understand the ecological and economic importance of these local forest patches, as they provide critical and free natural services, like non-timber forest products, wild game, cultural heritage, and watershed protection. Given a stable political environment, improved education and adequate economic development, these patches of forest scattered across the island could provide the mesh tying together the "regreening" of the Sulawesi lowlands.

¹ NOTE: for the purposes of this discussion, "forest cover" is considered to be forested areas with little or no signs of obvious disturbance or conversion or **G2G** forest as defined below.

INTRODUCTION

Vegetation communities form the Tree of Life upon which humans, vertebrates, insects, birds, all organisms, are perched. The species composition and physical structure of the vegetation directly determines whether a particular location is good or bad habitat for animal species. Essentially, if the vegetation is lost or modified in a significant way, habitat for the resident species has been lost as well. It's a simple and direct process: lose the vegetation, lose the habitat, lose the animals, insects, snakes, all of life that once lived there. Fortunately, a rose is a rose is a rose and many plant species are ecologically indistinguishable and form 'guilds'. Plant species are fundamentally different than animal species in many regards and the processes producing them remain a mystery.

On top of their fundamental role in any ecosystem, plants are valuable and interesting in their own right. Their behavior and ecology are wonderfully complex, involving incessant competition with other plants, chemical warfare with insects and pathogens, cooperative relationships with fungi and pollinators, and frequent manipulation of seed dispersers. For long lived woody plants, these interactions and behaviors play out over time scales of centuries, making them difficult to directly observe. Fortunately, it is a very exciting time to be conducting research. Amazing breakthroughs in technology and theory have greatly increased our knowledge and understanding of plant biology over the past decade.

Unfortunately, our knowledge and understanding of the vegetation communities on Sulawesi remain quite limited. The number of plant collections per unit area is the lowest for any large landmass in Indonesia and many of these collections are concentrated in relatively few areas. Large areas of the island remain virtually unknown. In comparison to the neighboring island of Borneo, few detailed ecological studies have been completed, even at the descriptive level. Our ignorance is frustrated even further by the unparalleled biogeographic and environmental setting created by the geological and climatic history of the island. Sitting at the doorway between Asia and Australia, distantly related plant and animal groups, separated for eons by vast oceans, are back in direct contact, generating new species and ecosystems. The glancing collision between the Sunda and Sahul shelves has juxtaposed ancient metamorphic rocks against ocean crust and coral reefs slowly dredged up from the sea. Earthquakes, volcanoes, toxic soils, young jagged topography, all of this complexity found on an island without an 'interior'. No place is more than 100 kilometers from the coast, despite numerous mountains that reach >3000 m elev and the fifth deepest lake in the world.

This report is one of the first steps in the Nature Conservancy's ambitious effort to perform an Ecoregional Conservation Assessment of the island. Because of the large geographic scope and the relative lack of detailed evidence, this analysis is necessarily 'coarse' and the interpretations broad and general. A general synthesis of the major forest classes, in relation to their current condition and biogeographic distribution, is presented, followed by a discussion of conservation strategies and objectives emerging from this synthesis. The methods used and analyses performed are described in the last section, including a discussion of my observations and findings during the island-wide field survey performed in mid-2004.

Major forest classes on Sulawesi

For the purposes of this coarse filter analysis, a forest classification system based upon elevation, soils, and drainage was created. While a more detailed system should be used in smaller geographic contexts, only sixteen forest classes have been recognized for the purposes of clarity and simplicity. The full geological map for Sulawesi was simplified by lumping all soil types, except limestone, ultramafic, and alluvium, into a single 'intermediate' group. This step greatly over-emphasizes the similarity of these soils when comparisons between the northern arm and the central region are made but little consensus exists about the effects of the differences among the 'intermediate' soils on vegetation communities or species composition. On the other hand, the three extreme soil types support distinct vegetation communities. These specialized communities are generally less species diverse but often harbor distant migrants and genetically and ecologically divergent plants. Another simplification is the definition of forest types based purely on elevational limits, such as 'lowland'=0-850 m (Table 1).

While this system certainly has its limitations, the results from remote sensing techniques took a long time to optimize, particularly given the large number of individual satellite images necessary to cover the entire land area of Sulawesi.

Three forest habitats were combined with the four soil types to create 10 basic forest classes (alluvial soils are insignificant at high elevations, so only 'lowland alluvium' is described). Tropical forests, found above 2200 meters elevation, are lumped into a single category although slight variation in soils was observed. Three special forest classes were also recognized (mangroves, wetlands, and karst formations), based upon manual inspection of the satellite images. Some effort was spent searching for substantial areas (>50 hectares) of fresh-water swamp and peat forests, using both remote techniques and field surveys, but none were observed.

Table 1. Distribution of forest types by soil and elevation. The values are in hectares. The numbers inside the grey box were included in 'Lowland'. Four additional classes are listed in the lower half of the table.

	Alluvium	Intermediate	Limestone	Ultramafic
Lowland (0-850 m)	1,552,341	8,839,084	1,784,191	1,188,070
Upland (850-1500 m)	2,807	2,450,856	353,196	311,138
Montane (1500-2200 m)	129	1,055,421	65,693	73,168
Tropicalpine	>2200m elevation, stunted growth or open			161,806
Karst Formations	Uplifted 'pure' coral reef deposits			149,963
Wetlands	Constantly wet, without substantial forest			568,615
Mangroves	Coastal tidal areas, saltwater influenced			76,277
Add open mirror table				

Forest condition

Five classes of forest condition were recognized. Three of the classes were determined manually from the satellite images, based upon both field and remote experience. This manual classification was necessary because supervised automation, using various algorithms, did not appear to be reliable. The last two classes were determined using supervised automation.

“Old-growth” - few signs of wide scale disturbance, agreeable with natural levels in scope and structure.

- Total extent – 638,193 hectares (3% of Sulawesi land area)
- Largest single patch – 84,013 ha in West Central Sulawesi, on the border of several different kabupatens (Mamuju, Tana Toraja, and Mamasa)
- Median size patch – 792 hectares

“Good forest” - scattered signs of shifting cultivation or conversion but without roads. No substantial signs of conversion. Disturbance often clustered near rivers, valley bottoms, or ridge tops.

- Total extent – 5,056,290 hectares (26% of Sulawesi land area)
- Largest single patch – 393,036 ha in Central North Sulawesi, a substantial portion of which lies outside the borders of Bogani-Nani Wartabone National Park, in the kabupatens of Bolaang Mongondow and Gorontalo
- Median size patch – 2564 hectares

“Fair forest” – obvious signs of human activity, like roads, but at least half the forest cover intact, including selectively logged areas, intense shifting agriculture.

- Total extent – 3,682,550 hectares (19% of Sulawesi land area)
- Largest single patch – 175,264 ha on the border of East Central and Southeastern Sulawesi, in the kabupatens of Kendari and Kolaka
- Median size patch – 1571 hectares

“Poor forest” - heavily modified areas with less than half forest cover, occasionally containing substantial open patches.

- Total extent – 4,447,090 hectares (23% of Sulawesi land area)
- Largest single patch – 276,717 ha in a highly dissected patch mostly in Western North Sulawesi but in Western Central Sulawesi too.
- Median size patch – 10 hectares

“Open areas” and “converted forests” – no forest cover, cities, paddy fields, etc.

- Total extent – 5,269,570 hectares (27% of Sulawesi land area)
- Largest single patch – 2,137,270 ha in a highly dissected patch in Southwestern Sulawesi and Western Central Sulawesi.
- Median size patch – 9 hectares

Old-growth forest is uncommon on the island with only 3% of the total land area remaining undisturbed. The total amount and single largest patch of old-growth are an order of magnitude less than found in all other conditions. A relatively large amount of forest is still in good condition (26%) and well over half of this area is in fourteen contiguous patches, each over 100,000 hectares. These patches are present in all of the major biogeographic regions except Southwestern Sulawesi. This implies that the much of the forest retains interconnectivity.

MAJOR FOREST CLASSES: current condition and biogeographic distribution

The forest classes vary a great deal in the degree to which they have been disturbed and because of the complex geological history of the island, they are not evenly distributed among the biogeographic regions. The following provides a detailed description for each major class, including field observations during the rapid survey of the island. For the

Forest condition

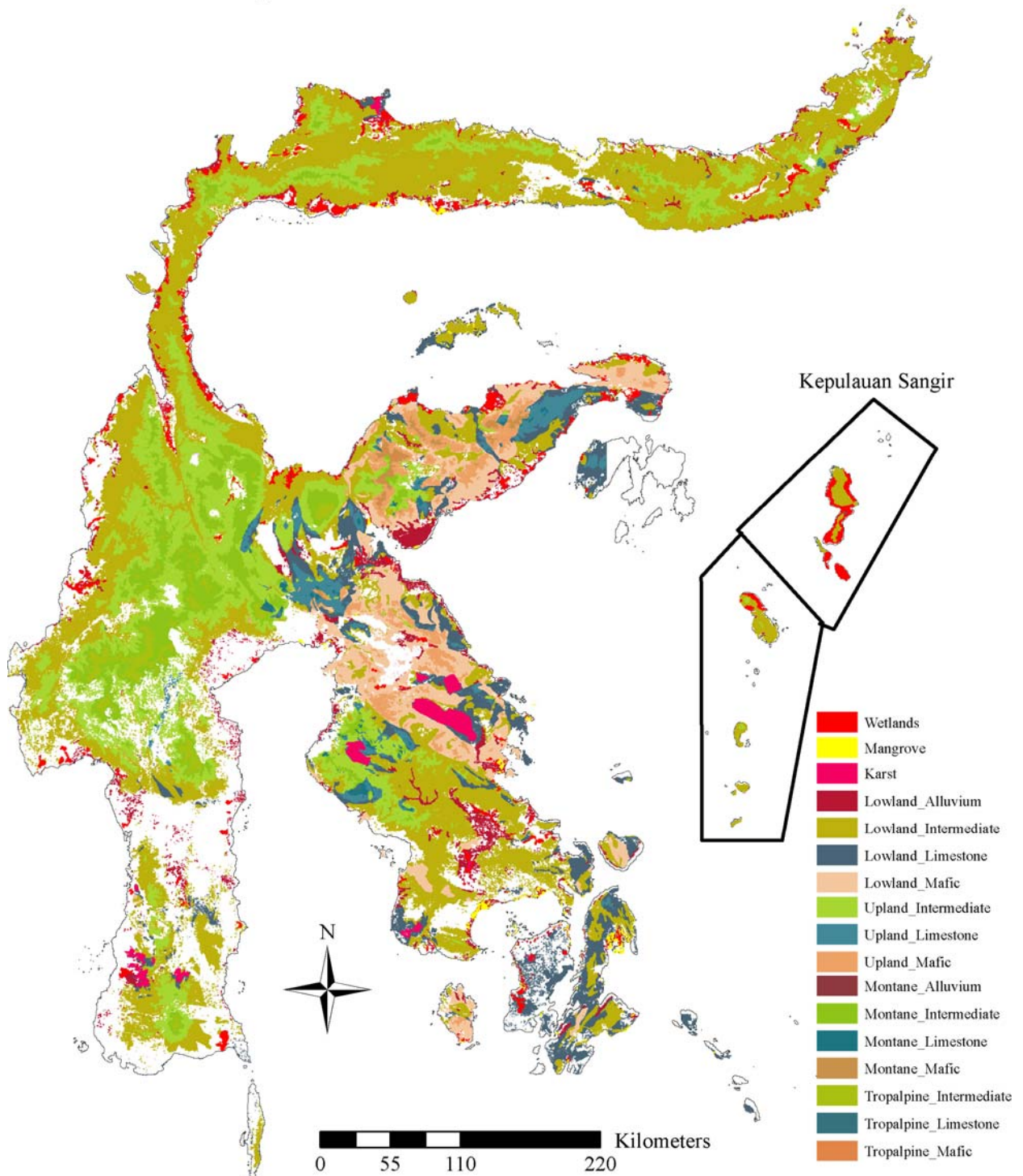
	Old_Growth		Poor
	Good		Open
	Fair		

purposes of a simple discussing forest condition, 'Old-Growth' and 'Good' are combined as "G2G" or "Good to Great" forests. The legend refers to the following series of figures showing the distribution and condition of each major forest class.

The following maps illustrate the distribution of the major forest types and the condition of these forests across the island. The first two maps illustrate all forests together across the entire island. The following series of maps show the distribution of each major forest type and its condition across the entire island. A final series of maps show the major forest types and their condition for each biogeographic region recognized in this analysis.

Forest cover by soil and habitat type

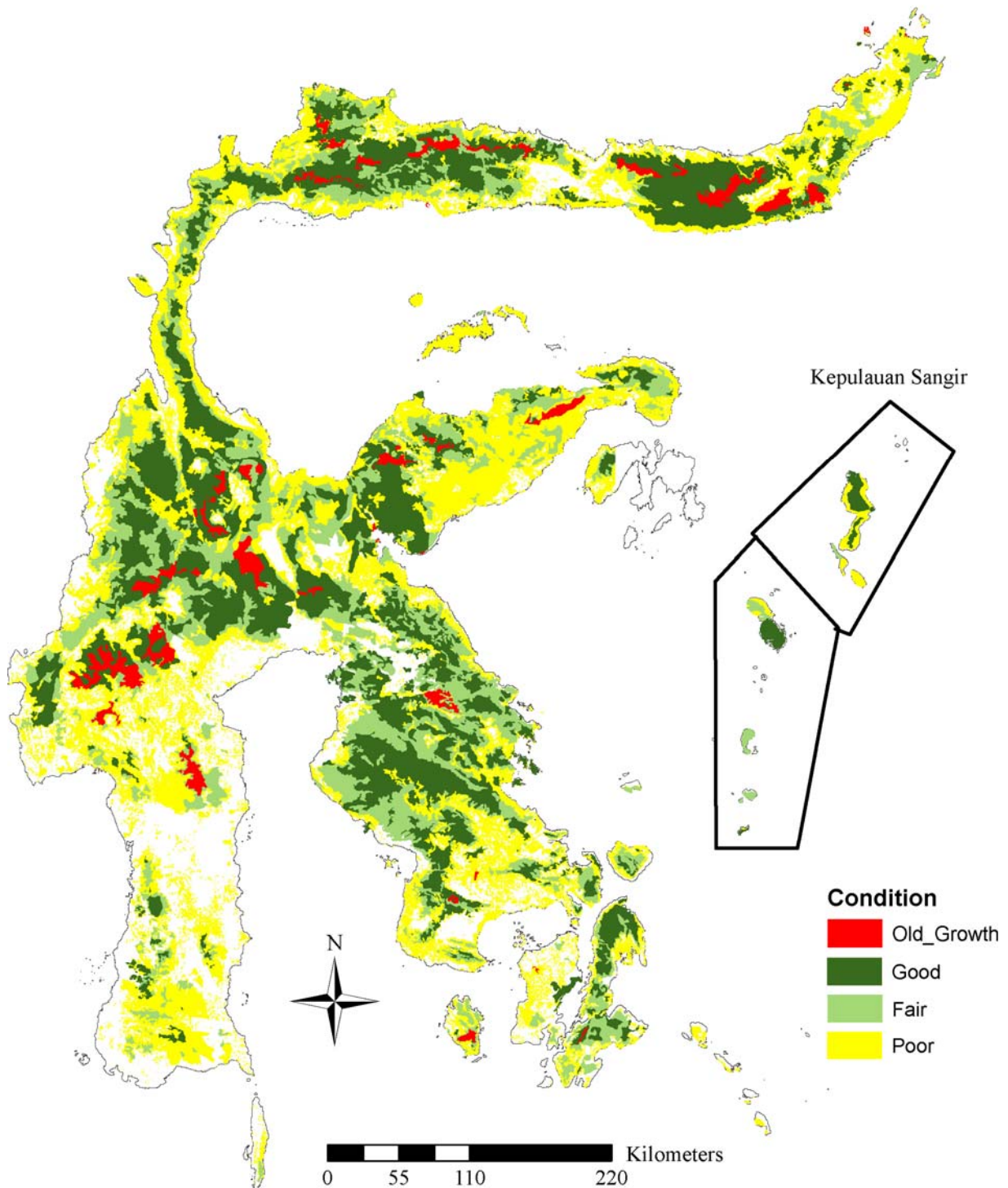
Ecoregional Conservation Assessment of Sulawesi



Major Forest Classes on Sulawesi (map)

Forest condition

Ecoregional Conservation Assessment of Sulawesi



Prepared by C.H. Cannon (Texas Tech University) for the Nature Conservancy, 2005

Forest Condition on Sulawesi (map)

Open Areas and Poor Condition Forests

Basic description

These areas are either bare of vegetation or have scattered open canopy structures, which is largely organized by obvious signs of human activity. This class includes urban areas and cities. Plantation forestry areas, which use obvious monocultures, are considered 'poor condition' forests because of their stark difference in structure and composition in comparison to mixed species closed-canopy forests. These plantation areas normally have higher rates of erosion and soil destruction, unless specific measures were taken to minimize these effects. Open areas occur on all soil types, in all forest types except 'Mangrove', and in all biogeographic regions on the island. The absence of open areas in mangrove forests is primarily a matter of definition, because mangrove forests are coastal. Some areas are naturally open: extremely rocky ridges and mountain peaks, frequently flooded deltas, and some of the driest areas surrounding Palu, but these types constitute a very small proportion.

Total extent: 9,289,300 ha (49.5% of total land area);

Open Areas: 5,007,710 ha **Poor Forest:** 4,281,580 ha

Largest single patch of 'Open Area': 220,526 ha in Southwestern Sulawesi surrounding the city of Ujung Pandang

Largest single patch of 'Poor Condition Forest': 106,858 ha on Sula Island

Current condition

Lowland areas on alluvial and intermediate soils have been modified to a much greater extent than other forest classes. Over three quarters of the alluvial soils in the lowlands have been heavily modified (76.9%) while a little over a quarter of lowland area on intermediate soils (29.9%) has been converted into open or highly disturbed vegetation communities. The amount of conversion obviously drops off with increasing elevation and decreasing fertility of the soils.

Biogeographic distribution

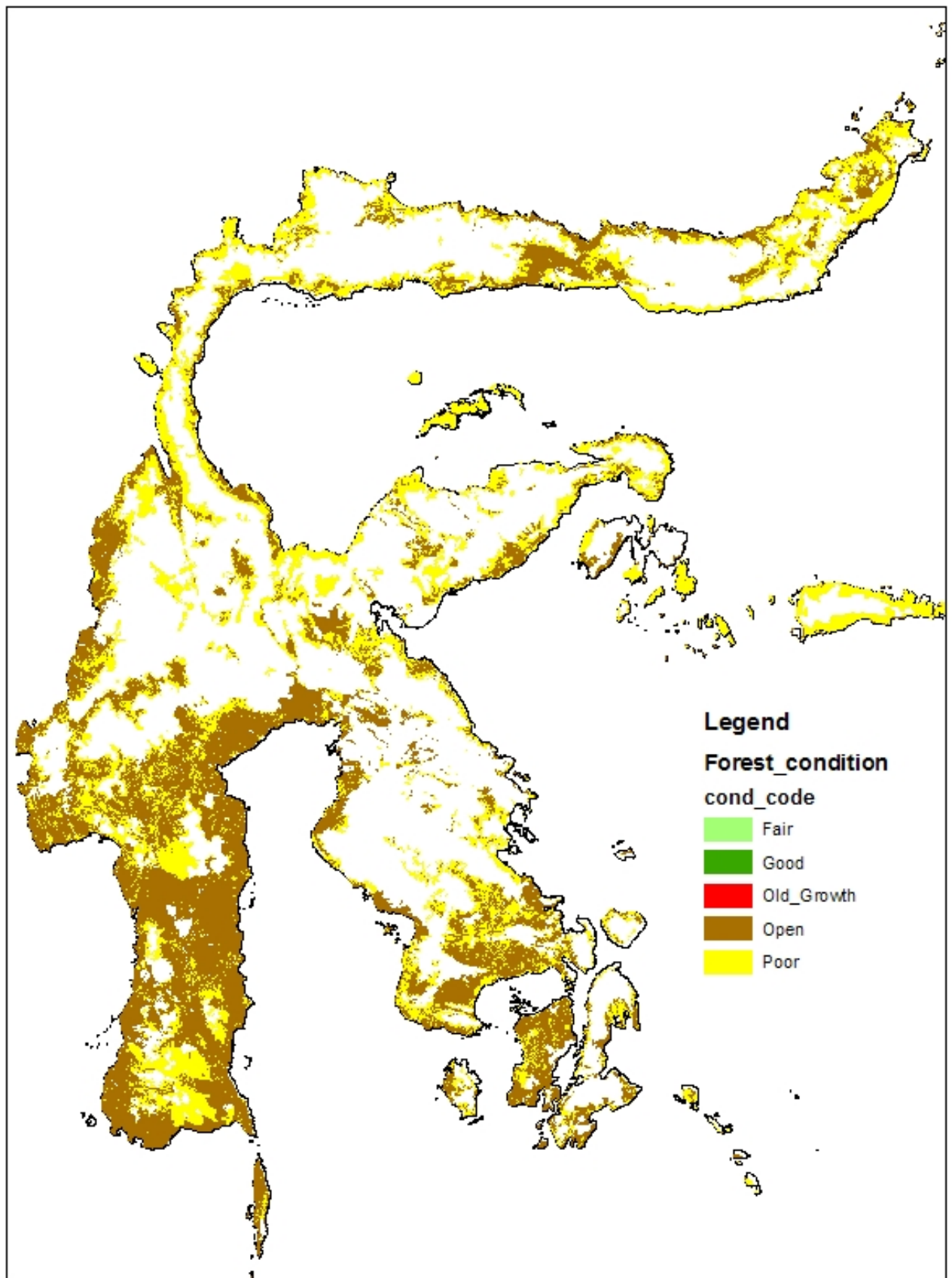
The Southwestern and West Central biogeoregions have an obvious and large concentration of open area and poor forests. The islands are generally heavily converted as well. Other than in the previously mentioned areas, including those surrounding Gorontalo, most of the heavily converted are concentrated near the coast, leaving much of the interior of the island in at least fair condition.

Field notes:

These open areas and poor forests can be quite distinct across the island. These quickly regenerating communities are often strongly affected by soil type and its nutrient status. The secondary forests on mafic soils are substantially different than those on rich volcanic soils..

The top three biogeoregions with the "Most Open" forest

Most Open	Most Poor	Most Open + Poor
West Central : 1,619,310	West Central : 1,018,740	West Central : 2,638,050
Southwest : 1,232,740	Western North : 454,483	Southwest: 1,631,770
Southeast : 573,191	Southeast : 416,978	Southeast: 990,170



Open Areas and Poor Condition Forests

Lowland alluvium

Basic description

Forests between 0-850 meters elevation on generally well-drained soils although they may be seasonally flooded. Alluvial soils can be derived from any parent source and therefore vary widely in their specific properties. Because of high organic content, its frequent replenishment and mixture, nutrients are normally rich in these soils. Forests are well-structured with a high density of large trees but species diversity may be slightly lower than other lowland well-drained sites. Generally good animal habitat, including terrestrial vertebrates. Once converted, often supports productive plantations and padi.

Total extent: 1,552,341 ha (8.3% of land area);

G2G Forest: 48,929 ha (3.2% of total extent).

Largest single patch of ‘Old-Growth’: 104 ha in East Central Sulawesi in Desa Parudongka, Kec. Asera, Keb. Kendari.

Current condition

Highly modified by human activity. These soils are agriculturally productive and valuable and therefore prone to conversion. The only substantial patch of G2G forest is in the Morowali nature reserve. These soils would have mainly been derived from ultramafic and limestone parent material, possibly reducing their fertility and vulnerability to conversion.

Biogeographic distribution

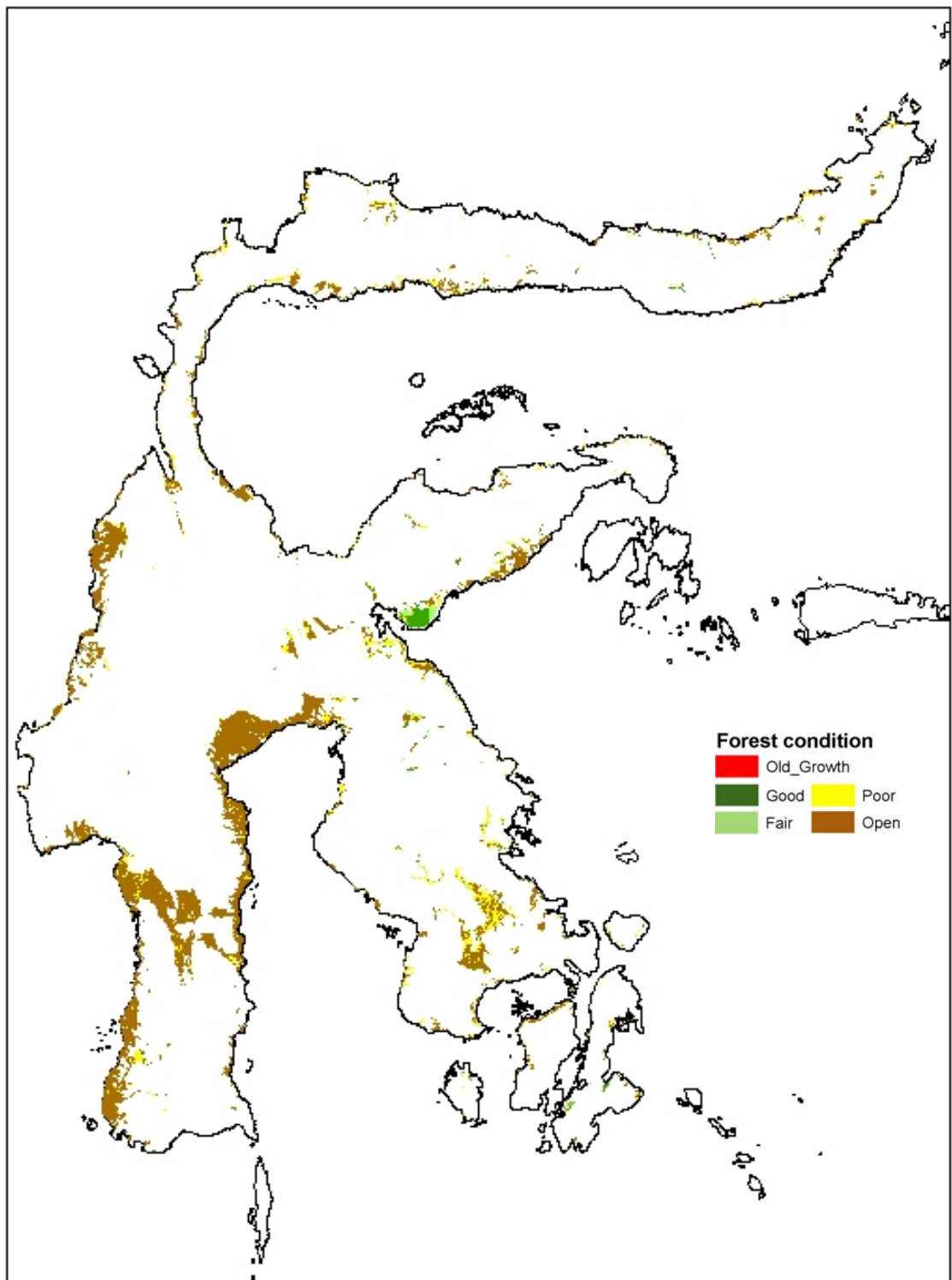
Southwest and West Central Sulawesi (WCS) contain the greatest amount of potential area for this forest class but almost all of it has been converted. These areas have probably been under cultivation for thousands of year and support heavy densities of people. The best conservation strategy for these areas is probably maintenance and restoration. The large area on the northwest coast of WCS (mostly in Kec. Pasangkayu, Kab. Mamuju) has been converted in the last fifteen years and is fringed by some decent forest cover. The large inland alluvial area in and around Rawa Aopa National Park has also largely been converted and only small fragments of freshwater swamp forest still exist. This forest class is virtually missing from the northern arm, simply because of its geological history.

Field notes:

No forested areas of this class were visited during the rapid survey.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
WCS : 498,739	LM : 29,963	WNS : 1.0
SWS : 369,242	ECS : 5166	SES : 2.0
SEC : 189,879	CNS : 4832	ECS : 3.5



Lowland alluvium

Lowland intermediate

Basic description

The largest and most important forest class on the island. Forests between 0-850 meters elevation on well-drained soils of various origin. The ‘intermediate’ class includes soils derived from a wide range of parent material. The nutrient status and physical properties of this soil class are therefore highly variable and the subsequent vegetation communities would also be highly variable. Forests are generally well-structured and often sustain the highest levels of species diversity. Excellent habitat for most vertebrates.

Total extent: 8,839,084 ha (47% of land area);

G2G Forest: 1,936,606 ha (22% of total extent);

Largest single patch of ‘Old-Growth’: 8190 ha in Central North Sulawesi in Kec. Kotabunan, Keb. Bolaang Mongondow

Current condition

These forests are very vulnerable in Southwest Sulawesi (SW) and the vicinity of Gorontalo, where G2G forest cover is down to less than 2%. Across the rest of the island, they are in fair to good condition. Several patches of old-growth are scattered across the northern arm, few of which fall within protected areas. The biggest block of G2G forest is east of Toli-Toli on the border between Sulawesi Tengah and Gorontalo provinces.

Biogeographic distribution

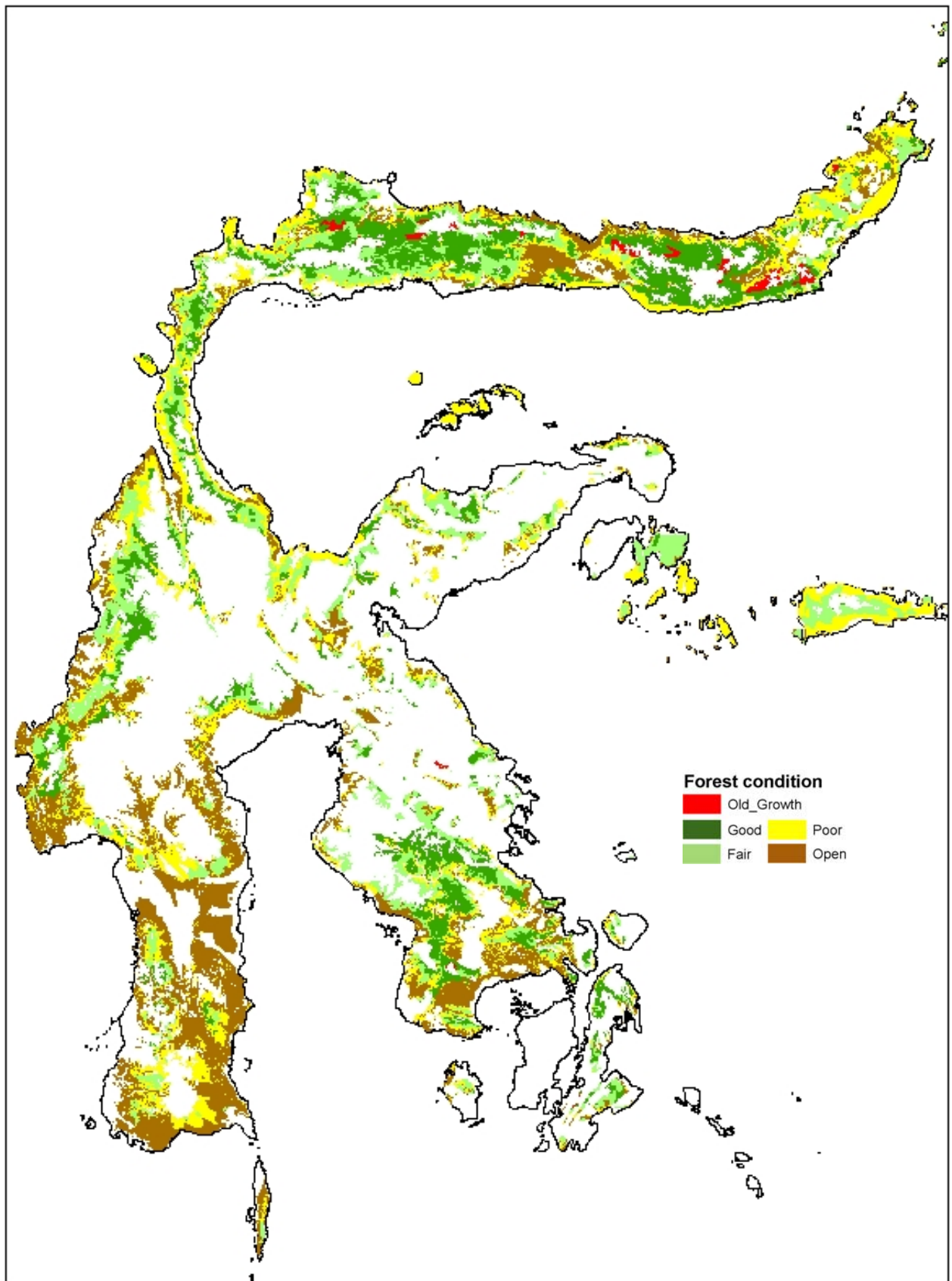
The northern arm is mostly comprised of this forest class and contains by far the largest concentration of good forest cover. The west coast of West Central Sulawesi also contains a significant portion of good forest. In Southeast Sulawesi, the large area of good forest is highly fragmented and probably quite vulnerable.

Field notes

Despite a search in Lore Lindu National Park in 2001, no significant stands were found. The transition to upland forest was a little higher than other parts of the island (near 1000 m) in Bogani-Nani Wartabone National Park.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
WCS : 2,002,940	CNS : 637,826	SWS : 1.7
CNS : 1,385,210	WNS : 360,312	BP : 2.0
SEC : 1,201,930	SES : 334,000	ENS : 9.8



Lowland intermediate

Lowland limestone

Basic description: Forests between 0-850 meters elevation on well-drained soils derived primarily from coral reef deposits. These soils are often quite basic and are highly erodable but these properties vary a great deal on the ‘purity’ of the limestone or how much other soil material is mixed with it. Plant communities are often less diverse and forest structure can be rather open with a lower density of big trees. Occasional high elevation taxa can be observed growing well here.

Total extent: 1,784,191 ha (10% of land area)

G2G Forest: 342,803 ha (19% of total extent)

Largest single patch of ‘Old-Growth’: 1720 ha in East Central Sulawesi in Desa Parudongka, Kec. Asera, Keb. Kendari.

Current condition: This forest class is in moderate condition, with almost complete conversion in Southwest Sulawesi and Muna Island but with some concentrations of G2G forest in East Central Sulawesi and the large island of Banggai. Buton Island also has quite a bit of fair to good forest.

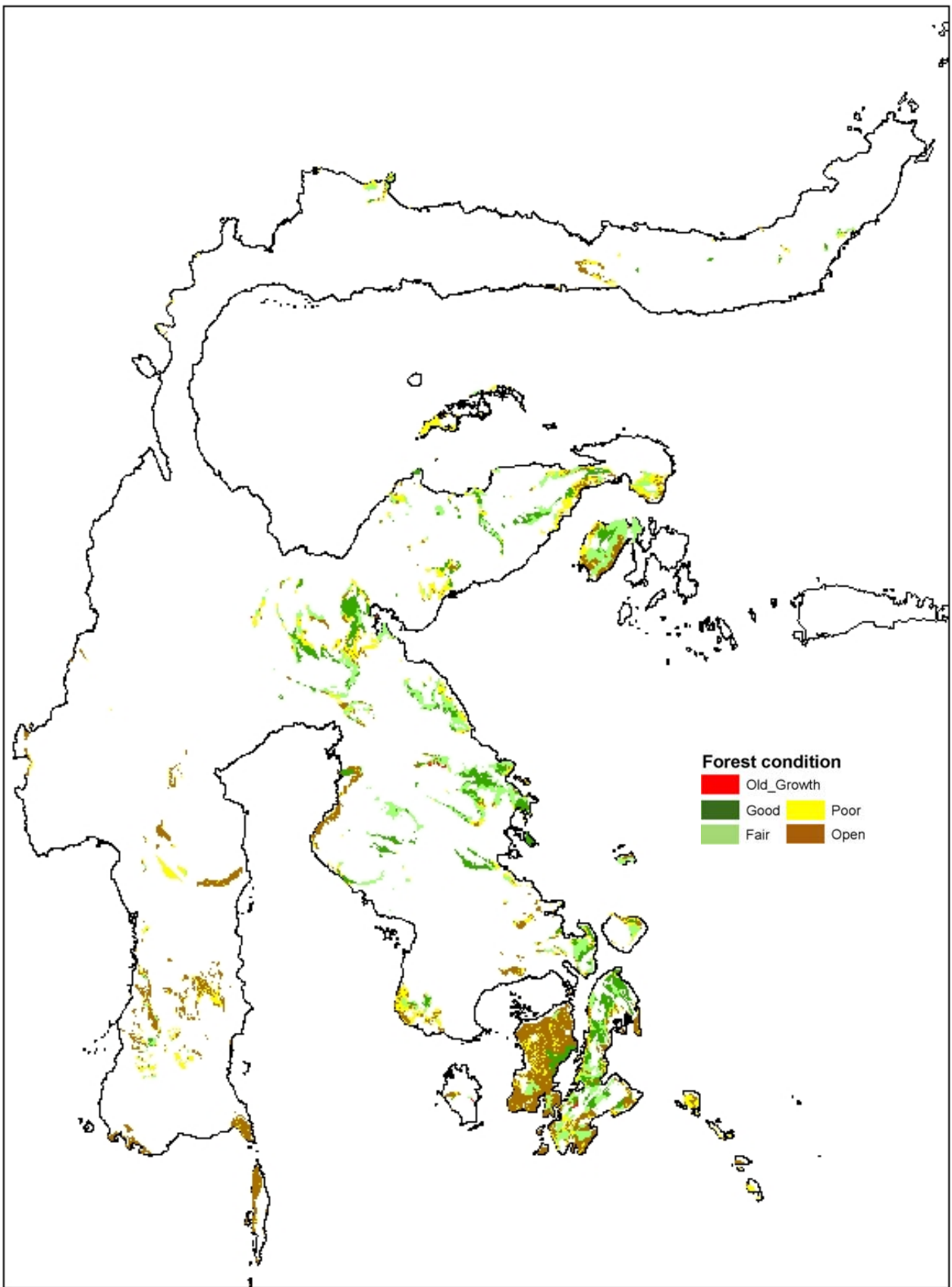
Biogeographic distribution:

The largest areas of this forest class are on the two large island groups of Banggai-Peleng and Muna-Buton-Kabaena, which makes sense as these areas have been recently uplifted. The scattered deposits in Southwest Sulawesi are obviously quite valuable because of their isolation and fragmentation. The largest area on the mainland is in Kec. Petasia, Keb. Morowali to the west of Morowali Bay.

Field notes: This forest class was visited in the Lombuyan Game Reserve in the Luwuk-Morowali region. This forest was well-structured and quite diverse. The limestone content was relatively low and overall the species composition was similar to what would be expected on lowland intermediate soils. The transition to upland limestone at this site occurred at a slightly lower elevation than normal. Increasing amounts of limestone content will normally lower species diversity and raise natural disturbance levels, making for a smaller more open forest structure.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
Muna: 520,687	ECS : 131,493	WCS : 1.7
ECS : 387,965	Muna : 94,045	SWS : 2.3
SES : 216,300	SES : 50,728	WNS : 6.3



Lowland limestone

Lowland mafic

Basic description: Forests between 0-850 meters elevation on well-drained soils derived from uplifted oceanic crust. These soils often contain high concentrations of heavy metals and often support rather stunted and species poor forests. Again, like limestone, these soils vary a great deal in their properties from place to place and with increasing mixtures of intermediate and alluvial soils, productivity increases. High elevation and beach plant groups occasionally dominate these forests. Probably contains the highest number of endemic species compared to other forest classes. Normally poor habitat for vertebrates.

Total extent: 1,188,070 ha (6% of land area)

G2G Forest: 574,151 ha (48% of total extent)

Largest single patch of ‘Old-Growth’: 15,781 ha in East Central Sulawesi in Desa Parudongka-Tirawonua-Routa, Kec. Asera, Keb. Kendari. (this is not a typo, there is an area of old-growth forest in this kecamatan which contains a rich mixture of forest types)

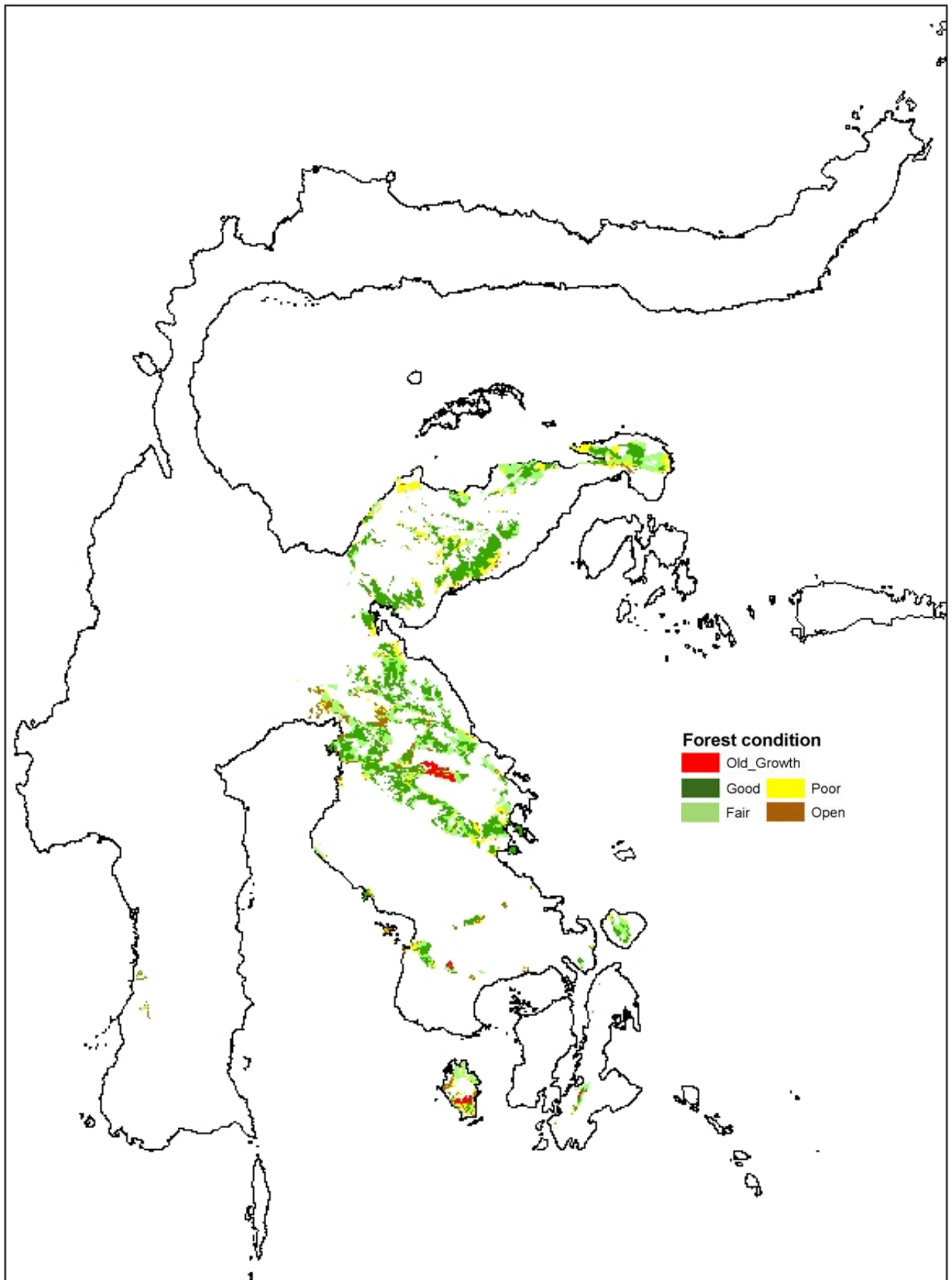
Current condition: The lack of agricultural productivity of these soils has protected these forests from conversion with almost half of the total extent still in G2G forest.

Biogeographic distribution: This forest class is completely absent from the western and northern parts of the mainland. The largest concentration is found in East Central Sulawesi, with a substantial amount of G2G forest. A substantial patch of good forest is also found in the Luwuk-Morowali region, both along the southern coast and in the mushroom’s cap region. The island of Kabaena possesses a large amount of this forest class, including some old-growth.

Field notes: Forest structure varies enormously in this forest class. The classic stunted forest communities, with abundant *Causarina* and *Agathis*, can be found in the Morowali Nature Reserve. The forest canopy is open and trees are small and closely placed together. Abundant terrestrial orchids and high densities of mafic endemic plants were observed, like *Kjellbergiodendron* and *Helicia*. These forests are vulnerable to conversion and are slow to recover, often becoming grassland-shrubland climax communities after the forest cover has been removed. Numerous areas of open grassland, marked by large rusty colored boulders and rocks, were observed across the island on these soils.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
ECS: 632,086	ECS : 313,769	Muna : 26
LM : 410,450	LM : 214,131	SES : 40
Muna : 71,707	SES : 26,164	ECS : 50



Lowland mafic

Upland intermediate

Basic description: The second most important forest class. Forests between 850-1500 meters elevation on well-drained soils and occasionally quite steep terrain. The ‘intermediate’ soil class varies widely in nutrient status and physical properties. Because of the steep topography found on much of Sulawesi, drainage conditions of this forest type can also range from rocky acidic ridge tops to narrow alluvial deposits generally creating a complicated mosaic of microhabitat. Forests are generally well-structured and often sustain high levels of species diversity. Moderate habitat for most vertebrates.

Total extent: 2,450,856 ha (13% of land area)

G2G Forest: 1,227,559 ha (50% of total extent)

Largest single patch: 25,934 ha in Central North Sulawesi which is almost entirely within the Bogani-Nani Wartabone National Park.

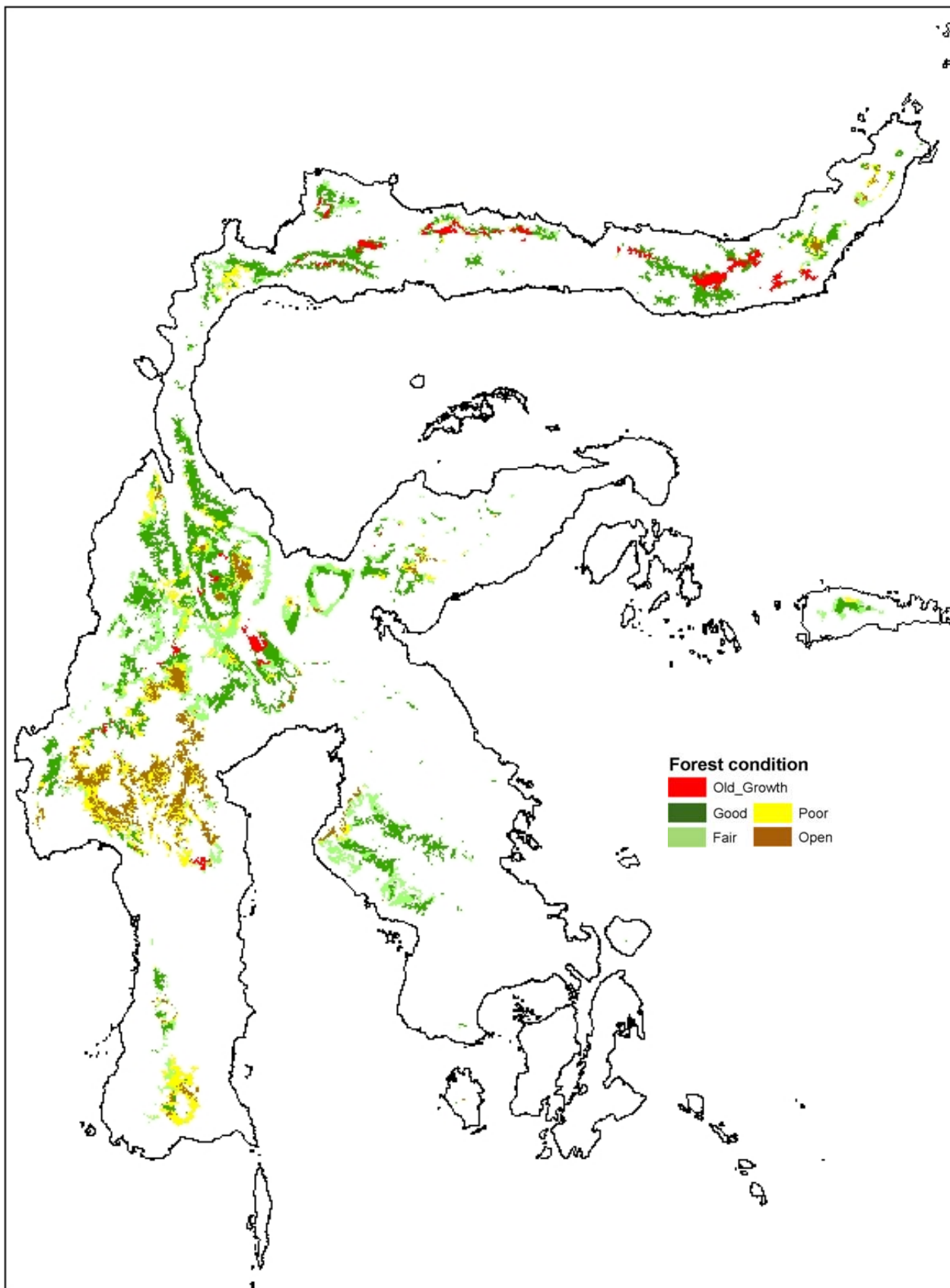
Current condition: Because of its general inaccessibility and steep topography, this forest class has gone through relatively little conversion, except in the Tana Toraja area where the local people have developed productive intensive agricultural practices for this landscape. The interior mountains of the northern arm are in excellent condition while large areas, inside and out of Lore Lindu National Park, are fragmented but still in quite good condition.

Biogeographic distribution: The vast majority of this forest class is in West Central Sulawesi on the old core of the rifting Sunda Shelf margin. The mountain arc across the northern arm possesses a narrow band of it. Southeast Sulawesi has a substantial area as well.

Field notes: Numerous examples of this forest class were seen across the island and the dominate plant groups and forest structure are quite consistent across the island. *Castanopsis accuminatissima* is probably the most abundant large tree on the island and provides a good indicator by its density and growth forms. The elevation at which lowland ⇔ upland increases with soil fertility but decreases with seasonality of rainfall.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
WCS: 1,399,630	WCS : 580,461	SWS : 19
CNS : 248,784	CNS : 223,390	WCS : 41
WNS : 218,815	WNS : 169,631	ENS : 43



Upland intermediate

Upland limestone

Basic description: Forests between 850-1500 meters elevation on well-drained soils derived from coral reef deposits and occasionally on quite steep terrain. These soils are often basic and are highly erodable but these properties vary a great deal with the ‘purity’ of the limestone or how much other soil material is mixed with it. Plant communities on mixed limestone soils are generally indistinguishable from intermediate soils.

Total extent: 353,196 ha (2% of land area)

G2G Forest: 218,234 ha (62% of total extent)

Largest single patch: 21,202 ha in Luwuk-Morowali in Kec. Pagimana, Kab. Banggai, west of the Lombuyan protected areas.

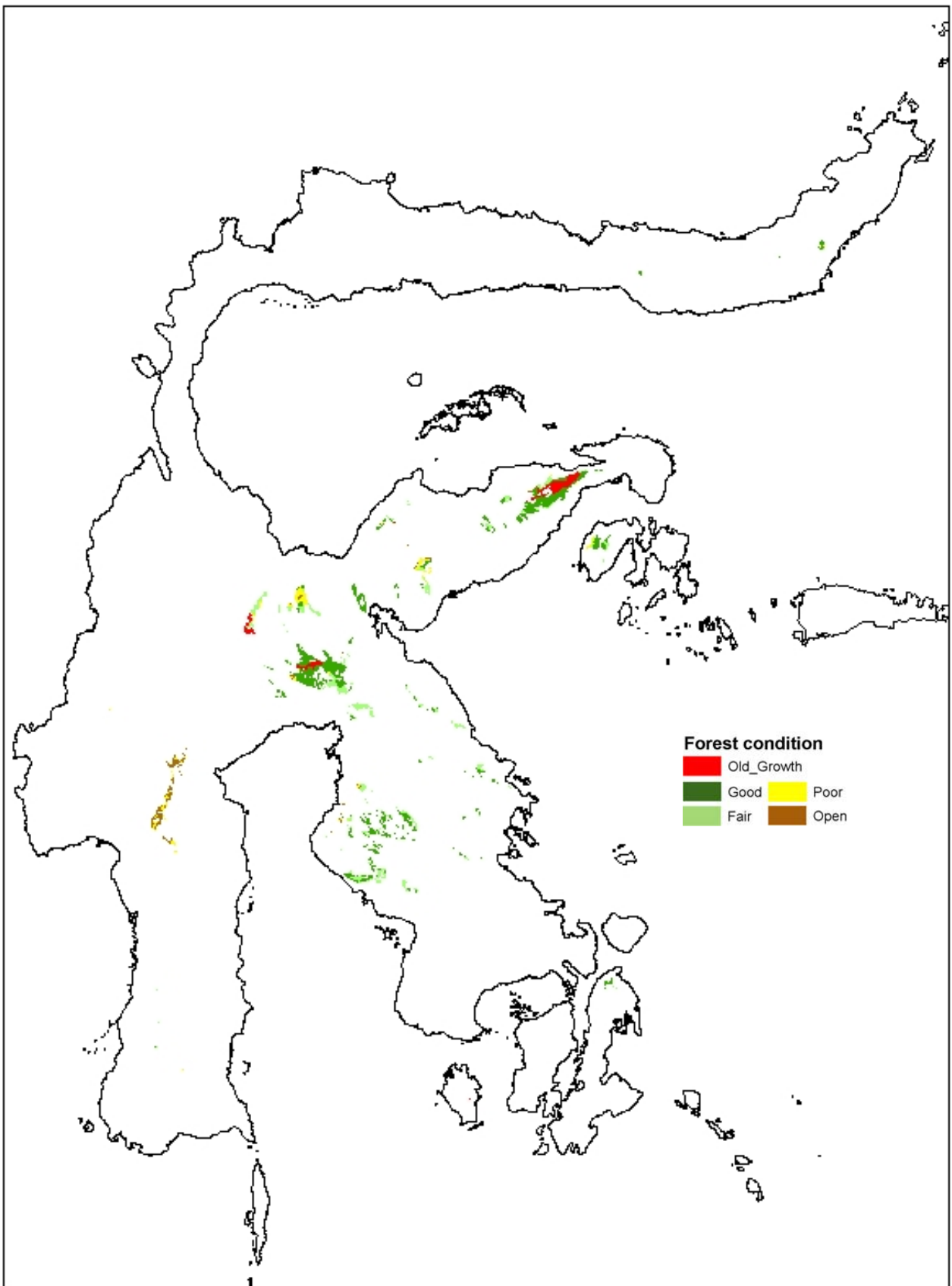
Current condition: Generally in good condition, except in Southwest Sulawesi. Several areas remain almost entirely old-growth forest.

Biogeographic distribution: The vast majority of this forest class is found in only three regions, East Central Sulawesi, Luwuk-Morowali, and Southeast Sulawesi. Very little area exists in the northern arm or West Central Sulawesi. The scattered patches in Southwest Sulawesi have been completely converted.

Field notes: This forest class was visited in both the Lombuyan and Feruhumpenai Nature Reserves. This forest was quite impressive in its stature and diversity but the soils were also quite mixed and the region resembled an uplifted alluvial plain. Again, as in the lowland limestone class, the limestone content of the soils is relatively low, meaning that forests structure and diversity are high and species composition was indistinguishable from ‘upland intermediate’ except for the notable absence of *Castanopsis accuminatissima*, the dominant tree species in this forest class on intermediate soils across the island.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
ECS: 124,427	ECS : 82,875	WCS : 22
LM : 95,448	LM : 72,910	BP : 58
SES : 62,509	SES : 38,172	SES : 61



Upland limestone

Upland mafic

Basic description: Forests between 850-1500 meters elevation on well-drained soils derived from uplifted oceanic crust. These soils often contain high concentrations of heavy metals and often support rather stunted and species poor forests. These soils vary a great deal in their properties from place to place and with increasing mixtures of intermediate and alluvial soils, productivity increases. Probably contains the highest number of endemic species compared to other forest classes. Normally poor habitat for vertebrates.

Total extent: 311,138 ha (2% of land area)

G2G Forest: 245,590 ha (79% of total extent)

Largest single patch: 2,702 ha in Luwuk-Morowali in Kec. Tojo, Kab. Poso, north of the Morowali Nature Reserve.

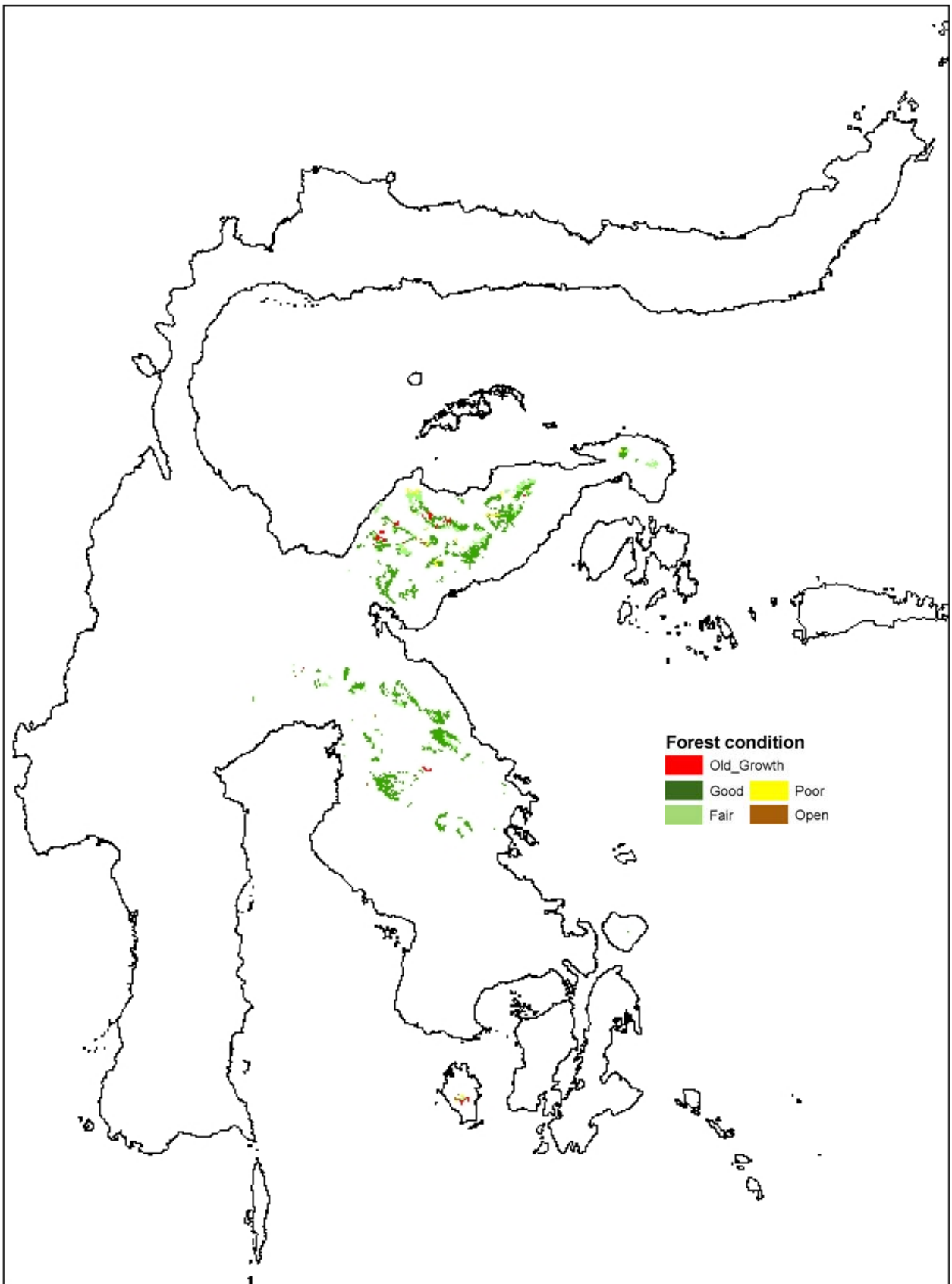
Current condition: These areas are largely undisturbed by human activities with G2G forests covering over 78% of total area. While most areas are classified as ‘Good’ instead of ‘Old-growth’, this may be due to higher levels of natural disturbance and poor development of canopy structure often found in these vegetation communities.

Biogeographic distribution: Largely concentrated in the Luwuk-Morowali bioregion, this forest class has a restricted geographic distribution on the island. Large areas also exist in Southeastern Sulawesi, primarily around Lake Towuti.

Field notes: No visit to this forest class was possible during the field survey. Very little is known about this forest class on Sulawesi, despite the fact that this is one of the largest extents of this unusual and often highly endemic forest type on Earth.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
LM : 188,586	LM : 140,524	Muna : 35
ECS : 114,964	ECS : 100,380	LM : 75
Muna : 3858	SES : 2,737	ECS : 87



Upland mafic

Montane Intermediate

Basic description: Forests between 1500-2200 meters elevation on well-drained soils and normally steep terrain. The 'intermediate' soil class varies widely in nutrient status and physical properties. Because of the steep topography found on much of Sulawesi, drainage conditions of this forest type can also range from rocky acidic ridge tops to narrow alluvial deposits generally creating a complicated mosaic of microhabitat.

Total extent: 1,055,421 ha (6% of land area)

G2G Forest: 732,423 ha (69% of total extent)

Largest single patch: 37,577 ha in West Central Sulawesi, spread across three kabupatens, Tana Toraja, Mamuju, Polewali Mamasa

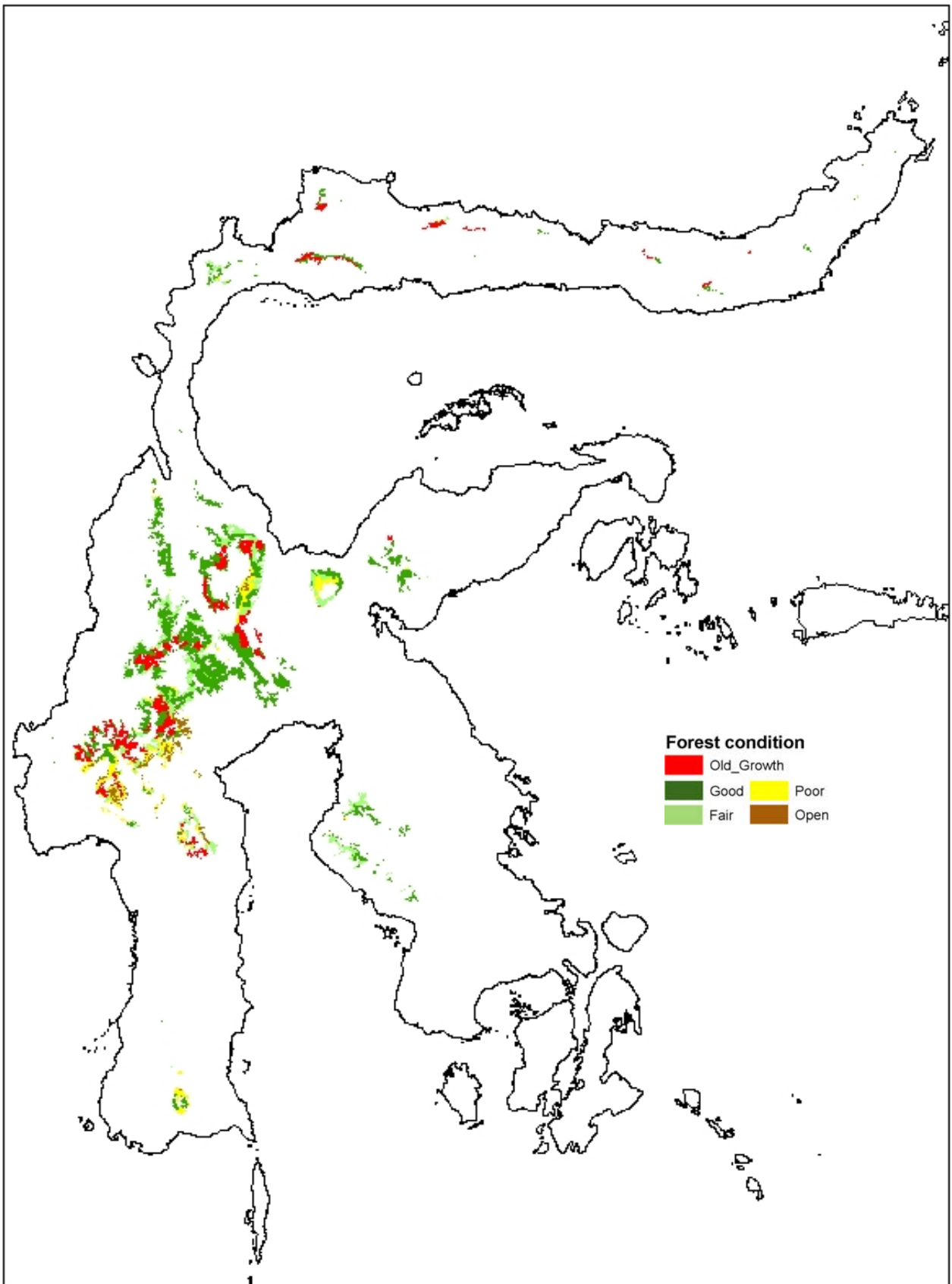
Current condition: These areas are in overall good condition, with almost 70% of total land area in G2G forest. A large portion of this area is actually in old-growth forest. Some of these areas are adjacent to open and poor forests, making them highly vulnerable to conversion and degradation.

Biogeographic distribution: Over 80% of this forest class is found in West Central Sulawesi. It also forms almost 20% of this bioregion, making it unusual because of the continuity of this montane forests. Scattered patches of G2G condition are found in the northern arm and Southeastern Sulawesi.

Field notes: This forest type was primarily observed in the Lore Lindu National Park but because of the contiguity of this forest class in the central portion of the island, this previous description will probably be accurate for majority of this forest class.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
WCS: 861,426	WCS : 606,449	ECS : 30
SES : 48,261	WNS : 36,661	SWS : 42
WNS : 43,173	SES : 27,213	SES : 56



Montane Intermediate

Montane limestone

Basic description: Forests between 1500-2200 meters elevation on well-drained soils derived from coral reef deposits and occasionally on quite steep terrain. Because these areas represent uplifts from below sea level, the distribution of this forest class is quite patchy and fragmented.

Total extent: 65,693 ha (0.4% of land area); **G2G Forest:** 57,299 ha (87% of total extent); **Largest single patch:** 2,556 ha in Luwuk-Morowali in Kec. Pagimana, Kab. Banggai, west of the Lombuyan protected areas.

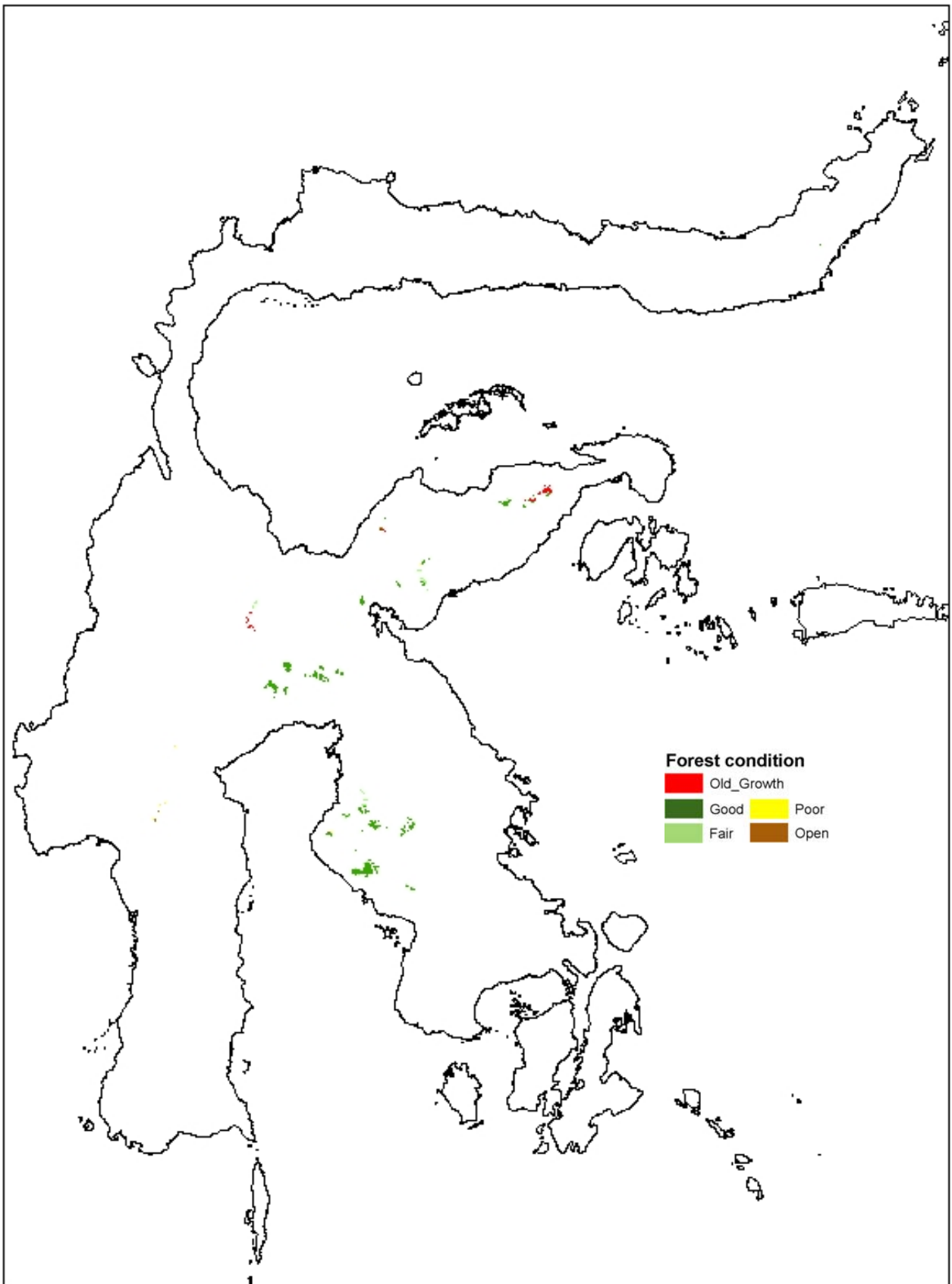
Current condition: The vast majority (>87%) of this forest class is in G2G condition, primarily because of its inaccessibility.

Biogeographic distribution: The largest areas of this forest class are found in Southeastern and Eastern Central Sulawesi with a significant patch of old-growth in Luwuk-Morowali as well. This forest class is entirely absent from all other bioregions.

Field notes: No areas of this forest class have been visited and virtually no published information exists.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
SES: 26,637	SES: 23,448	WCS : 80
LM : 14,641	LM: 12,345	LM : 84
WCS : 14,258	WCS : 11,370	SES : 88



Montane limestone

Montane mafic

Basic description: Forests between 1500-2200 meters elevation on well-drained soils derived from uplifted oceanic crust. These soils often contain high concentrations of heavy metals and often support stunted and species poor forests. Because of the high elevation and their uplifted nature, these forests are often on quite thin deposits. Very little is known about these forests.

Total extent: 73,168 ha (0.4% of land area); **G2G Forest:** 66,900 ha (91% of total extent); **Largest single patch:** 6,106 ha in Luwuk-Morowali in Kec. Ulu Bongka, Kab. Poso, north of the Morowali Nature Reserve

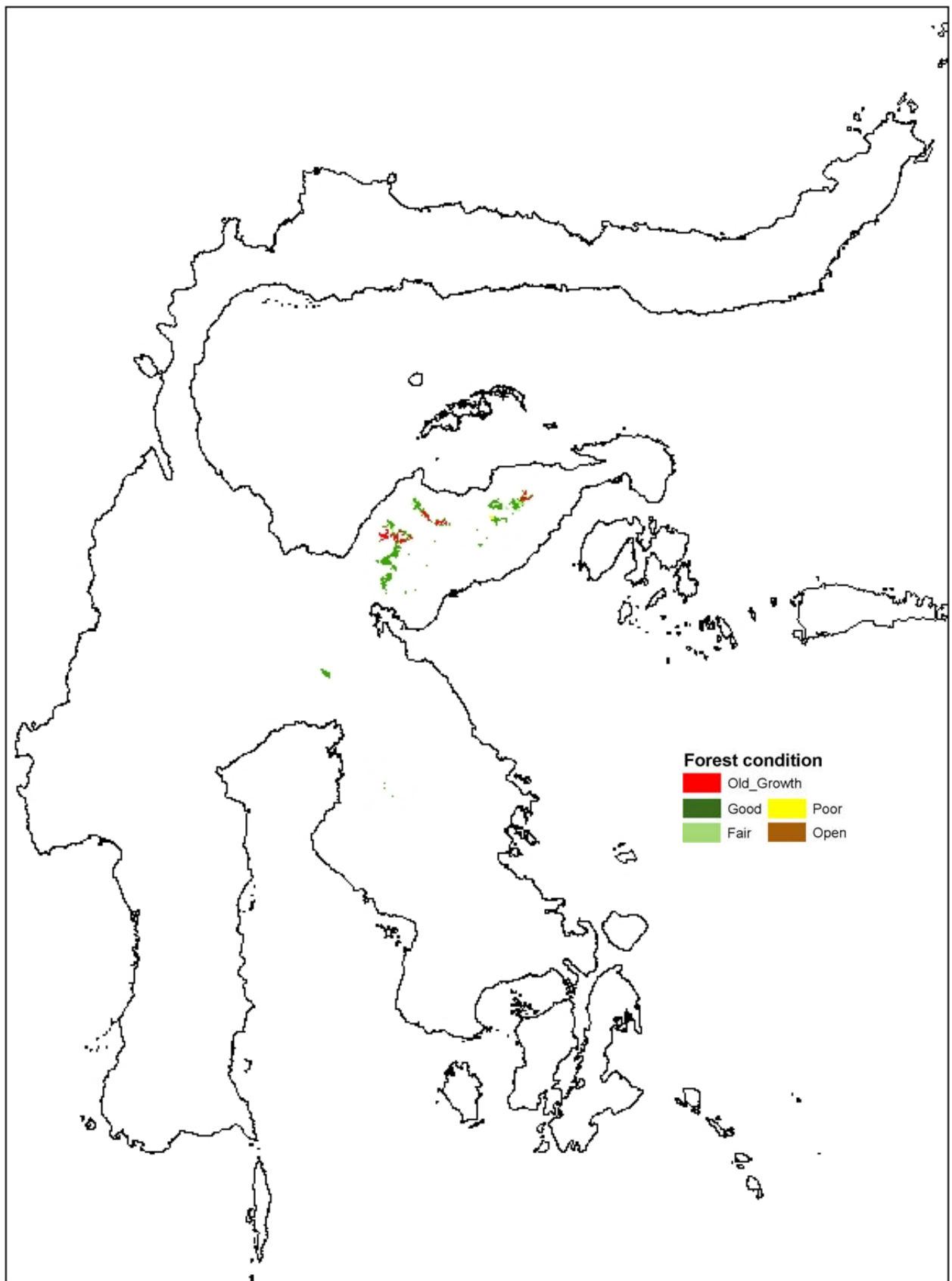
Current condition: Virtually untouched by human activity, this forest class is almost entirely (>90%) in G2G condition.

Biogeographic distribution: Almost entirely in Luwuk-Morowali bioregion, this forest class occurs in several large contiguous patches, much of which is in the Morowali Nature Reserve. A tiny patch is just outside the Faruhempenai Reserve.

Field notes: No areas of this class supporting G2G forest have been visited.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
LM : 70,167	LM : 63,968	LM : 91
ECS : 2,908	ECS : 2,845	ECS : 98
WCS : 72	WCS : 72	WCS : 100



Montane mafic

Tropalpine

Basic description: Forests above 2200 meter elevation on a variety of soils, which are often thin and rocky. Forests are often densely structured with a large number of small trees. Species diversity often quite low among the woody plants but herbaceous plants are often most diverse in this forest class. This forest class also supports the most unique set of plants, often with only distant relatives found in more temperate regions.

Total extent: 161,806 ha (1% of land area)

G2G Forest: 125,739 ha (78% of total extent)

Largest single patch: 25,004 ha in West Central Sulawesi, spread across three kabupaten, Tana Toraja, Mamuju, Polewali Mamasa.

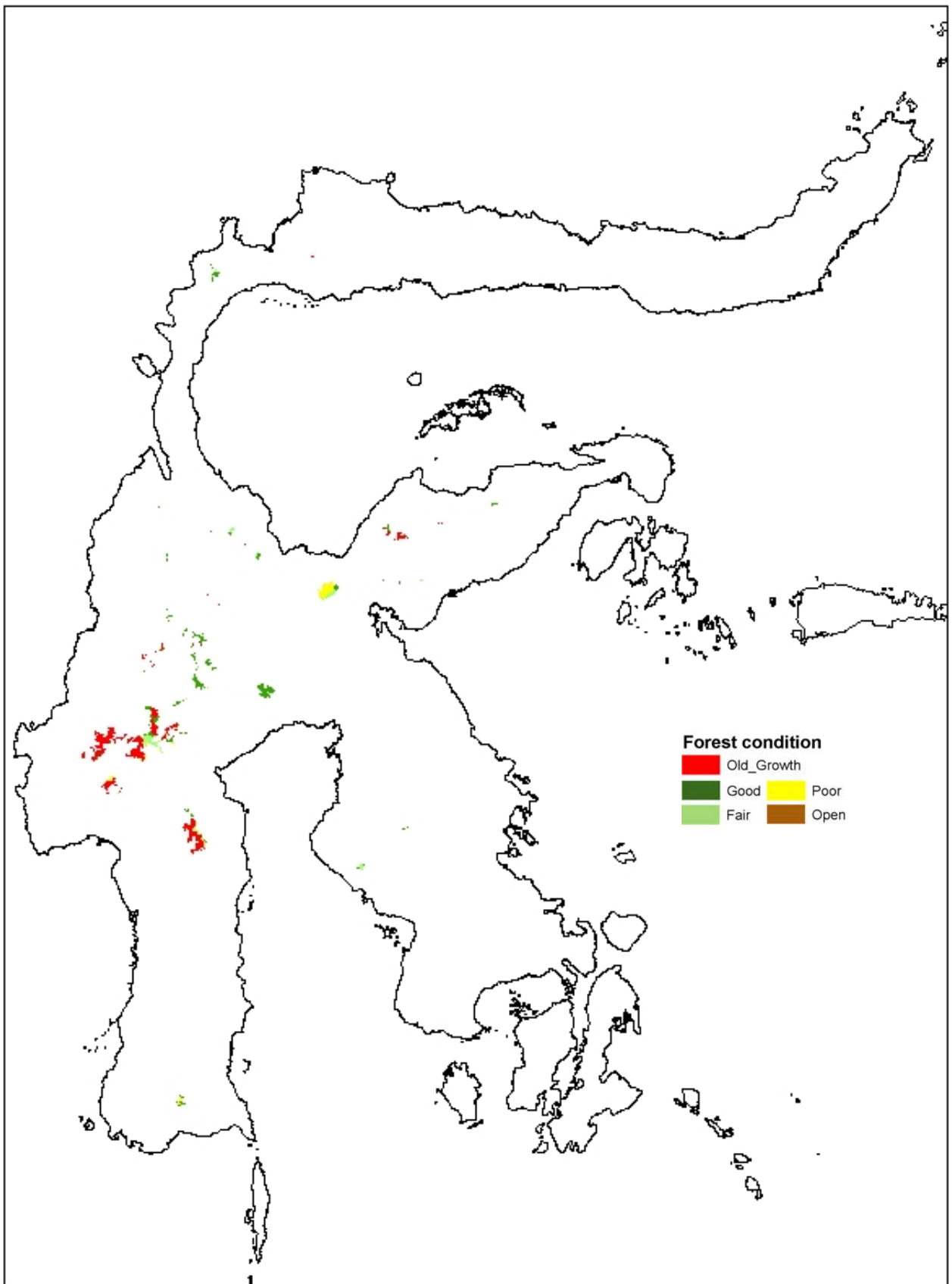
Current condition: Mostly in good condition, with a very large area of old-growth forest in West Central Sulawesi. These forests are quite vulnerable to conversion and slow to recover.

Biogeographic distribution: Small patches of this forest class are scattered across the island with each of the mainland bioregions possessing at least a small area, except for the northern arm. Because of their geological nature, this forest class often exists as a 'sky islands', although an unusually large area exists in the southern portion of West Central Sulawesi, virtually all of which is old-growth forest.

Field notes: No areas of this class supporting G2G forest have been visited.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
WCS : 131,200	WCS : 110,963	ECS : 10
ECS : 13,820	LM : 7,450	SWS : 64
LM : 7,763	WNS : 3,029	WNS : 84



Tropalpine

Karst formations

Basic description: Forests on almost pure coral reef deposits which form extremely sharp-sided topography, contain abundant cave formations, and are highly erodable and normally nutrient and water stressed. Karst formations on Sulawesi are found at a range of elevations, from near sea level up to over 1000 meters elevation. These forests are often poorly structured with mostly small trees at relatively low densities. They are also normally rather species poor but these species are also often restricted largely to this forest type. These forests are quite fragile and rapid soil degradation normally follows their conversion. Often relatively poor habitat for animals.

Total extent: 149,963 ha (1% of land area)

G2G Forest: 82,288 ha (55% of total extent)

Largest single patch: 1,000 ha on Kabaena Island in Kec. Lawa, Kab. Muna.

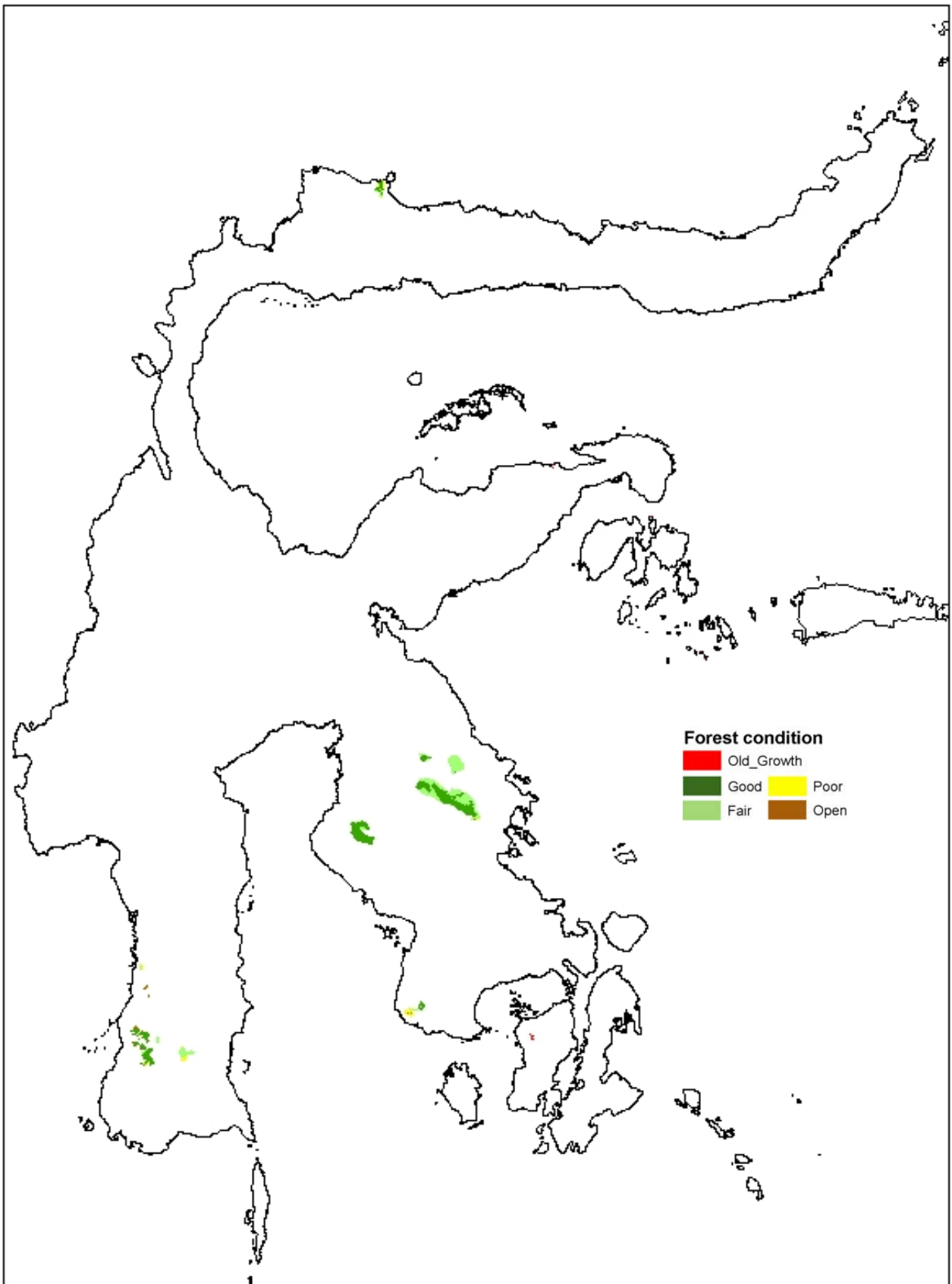
Current condition: In generally good condition, with a little over half in G2G condition. Again, because of high natural rates of turnover, much of the forests in fair condition may be that way due to natural processes and not human activity.

Biogeographic distribution: The largest region is on the border of East Central and Southeastern Sulawesi. No prior reports exist of this large karst formation but after careful examination of the satellite images and geological patterns, the presence of this area of karst seems reasonable. Field verification of this formation is necessary. The karst formations north of Makassar are well-known and quite distinct from the surrounding forests.

Field notes: The protected areas within the Karaenta Nature Reserve support typical forests on these formations. The canopy is relatively open and of short stature, with a relatively high proportion of mid-phase to pioneer species.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
ECS : 82,134	ECS : 36,770	ECS : 45
SWS : 31,487	SES : 21,953	SWS : 57
SES : 28,223	SWS : 17,998	WNS : 59



Karst formations

Wetlands

Basic description: These areas normally occur along or near rivers as they approach the coast and begin to flatten out on the associated alluvial plants. Occasionally, wetlands are also formed inland where constricted drainage creates a large flooded areas. Wetlands are normally flooded year round and do not normally sustain substantial woody vegetation but instead support large populations of water plants, like Nelumbo and sedges. These areas are important habitat for water fowl and other associated wetland species.

Total extent: 568,615 ha (3% of land area)

G2G Forest: 1,819 ha (<1% of total extent)

Largest single patch: 1,772 ha in Southeast Sulawesi within the Rawa Aopa National Park.

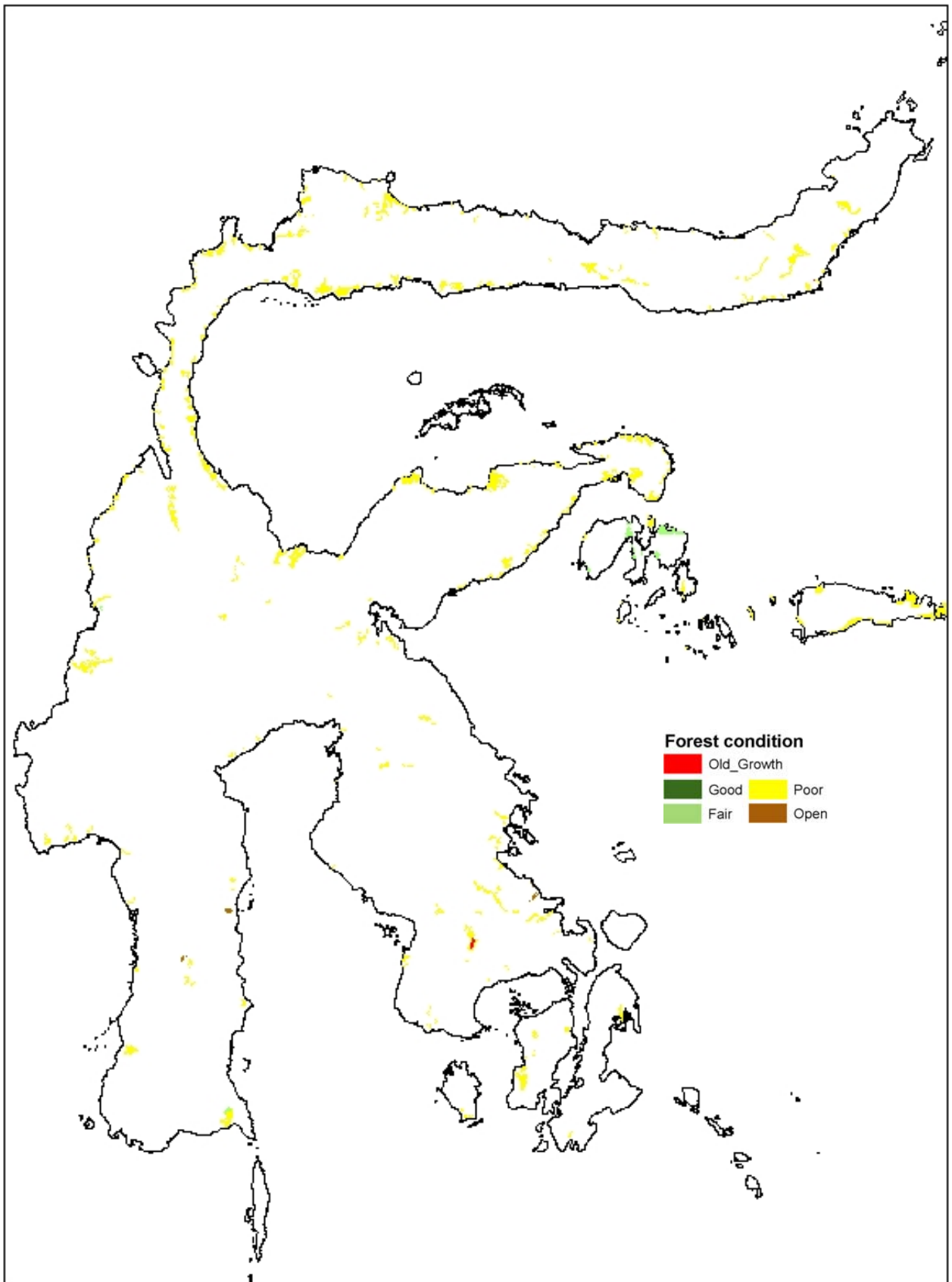
Current condition: Mostly in poor condition because of the agricultural productivity of these regions and their accessibility. A substantial area of wetlands exist in the Rawa-Aopa National Park. These areas are often drained and their flooding controlled through irrigation.

Biogeographic distribution: Scattered around the margins of the entire island, these wetland areas are an important coastal vegetation community.

Field notes: A large wetland area was visited to the west of Kolonedale in Eastern Central Sulawesi. Because of the variable drainage conditions, these areas sustain some patches of fresh-water swamp forest, scattered throughout. Much of the area was flooded and vegetation consisted of pandans, sedges, water lilies, and other water plants.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
WNS : 107,286	SES : 1,772	WCS : 0
LM : 78,745	ECS : 39	LM : <<1
WCS : 70,357	LM : 5	WNS : <<1



Wetlands

Mangroves

Basic description: Forests on coastlines and inlets strongly influenced by tidal seawater. These forests form a very distinct community with sharp boundaries. Species composition is quite uniform around the island and across Southeast Asia, as these species are sea-faring and easily travel between landmasses. Species richness is normally low with one or two species normally dominating a particular area, although the dominant species may vary from place to place. These forests are very important in terms of buffering inland areas from tidal and wave action, filtering waste and sediments and providing habitat for a large number of important ocean fish and animals.

Total extent: 76,245 ha (1% of land area)

G2G Forest: 3,457 ha (5% of total extent)

Largest single patch: 508 ha in Luwuk-Morowali area, Kec. Petasia, Kab. Morowali.

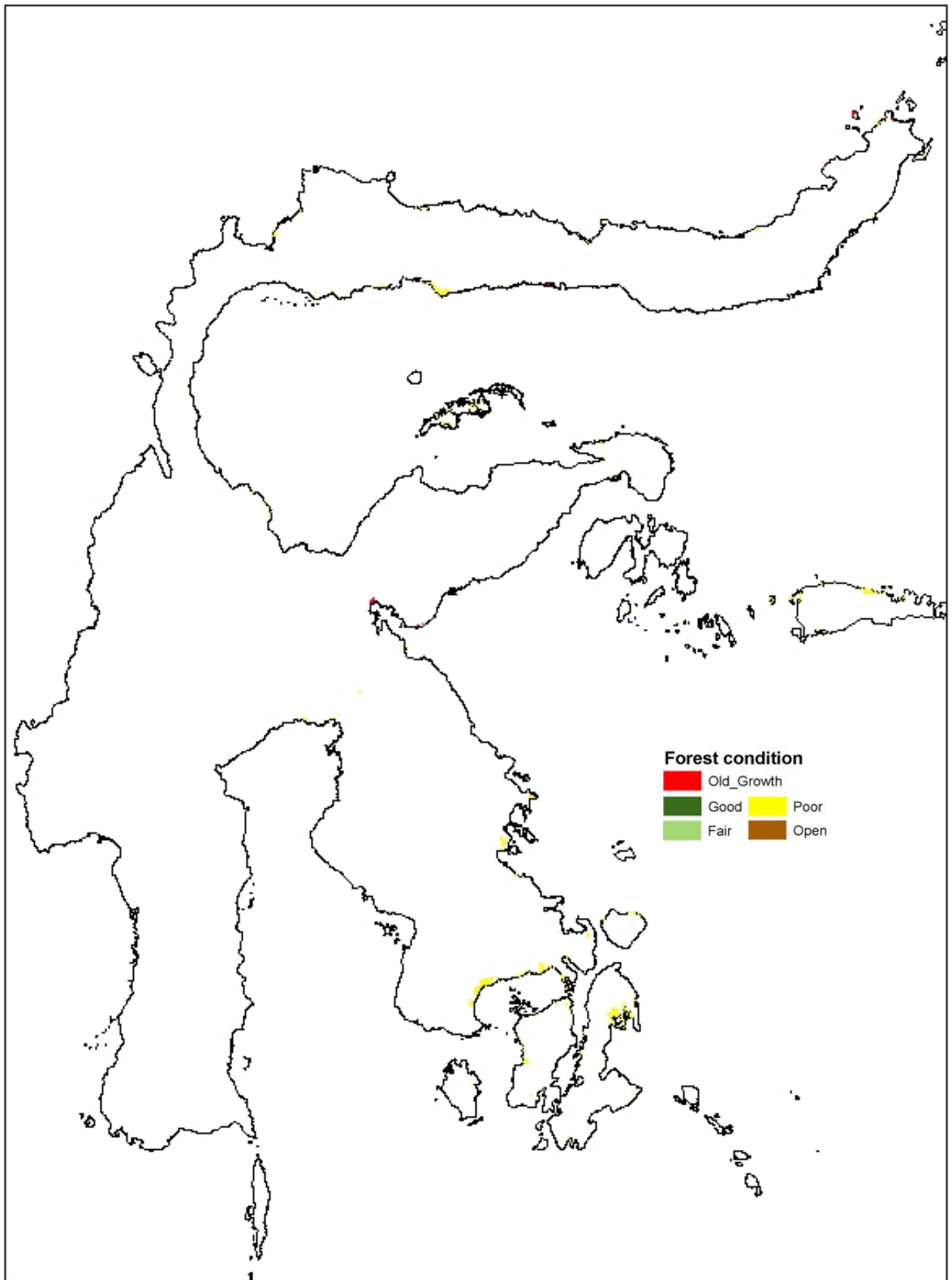
Current condition: Most areas show signs of human disturbance and activity. Because of their ready accessibility and the rich aquaculture possible, these forests are critically vulnerable to conversion.

Biogeographic distribution: The formation of mangrove forests is largely limited to flat alluvial plains and rather sheltered waters, such as in the interior of bays and inlets. Because of the general lack of development of alluvial plains on Sulawesi, substantial areas of mangrove are limited, although very small patches are scattered around the entire coast. The largest area of mangrove forest is in the Buton/Kabaena/Muna and Southeast Sulawesi bioregions. Much of this is still in fairly good condition and a sizeable piece lies within the Rawa Aopa National Park. An old-growth stand, verified during the field survey, exists in the Kolonedale Bay.

Field notes: The mangrove forests of Sulawesi appear to be perfectly typical of mangrove forests elsewhere in Southeast Asia. Dominated by a few species of Rhizophoraceae, Pandanaceae, and Bombaceae. It seems that a potentially endemic species of *Nypa* palm exists on the island of Buton, as these plants are significantly smaller than *Nypa* seen on Borneo.

The top three biogeoregions with the “**Largest**” single patch of forest of this type; the “**Most G2G**” or “great to good” quality forest of this type; and the “**Least % G2G**” or least percentage of great to good quality forest of this type.

Largest	Most G2G	Least % G2G
Muna : 18,557	ENS : 1,152	Muna : <<1
SES : 15,590	LM : 1,076	SES : <<1
WNS : 9,134	ECS : 556	WNS : <1

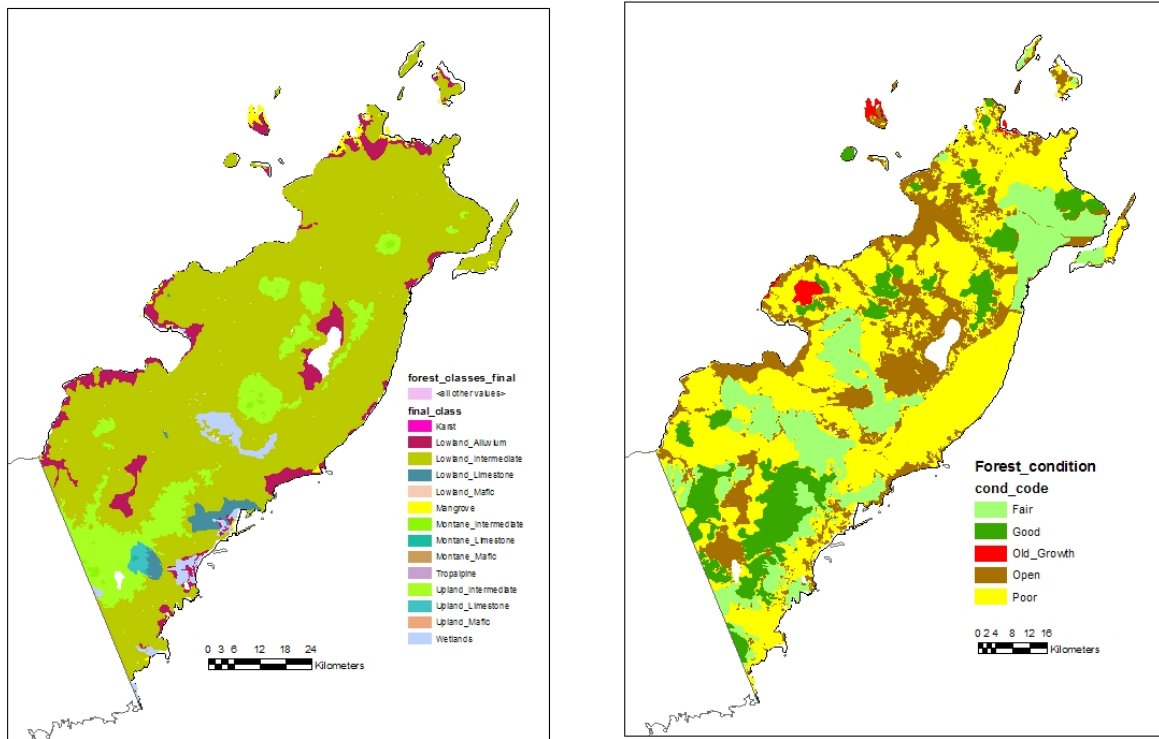


Mangroves

BIOGEOGRAPHIC REGIONS: forest classes and condition

Eastern North Sulawesi

Total extent: 563,293 ha (3% of Sulawesi); **G2G Forest:** 75,570 ha (13% of total extent)



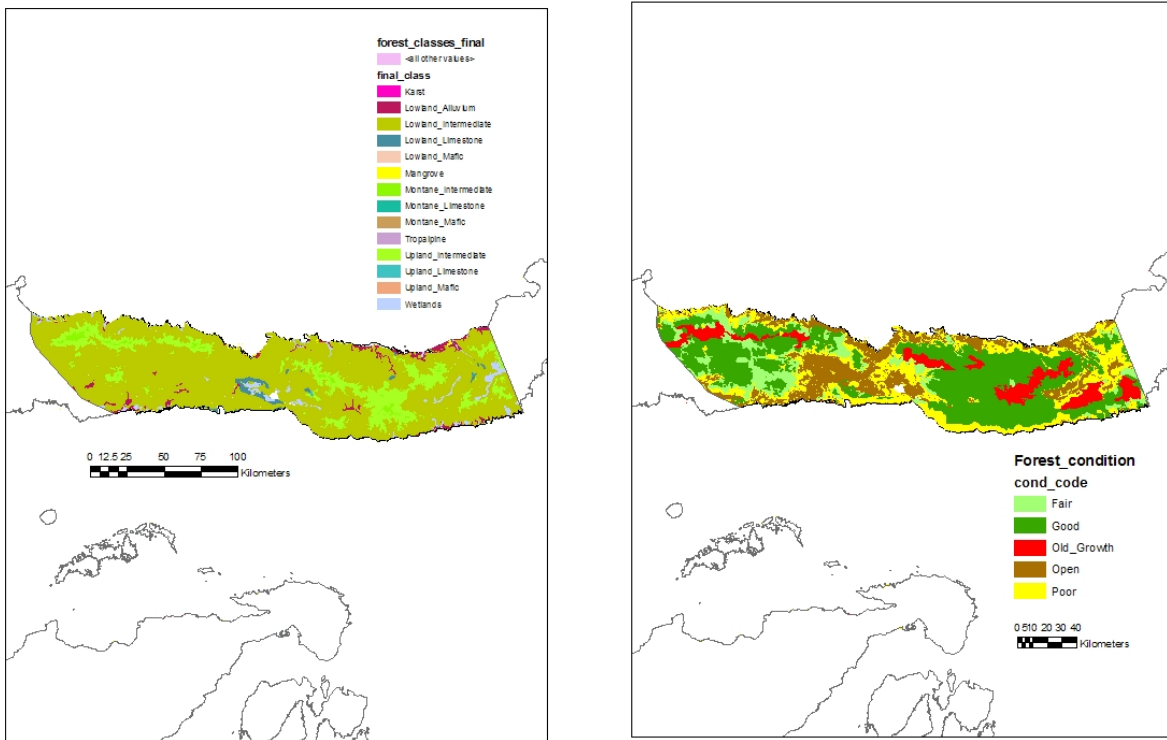
Current condition: This heavily populated region has largely been converted to plantation forests of clove and coconuts. Most of the G2G forest exists in highly fragmented and isolated patches. The small piece of old-growth forest in the Mt. Manembo-nembo Reserve is a vulnerable and valuable piece of lowland intermediate forest. A sizeable old-growth mangrove forest exists in the Bunaken National Park and this region contains the greatest area of old-growth mangrove in the ecoregion.

Biogeographic significance: This northern tip of the mainland possesses rich youthful soils and an important connection to the southern islands of the Philippines. While little solid evidence exists, the vegetation of this bioregion probably has strong ties to the north. The fragmentation of the forest will only intensify the conservation significance of the remaining G2G sites.

Forest class	Total	G2G
Lowland intermediate	439,210	43,128
Upland intermediate	61,661	26,229
Lowland alluvium	35,222	166

Central North Sulawesi

Total extent: 1,768,715 ha (10% of Sulawesi); **G2G Forest:** 886,669 ha (50% of total extent)



Current condition: This bioregion possesses the highest percentage of G2G forest compared to all other bioregions. Numerous large patches of old-growth forest are scattered throughout. These forests are composed of critically endangered and ecologically dominant vegetation classes. The area surrounding Gorontalo has undergone extensive conversion, exposing many of these critical old-growth areas to potential disturbance or conversion. This bioregion has the single largest patch of old-growth forest in the lowland and upland intermediate classes and the greatest amount of G2G lowland intermediate on the island.

Biogeographic significance: This bioregion has deservedly received a great deal of attention from naturalists and conservationists. Formed by subduction and marked by volcanic activity and extremely sharp topography, this relatively young landscape forms a fascinating linear peninsula cut off from the majority of the mainland by a relatively small neck.

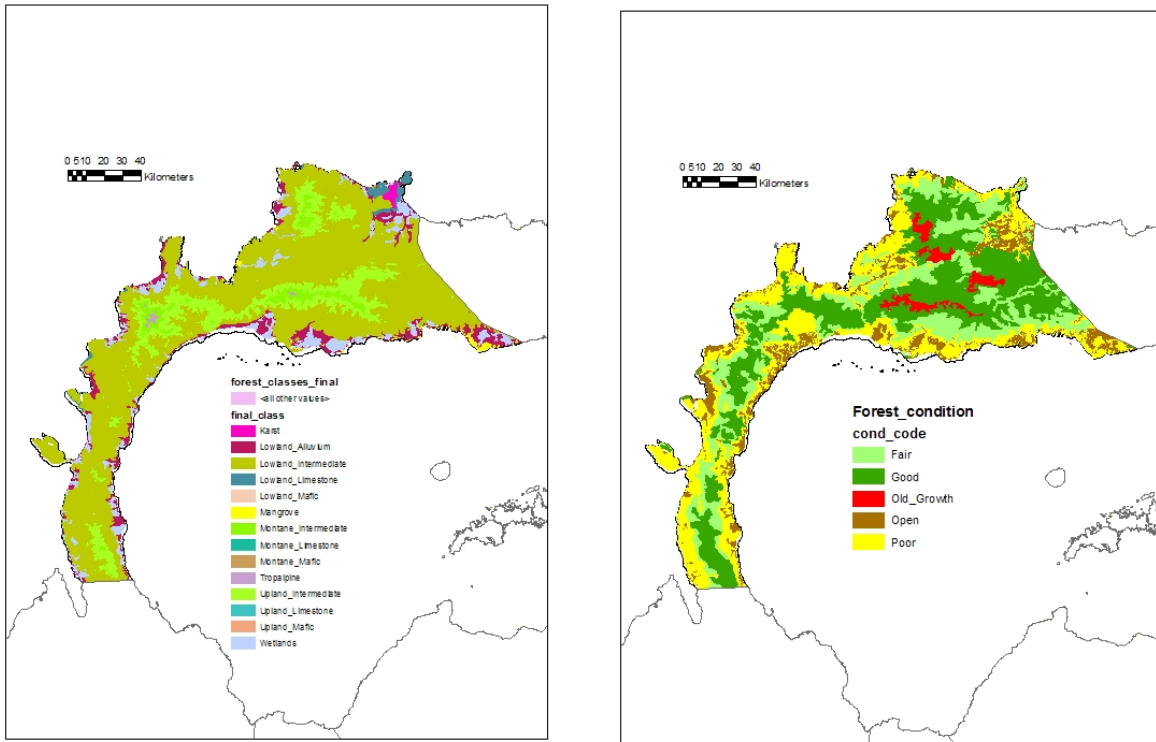
Some debate exists about whether this region possesses stronger connections to the Philippines, while most of the rest of the

island has a strong Papuan composition. This bioregion is primarily important because of the large intact areas of lowland and upland forests on intermediate soils.

Forest class	Total	G2G
Lowland intermediate	1,384,700	637,744
Upland intermediate	248,696	223,327
Lowland alluvium	44,349	4,828

Western North Sulawesi

Total extent: 1,556,817 ha (8% of Sulawesi); **G2G Forest:** 575,519 ha (37% of total extent)



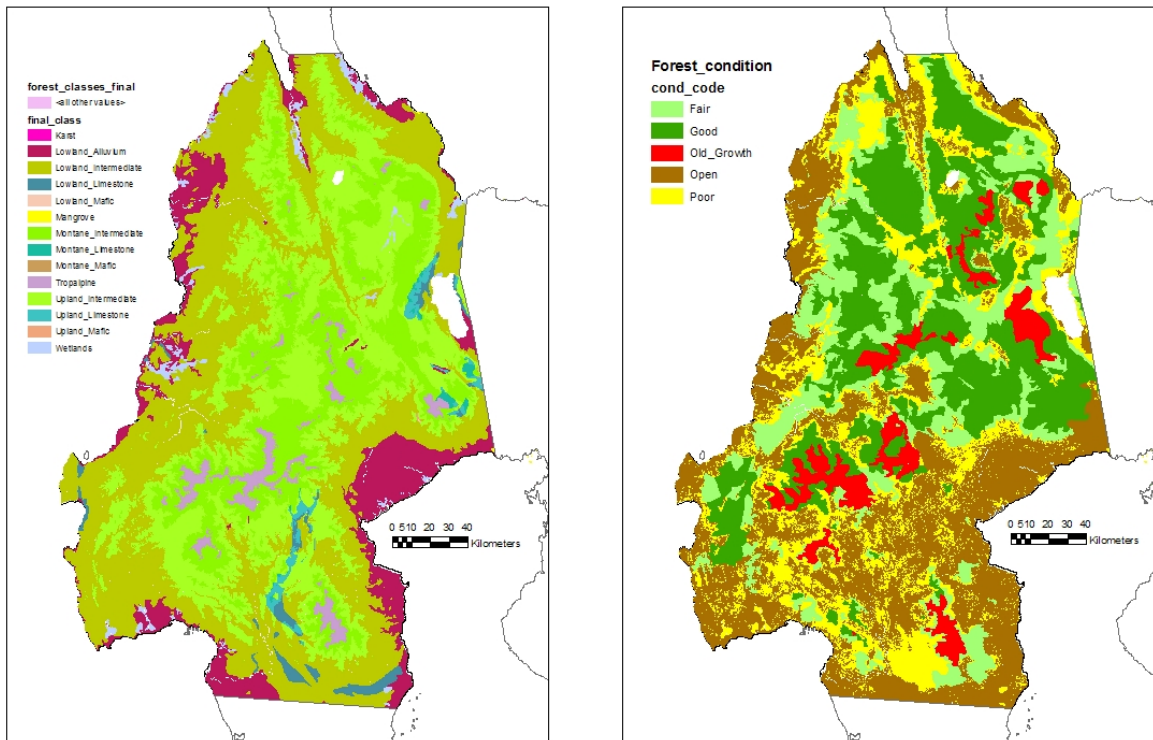
Current condition: This sparsely populated bioregion contains a large area of G2G forest in the Toli-Toli area, much of which is lowland intermediate forest. Little open conversion exists in the region, indicating the rapid forest rehabilitation may be possible in many areas. The soils are largely homogeneous in this bioregion and despite a relatively high level of disturbance in the neck, a fairly contiguous chain of G2G forest exists from end to end through this bioregion, connecting West Central and North Central Sulawesi.

Biogeographic significance: This region connects the relatively young and geologically homogeneous northern arm to the older and more heterogeneous central ‘heart’ of Sulawesi. The peninsula forming the neck is quite narrow and probably restricts migration between the two areas. Maintaining connectivity of G2G forests up this neck and across this bioregion seems of critical conservation importance. The tiny patches of tropalpine forest on the rather extreme mountains form an important stepping stone both between the Bornean highlands and between the northern arm and central Sulawesi.

Forest class	Total	G2G
Lowland intermediate	1,047,483	360,259
Upland intermediate	218,745	169,582
Wetlands	107,286	0

Western Central Sulawesi

Total extent: 5,108,158 ha (27% of Sulawesi); **G2G Forest:** 1,611,487 ha (32% of total)



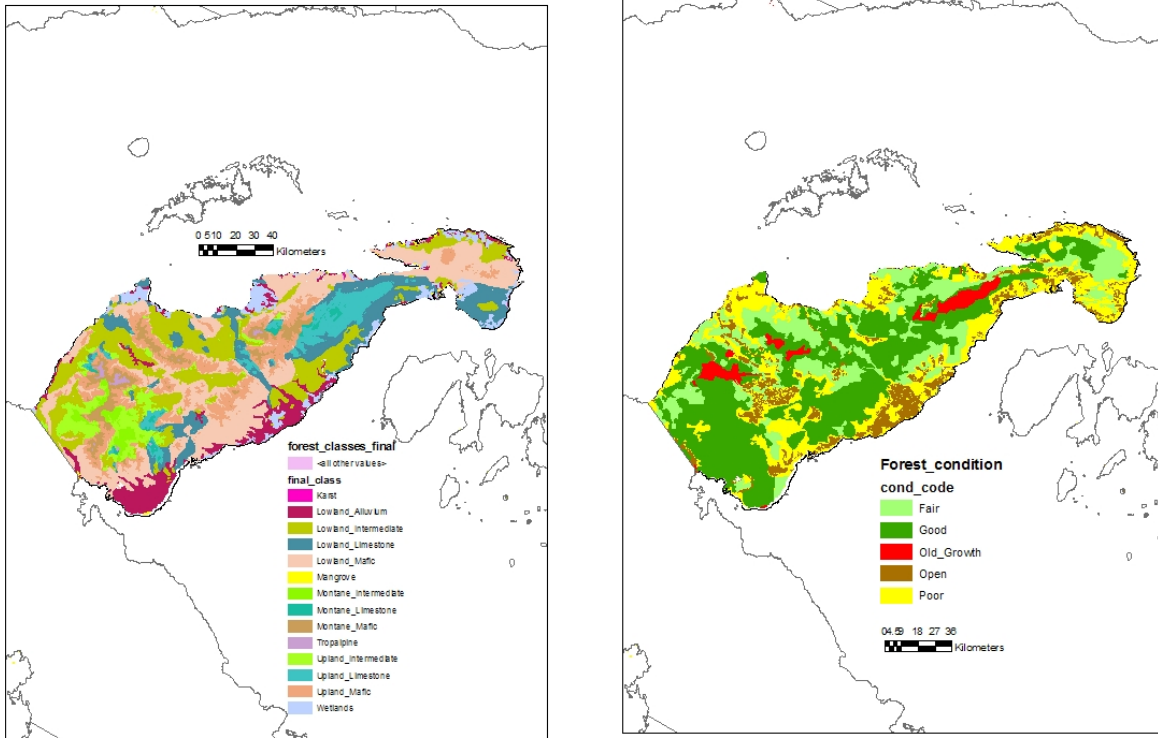
Current condition: The land area in this bioregion provides some of the strongest contrasts in forest condition across the island. While much of the lowland forests have been completely converted, large areas of G2G forest remain in the upland interior, frequently adjacent to converted areas. A nearly solid block of old-growth forest lies just to the west of Lake Poso with upland and montane intermediate forests. The G2G forests in the northern half are highly connected while the G2G forests in the southern half are highly fragmented and isolated. This bioregion contains the single largest patch of old-growth forest in the Montane intermediate and Tropicane classes. It also possesses the greatest area of G2G forest for the Upland and Montane intermediate and Tropicane classes.

Biogeographic significance: This bioregion represents the ‘heart’ of the mainland and also the some of the oldest emergent land area of Sulawesi. Its proximity to Borneo and large land area provide the major staging area for migration and invasion of the island from the west. The large amount of lowland intermediate forest along the west coast is of great biogeographic significance and conservation value. The high uplands and mountains of the interior harbor many ancient isolated plant species which have maintained populations here for millions of years.

Forest class	Total	G2G
Lowland intermediate	2,001,877	287,827
Upland intermediate	1,399,045	580,414
Montane intermediate	861,234	606,397

Luwuk Morowali

Total extent: 1,648,783 ha (9% of Sulawesi); **G2G Forest:** 735,222 ha (45% of total extent)



Current condition: This region contains a large amount of valuable G2G and even old-growth forest on both limestone and mafic soils. This forest also remains largely contiguous from end to end in the region, an important conservation aspect. While certain areas near the coast have undergone extensive recent disturbance, much of the inaccessible interior remains in quite good condition. This bioregion contains the single largest patch of old-growth forest for the Upland limestone and mafic, Montane limestone and mafic and Mangrove classes. It also possesses the greatest amount of G2G forest for the Lowland alluvium, Upland and Montane mafic classes.

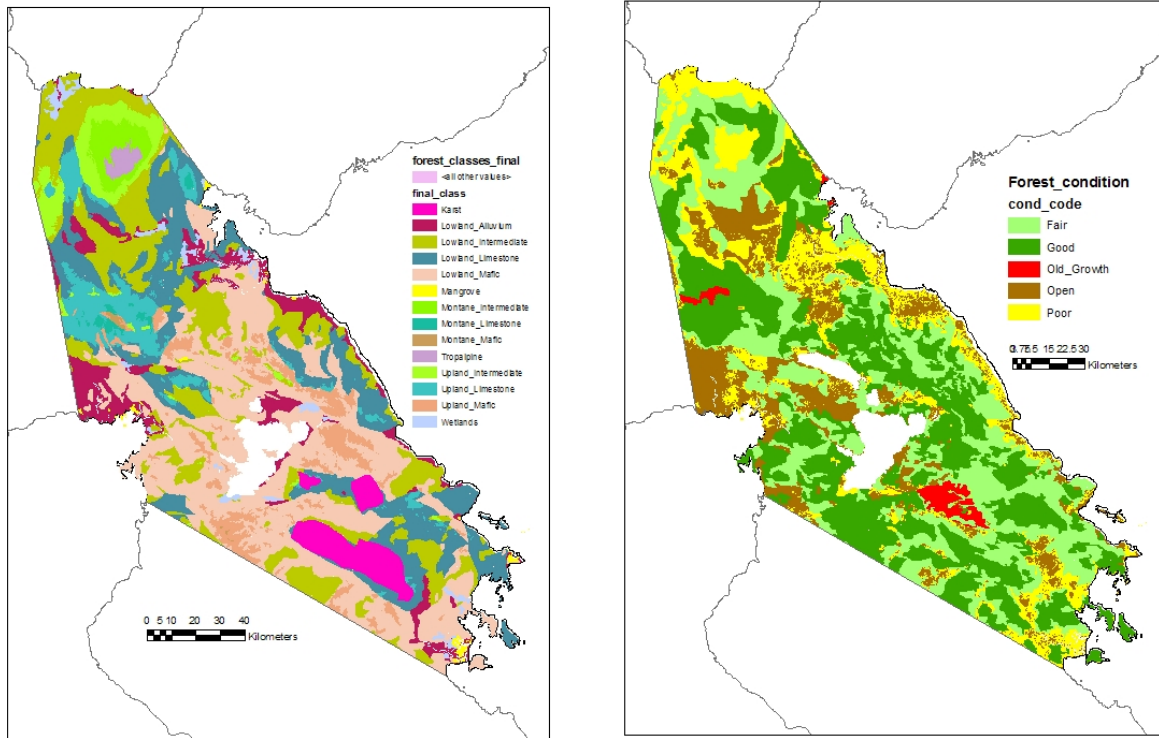
Biogeographic significance: This bioregion represents the peak of complexity and heterogeneity in forest class while also providing one of the more promising areas for conserving large chunks of valuable G2G forest. The peculiar shape of the region has left it largely isolated from the mainland and the Morowali Reserve sits right at this juncture between the 'heart' of the mainland and the chain of mountains running out to the 'mushroom cap'. The topography is

fantastically rugged throughout the region and the relatively large amount of intermediate soils intermixed with the mafic and limestone areas indicates that these formations are less extreme in their nutrient availabilities and demands on the vegetation community. This mixture of soils probably makes for greater mixture of plant species across forest classes.

Forest class	Total	G2G
Lowland ultramafic	410,318	214,092
Lowland intermediate	338,941	73,327
Upland ultramafic	188,536	140,505

Eastern Central Sulawesi

Total extent: 2,090,099 ha (11% of Sulawesi); **G2G Forest:** 793,900 ha (38% of total extent)



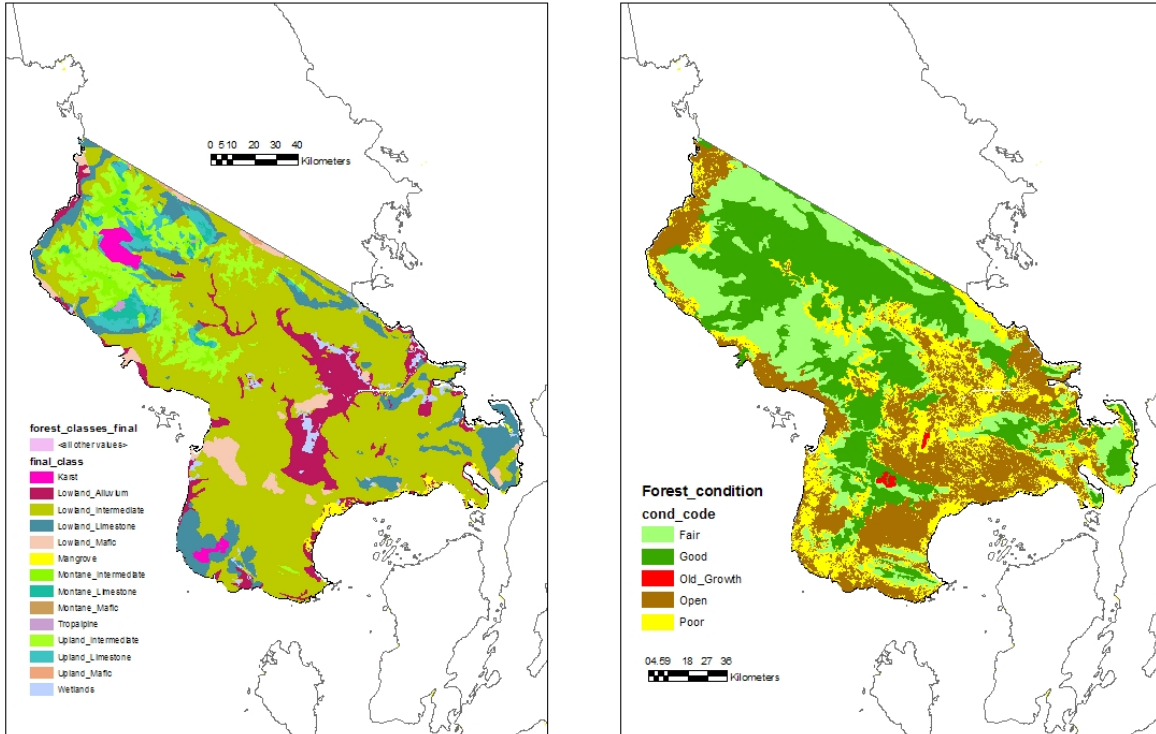
Current condition: The lowlands on intermediate and alluvial soils in this bioregion have been largely converted with the mining activities south of Lake Matano causing a large amount of disturbance as well. Most of the G2G forests exist either within and around the Farumhempenai Reserve or south and east of Lake Towuti. The extensive area of mafic and limestone soils in these areas form a largely contiguous and unfragmented patch of unique vegetation communities. This bioregion has the single largest patch of old-growth forest in the lowland alluvium, limestone and ultramafic classes. It also contains the greatest amount of G2G forest in the Lowland limestone, ultramafic, Upland limestone and karst classes.

Biogeographic significance: This region contains the single greatest mixture of forest classes on the entire island and in combination with the Luwuk-Morowali bioregion represents one of the largest mafic areas in the world. Because of the juxtaposition of so many different vegetation communities, this region provides for a rich mixing ground and abrupt transition zones between non-overlapping sets of plant species. If the large karst formation southwest of Lake Towuti actually exists, it would be the largest formation on the island and again, one of the larger examples in Southeast Asia. The eastern coast of this region and into the interior is very poorly known but represents an amazing opportunity for comparative studies of ecological specialization and biogeographic structuring of communities.

Forest class	Total	G2G
Lowland ultramafic	631,858	313,739
Lowland intermediate	412,468	57,752
Lowland limestone	387,788	131,481

Southeastern Sulawesi

Total extent: 2,107,398 ha (11% of Sulawesi); **G2G Forest:** 635,352 ha (30% of total extent)



Current condition: The southern coastal region has been largely cleared of forest, as well as the northwestern edge. The Rawa-Aopa National Park contains little G2G forest and the largest patch of old-growth forest lies just outside of the protected area on mafic soils. The interior of bioregion contains one of the larger areas of lowland intermediate forests in fair to good condition. A montane karst formation is also present in the northwestern corner and is mostly in G2G condition but its presence needs to be ground-truthed. This bioregion contains the single largest patch of old-growth wetlands and the greatest area of G2G forest in the Montane limestone and Wetlands classes.

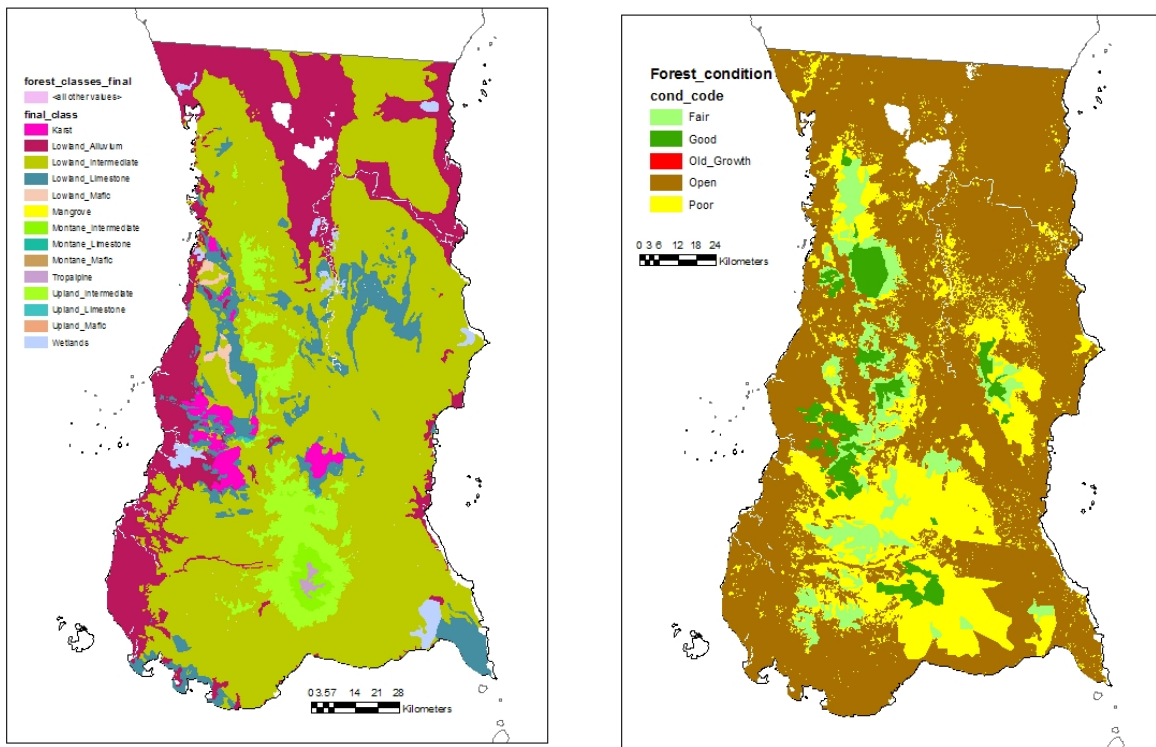
Biogeographic significance: The sharp difference between the largely intermediate soils of this bioregion and the limestone and mafic formations of the neighboring Eastern Central Sulawesi isolates the vegetation communities in this bioregion from the ‘heart’ of the island.

Very little is known about the vegetation communities in this bioregion although species composition appeared to be fairly consistent with the rest of the island. The scattered pieces of karst and mafic soils probably provide stepping stones across the bioregion into the larger areas to the north and may harbor endemic species. The vast area of good quality forest along the northern margin is primarily lowland and upland intermediate forests, making this a highly valuable for conservation purposes.

Forest class	Total	G2G
Lowland intermediate	1,201,558	333,946
Lowland limestone	216,177	50,722
Upland intermediate	209,906	104,468

Southwestern Sulawesi

Total extent: 1,829,494 ha (10% of Sulawesi); **G2G Forest:** 71,824 ha (4% of total extent)



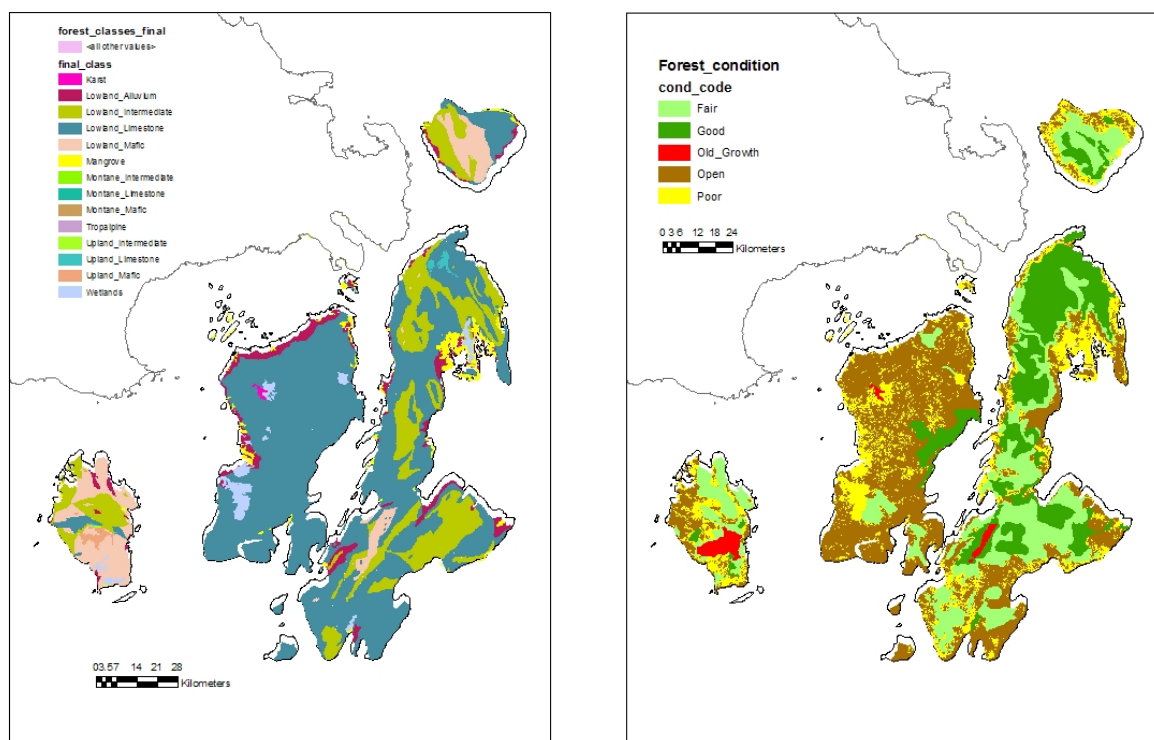
Current condition: Highly modified by human activity, with virtually no old-growth forests and only scattered and highly isolated pieces of good forest. The large area of lowland alluvium has been completely converted (less than 0.1% remaining in G2G condition) and lowland intermediate forests have little more than 1% in G2G forest. The scattered pieces of karst in the midwestern area contain some of the best condition forest, as well as some of the more mixed limestone soils.

Biogeographic significance: This area at one point in the past probably supported some of the best forests on the island but the conversion of these forests also probably occurred quite some time ago, meaning that human activity has already had a lasting impact on the distribution and movement of plants across the region. The lowland alluvium forest class should be considered of high conservation value and even the tiny scattered fragments should be explored and evaluated for possible rehabilitation and management. The mountainous area in the south represents an isolated sky island of montane and tropicane forest.

Forest class	Total	G2G
Lowland intermediate	1,119,280	19,038
Lowland alluvium	369,191	406
Lowland limestone	143,531	3,235

Muna, Buton and Kabaena Islands

Total extent: 840,227 ha (5% of Sulawesi); **G2G Forest:** 173,026 ha (21% of total extent)



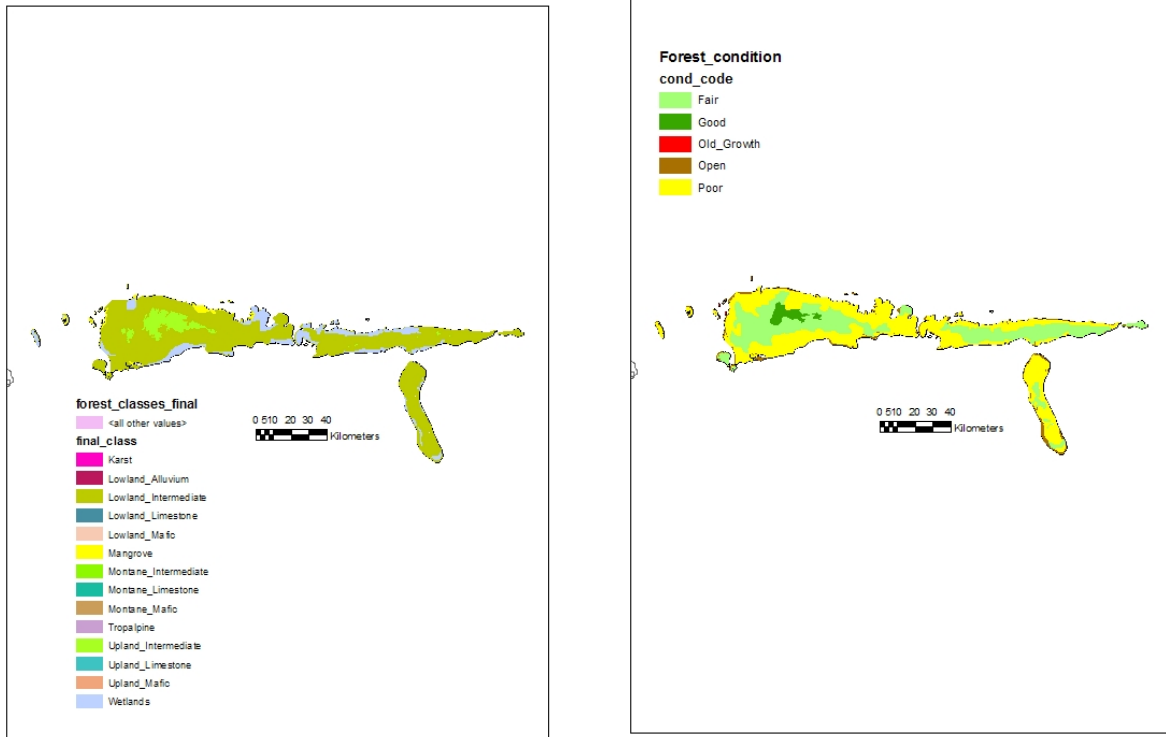
Current condition: Muna Island appears to be largely cleared of forest, primarily containing plantation forestry. Buton Island on the other hand is heavily forested and possesses a large mangrove forest within the northeastern bay. The island of Kabaena contains a large patch of old-growth mafic forest which is highly vulnerable to the surrounding areas of poor forest and open vegetation. The island of Kabaena contains the single largest patch of old-growth karst in the ecoregion.

Biogeographic significance: These islands, particularly Buton, contain relatively large amounts of G2G forest cover in comparison to the other island bioregions, on at least three different soil types. During the field survey, the transition between lowland and upland forests appeared to occur at a lower elevation than generally does on the mainland. Excellent patches of lowland forest were observed within the North Buton Island reserve. These forests also appeared to be slightly more seasonal in their rainfall. Overall, this island group represents one of the most important and substantially intact groups in the ecoregion. It is also fairly well collected and studied, particularly with the presence of Operation Wallacea and their research teams.

Forest class	Total	G2G
Lowland limestone	520,468	94,035
Lowland intermediate	162,506	52,145
Lowland ultramafic	71,648	18,809

Sula Islands

Total extent: 477,953 ha (3% of Sulawesi); **G2G Forest:** 14,643 ha (3% of total extent)



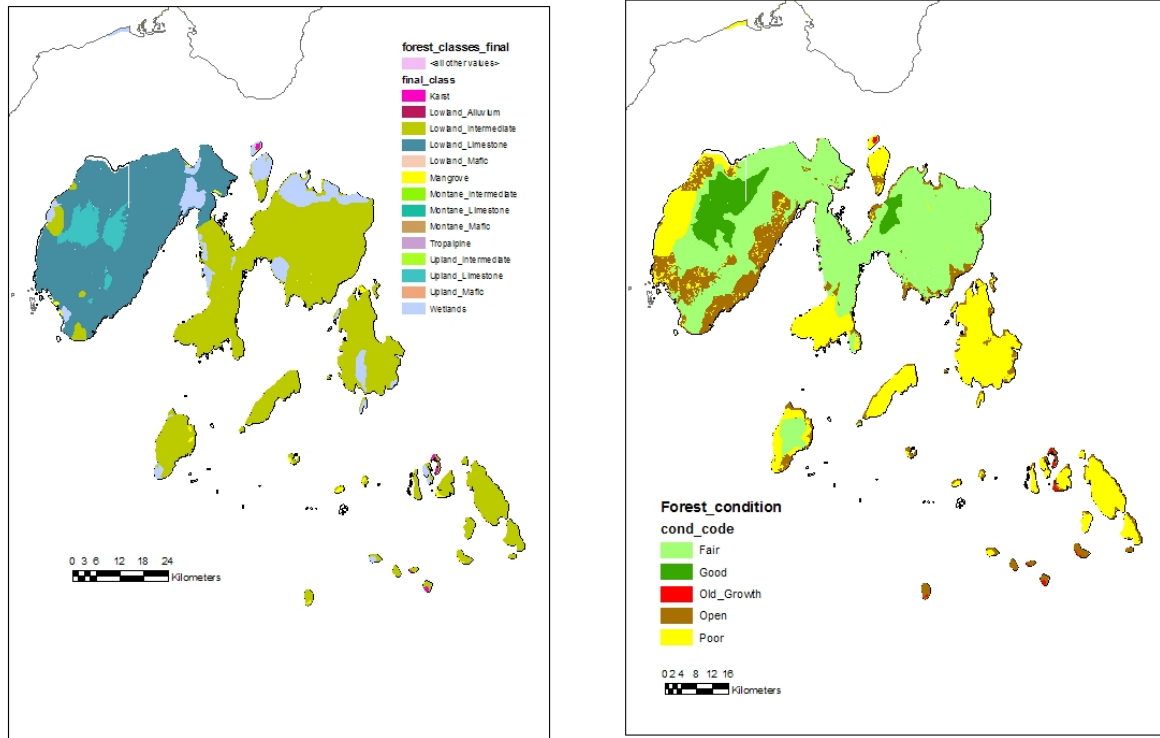
Current condition: Little forest cover remains on this island, primarily in the uplands where almost half of the forest is still in G2G condition. But this area represents a small proportion of the entire island. The small area of wetlands appear to be completely converted.

Biogeographic significance: These islands provide a connection between the mainland and the Maluku Islands to the east. As mentioned for other island bioregions, the vegetation type may have inherently high natural disturbance levels and the proportion of fair forest may include some level of natural community.

Forest class	Total	G2G
Lowland intermediate	375,427	582
Wetlands	62,511	0
Upland intermediate	32,173	13,948

Banggai Peleng

Total extent: 303,480 ha (2% of Sulawesi); **G2G Forest:** 22,023 ha (7% of total extent);



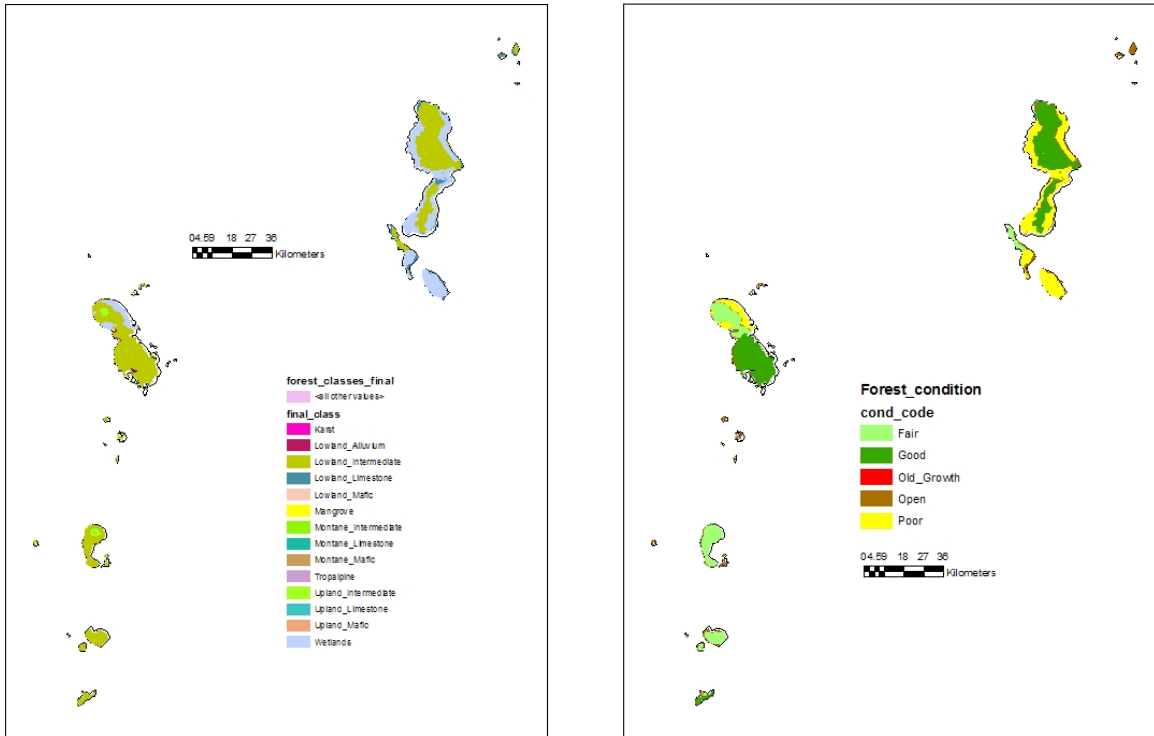
Current condition: No detectable old-growth vegetation exists on the Banggai-Peleng island group. Given the small extent of the land area and the lack of highlands, this is not surprising. Islands have distinctive vegetation communities which normally have high intrinsic rates of disturbance, making the formation of old-growth unlikely. The western ‘lobe’ the main island is heavily disturbed in the coastal areas but also contains the largest area of good forest. Most of the area on intermediate soils has fallen into fair or poor condition. Given the patterns, the limestone soils have mixed little with other soils, making this class on the island more distinct and extreme than limestone soils elsewhere.

Biogeographic significance: This island group, lying to the south of the Luwuk-Morowali eastern arm of Sulawesi, is a relatively recent emergent in the ecoregion and historically, has played little role in connecting the mainland of Sulawesi to other more eastern landmasses. The vegetation communities on this island, being heavily disturbed and characteristic of other island communities, probably harbors few, if any significant, plant endemics or endangered populations.

Forest class	Total	G2G
Lowland intermediate	156,602	3,183
Lowland limestone	107,019	10,848
Upland limestone	12,242	7,048

Sangihe Talaud Islands

Total extent: 167,105 ha (1% of Sulawesi); **G2G Forest:** 69,309 ha (42% of total extent)



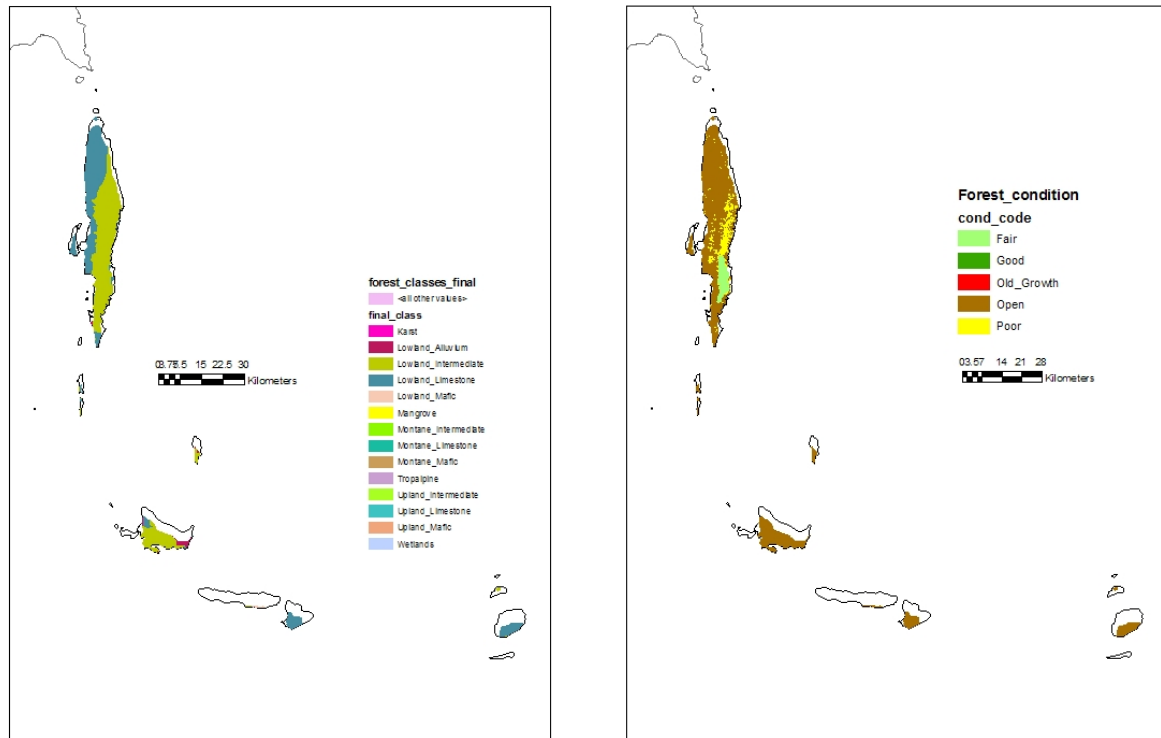
Current condition: These islands have a fairly large portion of G2G forest, which is almost entirely in the critical lowland intermediate forest class. The wetlands have been almost completely converted.

Biogeographic significance: These string of small islands greatly extend the ecoregion to the north, lying closer to the southern islands of the Philippines than it does to the mainland of Sulawesi. Given the relatively intact forest on these islands, they could provide a strong connection between the two ecoregions. These forests also provide some of the best examples of oceanic island vegetation communities in the Sulawesi ecoregion and therefore contribute valuable conservation potential.

Forest class	Total	G2G
Lowland intermediate	106,792	67,399
Wetlands	50,447	0
Lowland limestone	6,342	1,316

Selayar, Jampea, and Kayu Adi Islands

Total extent: 75,456 ha (<0.1% of Sulawesi); **G2G Forest:** 0 ha (0% of total extent)



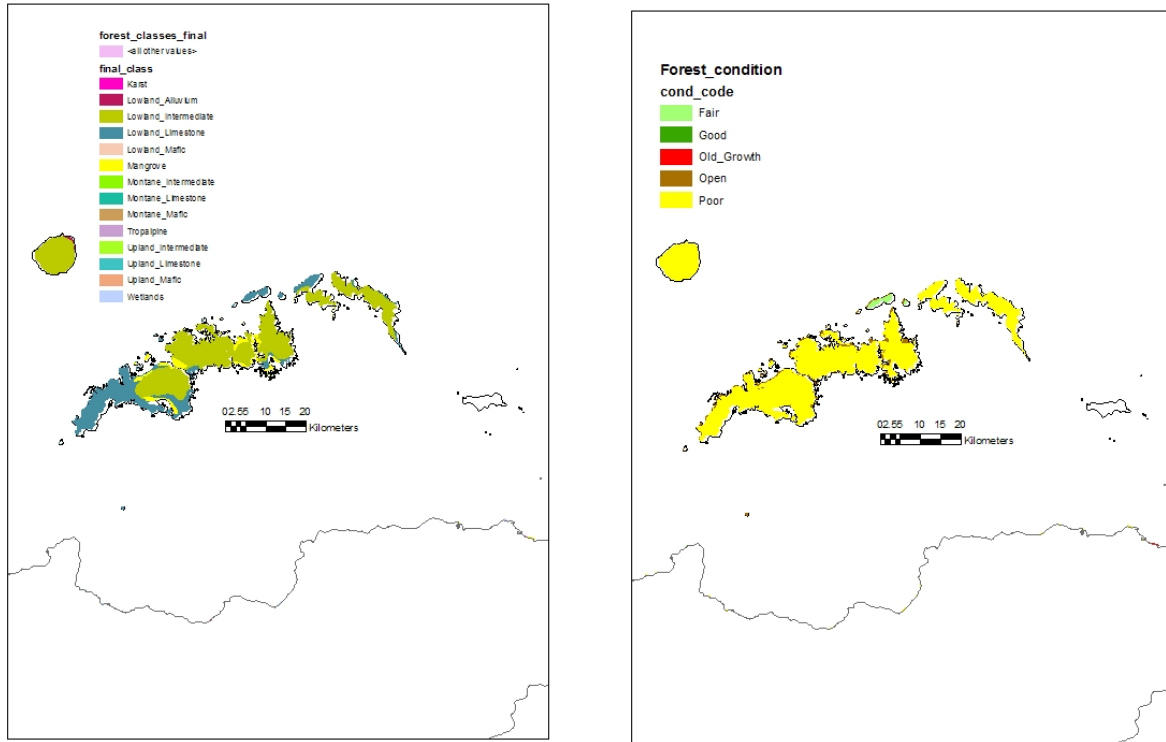
Current condition: No G2G forest appears to remain on these islands. In that respect, little forest cover at all appears to remain.

Biogeographic significance: Because of their lack of significant vegetation, these islands represent little conservation value.

Forest class	Total	G2G
Lowland intermediate	43,142	0
Lowland limestone	30,821	0
Lowland alluvium	1,206	0

Togian Islands

Total extent: 65,878 ha (0.4% of Sulawesi); **G2G Forest:** 0 ha (0% of total extent)



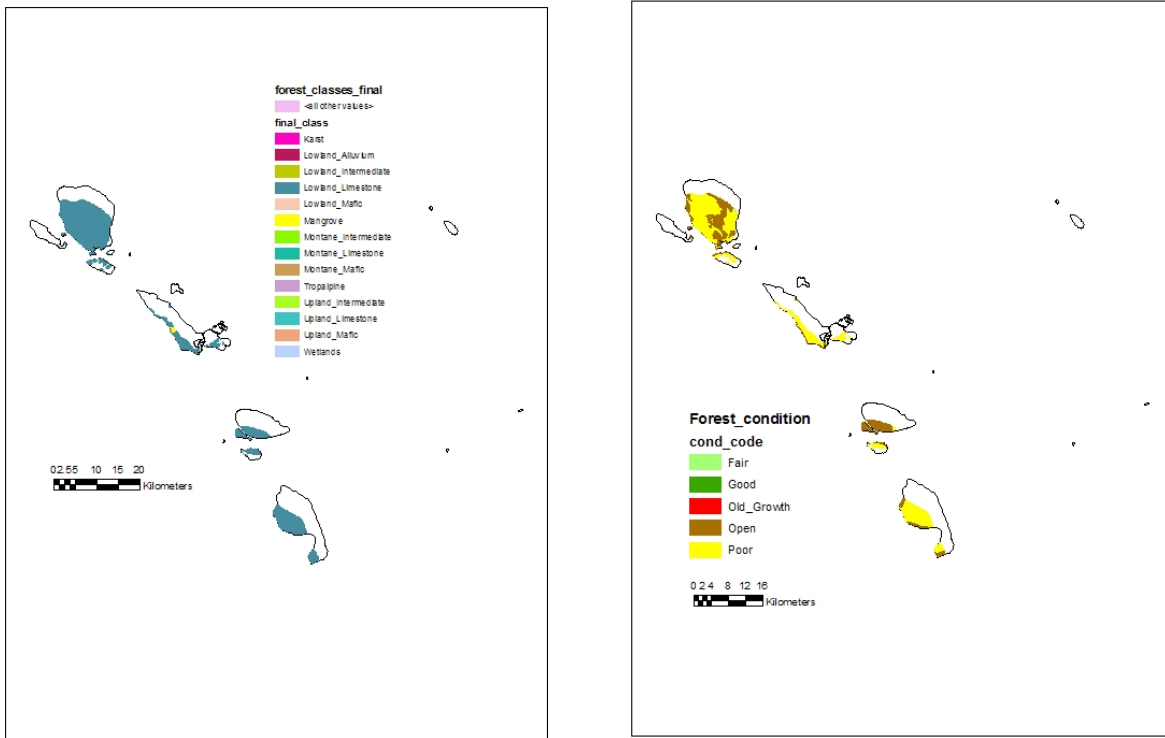
Current condition: This small island group appears to have no forest cover remaining.

Biogeographic significance: Because of its lack of forest cover, efforts to rehabilitate and restore forests on these islands should be attempted. Even if the vegetation communities are not terribly interesting, they provide important control for sedimentation and regulation of the important marine environment surrounding them.

Forest class	Total	G2G
Lowland intermediate	44,770	0
Lowland limestone	17,603	0
Mangrove	3,288	0

Paternoster, Kalotoa, and Tukang Besi Islands

Total extent: 19,306 ha (0.1% of Sulawesi); **G2G Forest:** 0 ha (0% of total extent)



Current condition: Virtually no forest cover remains on these islands.

Biogeographic significance: Because of their almost complete conversion and tiny area, these islands do not have a great deal of conservation value in relation to vegetation communities.

Forest class	Total	G2G
Lowland limestone	19,156	0
Mangrove	144	0
None	0	0

METHODS

Vegetation classification

The classification of forest types was performed using various types of evidence, including

- geological patterns obtained from REPPROT maps,
- a digital elevational model,
- LANDSAT imagery,
- extensive field surveys in Lore Lindu National Park, and
- a four-week island-wide field survey.

Ultimately, the geographic scale of the island and the complexity of the underlying patterns require an over-simplification of the classification scheme for clarity's sake. At the scale of the entire island, a few types of forest observed locally in small patches or reported from other sources did not contribute a significant enough area to be included. Also, many factors affect the distribution of the forest classes described here, particularly local patterns of rainfall and soil condition. While I have confidence in the validity of these classes in a broad sense, the transitions and exact cutoffs between forest classes may vary substantially under certain conditions.

Geology

The nutrient availability and drainage conditions of the soil have a great impact on the development of vegetation communities. The stark contrast of soil types on Sulawesi is directly related to its complicated geological history. The south and central parts of the island represent a rifted fragment of Borneo and the Sunda Shelf, while the eastern and southeastern arms form the largest area of mixed ultramafic and limestone formations to be found on Earth. The northern arm was recently formed by subduction and consists of largely of rich volcanic soils. Several clear transitions from nutrient-rich to nutrient-poor soils can be found over relatively small geographic scales. In contrast to the other major Indonesian islands, Sulawesi has few well-developed alluvial plains or low-lying seasonally flooded areas. These conditions present a unique and diverse setting for plant growth.

The most detailed source for geological information is the series of reports put together by the Transmigration program (Regional Physical Planning Programme for Transmigration or RePPProT). These maps and their information were digitized (get the details from Marcy and Salim) and georeferenced. To avoid creating artificial divisions at the boundaries of each map, the shapes were dissolved so that contiguous geological areas on adjacent maps were joined into a single shape (get details from John about what he did). This data was not available for Sula island and some of its neighboring islands so corresponding information was adopted from a United States Geological Survey report on the tectonics of Southeast Asia (Hamilton 1979).

The ten major geological classifications presented in the RePPProT maps were simplified to four classes: 'limestone', 'ultramafic', 'alluvium', and 'intermediate'. Because of the large geographic scale of the ECA, our analyses only retained those soil types which

are known to cause clear differences in vegetation community. Extreme soil types, like limestone and ultramafic derived soils, often have a number of associated species which are specialized to thrive on these soils. The alluvial deposits on Sulawesi are rather limited in geographic scope and much of their area has already been converted to intensive agriculture and plantation forestry. Although a certain amount of overlap in species composition is generally noted between alluvial deposits and their associated parent soils, these deposits are normally much richer in nutrients, support more dense forests, and are often have lower species diversity. All other soils were placed into a single class. A large amount of study has been conducted on 'intermediate' soil types on Borneo and only marginal evidence suggests that these soil types, whether sedimentary or metamorphic in origin, support unique forest communities. The differences are generally more strongly related to elevational differences.

Detailed descriptions of the geological classes used in the ECA follow. The Ecology of Sulawesi (Whitten, Muslimin et al. 1987) remains the best authority on the geological patterns of the island and the details of how and why different soils support different vegetation communities.

Limestone – coral reef deposits of varying age and purity. The definition used here for limestone is broader than that discussed by Whitten and his co-authors. With sufficient mixture of other soils, 'limestone' forests are indistinguishable from intermediate soils. Several examples of this were seen during the field survey. But, without comprehensive evidence and to take a conservative approach to classification, the limestone areas marked on the geological map were accepted as a separate class. An additional class 'karst' was also recognized due to the extreme conditions caused by these 'pure' deposits.

Ultramafic – these soils are generally unfertile and occasionally toxic to many plant species. They also vary a great deal in composition and specific properties but are normally quite high in heavy metal content and have a deficiency of available calcium, nitrogen and other fundamental compounds. They are generally hard red to sulfur yellow in color and can often have a greasy feel between the fingers. These soils vary in their 'purity' and often contain mixtures of other soil types. When the fraction of ultramafic soil is high, the vegetation communities are often stunted and open in structure and the species composition can be quite distinct with a large number of specialist species present. As the fraction of ultramafic soil declines, the vegetation community becomes more similar to communities on intermediate soils.

Alluvium – formed by the continued deposition of eroded materials in valleys, floodplains and coastal plains, these soils are normally quite rich in organic matter and do not have well defined layers. Because of their frequent replenishment with organics and nutrients, these sites often support high biomass communities, whether it be natural forest or intensive agriculture. The vegetation communities formed on these soils are often not quite as diverse nor distinct from communities on more intermediate soils but they also often support high densities of species which are rare elsewhere or even rich soil specialists.

Intermediate – this soil class contains a very wide range of soil types and origins, from sedimentary to metamorphic, from rich volcanic to poor leached soils, but not clear effects have been discovered on vegetation communities, not in comparison to the other three soil classes defined here. This simplification of 'intermediate' soils is only

necessary at the broad ecoregional scale and once more specific assessments of smaller geographic areas are performed, more detailed classification systems should be adopted.

Elevation

The transition in species composition and forest structure from lowland to upland areas has been widely documented and numerous classification systems have been created. While clear differences are apparent when a ‘good’ patch of these different forest types is examined, the transition zones between them can be very difficult to delineate in the field. The position of these transition zones can vary a great deal in their width, composition, and position depending particularly on rainfall patterns and soil richness. Where wet conditions or rich soils are prevalent, ‘lowland’ species can often be found at considerably higher elevation. This pattern is particularly clear in the northern arm, where rich volcanic soils are common (see Field Survey, Mt. Ampang and Bogani-Nani Wartabone). On the other hand, where rainfall appears to be more seasonal or soil conditions are unusually poor, upper elevation species can be found in the lowlands. Some species, particularly *Castanopsis accuminatissima*, also seem particularly gregarious on sites with thin soils and seasonal rainfall.

Most authors classify forests below 1000 meters elevation as ‘lowland’ but this scheme seems too broad in light of most current evidence. At many sites on Borneo, the transition in species composition begins at much lower elevations. Based upon my previous experience in the Lore Lindu National Park and an analysis of the woody plant checklist, a number of species are only found below 400 meter elevation and a major turnover in composition occurs below 1000 meters. These species are often critical food resources for lowland animal species and often define “good quality” habitat for these animals. In this sense, the definition of ‘lowland’ forest is based more upon the absence of these ‘indicator’ species at higher elevations, than in a complete turnover in species composition at the community level. This distinction seems important particularly as it relates to the conservation of animal habitat. A complete list of ‘indicator’ species for each forest type is provided in the Fine Scale analysis of the ECA, along with the methods used to determine the elevational classes from the collection database.

Detailed descriptions of the elevational classes follow:

Forest type	Lower bound	Upper bound
Lowland	0	400
Hill	400	850
Upland	850	1500
Montane	1500	2200
Tropalpine	2200	3428

For the purposes of clarity and presentation, the two lower elevational classes (“Lowland” and “Hill”) are merged in this report. While this is convenient for an analysis at the geographic scale of the entire island, these two classes should be considered separately in more detailed analyses.

Remote sensing

During the course of the forest condition analysis (see below), it became clear that three additional forest types could be differentiated quickly and easily. These three

Mangrove – coastal forests, strongly influenced by tides.

Wet forests – frequently inundated coastal, lacustrine, and riverine forests

Karst - determined by matching geology layer with a sharp and jagged topographic appearance of the area in the satellite image.

Smaller vegetation communities not included

These vegetation communities are known to occur on Sulawesi but are not included in this ecoregional analysis because of their small biogeographic scope or difficulty in classification.

‘Marsh’ often occurs in small isolated patches which are undetectable at the current scale of study. Several patches have been observed in the uplands of Lore Lindu National Park but these patches normally only encompass tens of hectares. Many rare and probably endemic plants inhabit these areas, including terrestrial orchids, rhododendrons, parasitic species of Burmanniaceae, and large stands of pandan trees. Healthy populations of carnivorous plants, such as pitcher plants and even sundews, are probably present although none were specifically observed. Because of their inherent nature as an isolated ‘fragment’, they support very small populations although dispersal between them is probably facilitated by attracting a unique set of dispersers. Marshes are poorly drained inland areas which normally have standing water in them but do not have a significant tree cover. They can occur on different soil types and at any elevation.

‘Monsoon forest’ form in equatorial regions which have strongly seasonal rainfall. The upper Palu valley contained one of the few truly monsoonal and even semi-arid forests in the Malayan archipelago. Unfortunately, it has been almost completely converted. Some effort was spent trying to find “old growth” areas in the northern extension of Lore Lindu National Park in 2001 but most of it had been substantially disturbed by human activity. These forests probably exist under naturally high disturbance rates, due to more frequent burning, much higher productivity at the terrestrial level, and small tree size making for easy conversion and convenient firewood. These forests regenerate vigorously and are dominated by thorny legumes, dragon lilies, and wild persimmons. In the river valleys, large stands of Garuga camphor trees can be found.

‘Peat swamp forest’ normally occurs on broad alluvial plains where soils are poor and organic matter accumulates. Because of the very active tectonics of Sulawesi, little development of the alluvial plains has occurred, particularly in comparison to Borneo, where peat swamp forest is a prominent ecosystem. A large area of peat swamp forest has been reported in the Rawa Aopa National Park but from remote sensing techniques and field observations, it appears that these areas have all been converted. A substantial wetlands now exists in the park which contains ‘blackwater’, which is heavy in organic matter and plant

phenolics like tannic acids. These waters result from the deep peat deposits, from which the forests have been removed.

'Heath forest' generally cover smaller areas found in the upland and montane regions, particularly in depressions and flat ridges. These upland and montane deposits are normally small in area and support unique communities, including a diversity of pitcher plants and rhododendrons. They are often water-stressed and the growth is dense and stunted. A large montane heath forest exists outside of the Lore Lindu National Park, to the northeast. Attempts at isolating this forest type using remote sensing techniques were not reliable.

Field survey

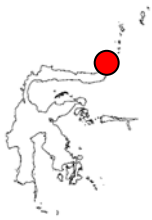
The field survey occurred from July 21 to August 16, 2004. The main field team consisted of the author and John Harting but we were joined by Marcy Summers and Oyong at different points. Field teams were assembled at each location in coordination with the local forestry, parks and police departments. The staff and personnel in these offices were always helpful and friendly. Without their help, it would have been impossible to conduct this field survey. During this four week period, we managed to visit over fourteen protected areas, numerous other sites, and see a lot of territory. Logistics and travel consumed most of our time but the field survey was successful in allowing us to directly and simultaneously compare similar vegetation communities across the island, from Gunung Ambang in the north to Pulau Buton in the south, including direct comparisons between different soil types and seasonality of rainfall.

A main goal of the field survey was to visit a range of forest types across the entire geographical scale of the ecoregion. Emphasis was placed on locations where relatively little information was available. Comprehensive field surveys of the vegetation communities in Lore Lindu National Park were completed in 2001 and no plans were made to visit the area. Wildlife Conservation Society has performed numerous rapid field surveys and ecological studies across the island and most of these sites were visited only briefly. A majority of our time was spent in the Luwuk-Morowali and East Central bioregions.

No formal methods were used for data collection. During our first few surveys, we attempted to gather 'real data' but found that performing even the most cursory measurements limited the amount of area that we could cover. Because we often needed to climb quickly up mountains to cross elevational gradients, data collection was limited to snapping digital images of interesting plants, quickly surveying by eye, watching for 'indicator' species developed from previous classification work performed in Lore Lindu National Park. This survey was at times frustrating because we would just be reaching interesting forest and gaining some understanding of an area and it would be time to immediately turn back and catch the next bus. We spent at least twice as much time traveling as we did actually performing the field survey.

The following description follows the sequence of locations visited during this rapid survey. For most of the journey, John Harting and I traveled together. We were accompanied by Oyong from Palu for the second half of the trip. John and Oyong covered the journey from Faruhumpenai to Kendari, passing through the northern half of Southeast Sulawesi, while I traveled around the eastern margin of Teluk Bone, visiting several sites along the way, until I rejoined them in Kendari.

Mt. Ambang Nature Reserve

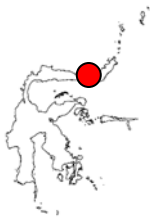


On the drive from Manado to Kotamobagu, we stopped briefly near the summit of Mt. Ambang at roughly 900 m elevation. The forest was heavily disturbed at lower elevations and largely converted into clove and palm plantations. After climbing upslope for a few hundred meters, relatively good and intact forest was encountered. The species composition was dominated by lowland species, particularly of the genus *Aglaia* in the family Meliaceae and several Myristicaceae or nutmeg species, despite the rather high elevation. A fairly large number of naturalized plantation individuals and common pioneer things was present, suggesting sustained exposure to the surrounding intensive agriculture has allowed the invasion of these 'domestic' plants. The understory was rich in gingers and orchids, probably due to the open forest nearby and the steep slopes. This site possesses rich volcanic soils which might explain the presence of lowland species at this high elevation. It also lies along a very steep gradient in rainfall which decreases rapidly north to south. This nature reserve represents an important 'stepping-stone' habitat between East and Central North Sulawesi.



Alpinia – ginger common to disturbed sites

Bogani-Nani Wartabone National Park



We entered the park from the Wildlife Conservation Society's field station near Kotamobagu and climbed to about 1000 meters elevation.

The lowland forest was fairly heavily disturbed up to about 500 meters. Numerous felled trees of *Koorsiodendron* sp. (Anacardiaceae) were observed along the trail and a few ridgetops were basically deforested. Most taxa were typical of 'lowland' forest, with abundant Sapindaceae, Burseraceae, Anacardiaceae species and an overall diverse composition with few dominants. As we reached 900 meters elevation on a gently sloping ridge, the first signs of upland forest began to appear. As at Mt. Ambang, the elevational range of lowland forest seems to extend further upslope than on sites with poorer soils, potentially due to the rich volcanic nature of soils here. The upland forest (what was seen of it) appeared typical for this forest class across the island, with *Castanopsis accuminatissima* becoming dominant. A vast amount of the park remains largely unvisited and unstudied. This protected area contains the most significant contiguous patches of lowland and upland forests on rich soils on the island.



Myristica – wild nutmeg

Mt. Tampotika

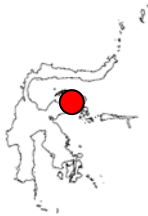


The interest in visiting this site was to examine forests on mafic soils but at a great geographic distance from the better known areas in Morowali. We traveled towards the base of Mt. Tampotika, hiking upriver along a rocky stream, which climbed gradually through lowland forest, which was occasionally fairly dense and diverse. Much of this forest had obviously been disturbed in the not too distant past. After camping out along the river, an attempt was made to reach a valley which reportedly contained old-growth forests of big stature. The hike led through a series of riverbeds, some dry, until a steep climb was made up to a sharp and narrow ridge. Species composition in this region occasionally went through rapid turnover. Some areas, particularly on steeper slopes, were composed almost completely of a small Annonaceae/Ebenaceae? tree, which grew quite densely and formed a low closed canopy. These trees were mixed with another common Fabaceae (*Cynometra*?) and Sterculiaceae (*Pterocarpus*) plant. These forests might represent advanced regeneration on poor mafic soils. In the riverbeds and alluvial sites, large trees could be found, particularly a high density of figs (*Ficus*), *Artocarpus* and other pioneer trees, like *Anthocephalus*. Some big individuals of *Diospyros*.

Our guide became lost after reaching this ridgetop, which was only at an elevation of 350 meters, but because of the poor nutrient status of the soils and the exposure of the ridge, upland species were already abundant, including *Dacrydium*, *Heritiera*, *Acer*, and various species of Lauraceae. Generally, a very dense understory of small trees were present. An abundant parasitic plant of *Balanophora* cf. *fungosa* was flowering at the time of our visit. A *Melanorrhoea* was fruiting as well, nice tree.

The drive to the area was quite interesting. It provided an excellent view of the mountain and the rather stunted nature of the mafic forests was apparent. Additionally, steep gradients in precipitation were apparent as well. Several areas were known to be seasonally dry and prone to fire. On mafic soils, these would often have poor regeneration and a sparse grass/sedge community would persist.

Lombuyan II Game Reserve

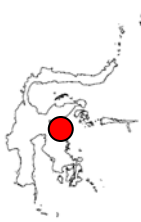


This small protected area at the base of the mushroom in the Luwuk-Morowali bioregion contained some beautiful lowland and upland forests on fairly rich limestone soils. From the remote sensing analysis, this protected area is the eastern tip of a much larger piece of G2G forest. It serves as an important watershed to the surrounding villages, like Salodik, and many of the local people use the forests for harvesting various important products. Convincing the local communities that these forests are important seems simple and direct.

The topography was rather sharp and a large number of limestone outcrops and boulders were encountered during the climb to the top. At the mountain pass at roughly 1000 m elevation, we were shown the entrance to a large cave which descended directly between two peaks. The upland limestone forests in this area, on relatively pure limestone soils, were well-structured and diverse. They were reminiscent of the uplands in Lore Lindu, although the understory may have been more densely vegetated by palms and shrubs. A healthy population of terrestrial orchids were observed (I have asked someone the name but no reply yet). The composition of trees was slightly unusual, indicative of a wettish climate, with lots

of Annonaceae and Loganaceae trees. The most notable difference from other upland forests was the complete absence of *Castanopsis acuminatissima*. The list of generic occurrences includes: *Vitex*, *Artocarpus*, *Elmerillia*, *Bischofia*, *Sloanea*, *Nauclea*, *Heriteria*, *Albizzia*, unknown *Viscaceae*, *Lithocarpus*, *Ascarina*, *Psychotria*, *Xylopia*, *Pigafetta*, *Arenga*, *Tabernaemontana*, *Horsfieldia*, and numerous species of *Eugenia*, *Litsea*, *Sapotaceae*, *Meliaceae*, *Rubiaceae*, *Euphorbiaceae*.

Boat ride down the southern coast of Luwuk-Morowali to Kolonodale



After departing Luwuk at 3 AM and driving as far down the coast towards Kolonadale as possible, we hired a small boat to take us to Baturube to catch a boat to Kolonodale. Still early morning, we had an excellent trip and given the good weather, much of the inland forests were visible. The extremely sharp topography of the limestone mountains in the interior of the eastern arm were quite spectacular and appeared to be consistently covered in forest, with few obvious signs of human disturbance.

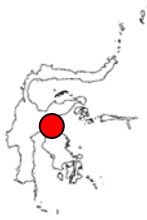
Upon arriving at Kolonodale, we arranged a meeting with the NGO Sehabat Morowali, led by Jabar. He is a very knowledgeable and helpful person, although somewhat dispirited because of the steady decline in the resources and support for his group and the general lack of real commitment from outside groups. He mentioned that one of the best maleo nesting sites he had ever visited was just down the eastern coast, in a region called Worsu, but was being threatened by logging and general conversion. During these discussions, we accepted his suggestion that we visit a large wetland area to the west of Kolonodale, which he felt was important habitat for migratory birds. These wetlands also fringed a small limestone mountain range which also contained forest.

Sampalo



We traveled to a small village, where we boarded a small outboard boat to travel upstream into the wetland area. On the drive to the village and during the boat trip, prominent limestone hills were visible throughout the journey. These hills were generally heavily disturbed but scattered patches of beautiful forest were also apparent. Some of the swampy area has been converted to padi but they have not been able to control the floods, so the cultivation has not been very intensive yet. A large open wetland area, with lots of floating water lilies and a diverse set of water fowl, led into a smaller stream. Very large and fantastic banyan figs arched over the river in several places, creating a wonderful network of stilt roots. As we entered forest with a more closed canopy, we came upon an area where sago palms were being harvested and processed. These were apparently being worked by the local Mari people, who ate sago. We climbed up until the limestone hills to a small pondok near the ridge summit. Most of this forest was heavily disturbed and converted into upland rice and vegetable gardens. We hiked back into the forest to visit a cave just over the ridge. The forest on the ridgetops was in quite good condition and contained a rich diversity of tree species, much like that seen at Lombuyan. Overall, the wetlands do provide a critical and unique resource and are under threat of general conversion into intensive agriculture.

Tambiyoli-Sumara Jaya



In order to visit the Morowali protected area, we chose to enter through the western margin, after traveling upstream from the coastal villages of Tambiyoli and the transmigration site of Sumara Jaya. Most previous visits and survey work had been performed near the alluvial soils on the southern part of protected area and adequate descriptions of these areas are already available from other sources. Two small lakes are also present in this alluvial area and we felt that this would be similar to the wetlands visited in Sampolo. Coming in from the western margin and hiking into some of the smaller Wana villages in the uplands seemed like an interesting strategy, particularly as it would take us across a mixture of limestone and mafic derived soils at different elevations. This would allow an interesting comparison with the forests in Lombuyan.

The boat across to Tambiyoli from Kolonodale took a long time to arrange and depart and the pilot seemed a little bit slow to leave. The trip into the inlet provided a spectacular view of the surrounding hills, most of which were still thickly forested, although most of it was rather stunted and open with *Casuarina* trees quite common at low elevations. The mountains on either side of the bay (Teluk Towori?) were heavily forested, up into the inlet. A very nice and relatively undisturbed patch of mangrove was present in the inlet to Tambiyoli. The Nipa palms here are noticeably smaller and obviously a different species than those on Borneo.

Morowali



We were led into the Morowali protected area by Pak Hadi from Sumara Jaya. He is locally in charge of managing and protecting a local maleo nesting site and maintains a station in the area. He expressed a certain amount of bitterness about the lack of support and interest he had received from outside organizations, particularly international ones. He was also an experienced trader with the Wana people who live inside of the Morowali forest. He could speak their language and also lead us on a tour. We began by hiking upstream of a very large and beautiful river, flowing out of a strongly mafic area. The alluvium was obviously derived from a loose conglomerate of pebbles and big rocks. The forests were quite stunted and open, containing a mixture of high montane and sandy soil species, like *Casuarina*, *Agathis*, and several genera of the Myrtaceae and Theaceae families. Turning rapidly upslope, forests remained very stunted and comprised of several unusual and endemic species, like a *Helicia* (in the Proteaceae family, one of the plant groups invading Sulawesi from the east) and *Metrosideros* (again, an invader from the east). A strange species of Gesneriaceae was also common (photos of the plant but without flowers are available on the webtour). It had a growth form like high montane plants on arid soils. These plants were all well below 400 meters elevation.

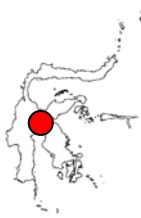
Once the top of the first ridge was reached, we emerged onto a fairly long plateau, where soils were obviously much deeper and more mixed, presumably with limestone derived soils. The common tree *Castanopsis accuminatissima* was very abundant, although many individuals did not exhibit the multiple-stem growth form that it possesses on almost every other part of the island. These normally upland trees were also present at a much lower elevation (possibly a new species?) and another common species of *Santiria* (Burseraceae) in this elevation range (400-700m) is normally a lowland species.

One of the biggest differences about this forest is the relative absence of figs, particularly large strangling figs. These trees are common in almost all other locations on the island, especially those with a history of disturbance. This absence of figs may indicate that these forests have experienced very little large scale disturbance in the recent past. A characteristic species of tree, which I was unable to identify, was a good indicator of richer, deeper soils (it was possibly an Olacaceae or even Hopea??? – no reproductive material and never really took the time to investigate). Myrtaceae was diverse as always and numerous individuals of Sapotaceae were present.

As we neared the first Wana village, the soil began to change in texture and color, obviously possessing rich organic matter. We passed through a series of fallow regions, containing the usual pioneer species on the island (Dendronide, the Urticaceae present throughout the island). Proceeding over this area, it became obvious that the soils were having a large impact on the forest composition and that transitions between more mafic soils and more limestone soils could be detected by species composition alone. On limestone soils, a richer and more representative group of lowland and some upland species were present, like Anacardiaceae (several genera), Dysoxylum, Litsea. Things very similar in composition to those in Lembuyan. Lots more Pigafetta in limestone areas.

Walk to second Wana village passed through areas primarily like limestone lowland/upland mixed forests. Most of the time we were around 700 m elevation. Still no figs.

Road trip from Kolonodale to Nuha (northern shore of Danau Matano)



The road trip between Kolonodale and Nuha passed through large plantations of rubber trees initially but then emerged into a more open and dry landscape which seemed to serve largely as pasture land, although the density of stock was quite low. These soils are mostly mafic and therefore are probably not very productive. The hills in the distance, both to the east and west, were generally well covered in forest, although it was impossible to determine anything about the composition of these forests. They did appear to be fairly low in stature, which would be appropriate for forests on mafic soils.

Soroako area



Because of the excellent network of roads connecting Soroako to the southwestern arm of the island and the fact that we had to obtain permits and letters from local government offices to visit any protected areas in the region, we hired a vehicle for two days to make the necessary office visits but to also simply drive around and cover as much territory as possible. Much of this region to the west of Soroako has been completely converted except for some hills which are still forested. Casuarina was once again quite common, indicating that the soils are mafic in nature but occasionally patches of hill forest would look quite well-structured and diverse.

While visiting offices, we were referred to the proper officials from whom we could obtain permits to enter the Faruhumpenai protected area. In discussions with these officials, a number of potential illegal logging and dumping activities were pointed out to the east of Soroako, particularly on the western shore of Danau Towuti.

Faruhumpenai



This large park is adjacent to the main road running south out of the Poso region and connecting it to the southwest. A fairly large amount of traffic moves down this highway and the areas outside of the protected area have been almost completely converted. A large mountain to the west of the cagar alam is almost completely covered in forest, because of its extremely steep slopes. We traveled up to around 900 m by car initially before entering the eastern edge, on mixed well-drained soils. The forest was in surprisingly good condition after hiking inside for a few hundred meters. A representative mix of species were present, given the elevation and soils, lots of *Castanopsis*, *Eugenia*, the big-leafed *Lithocarpus*, *Phyllocladus*, *Ternstroemia*, *Magnolia*, etc, with some mixture of *Knemas* and *Myristica*.

The next stopping point was at roughly 600 m elevation and we hiked up a small stream. More signs of slight disturbance were present but the forest was representative of mixed lowland upland species. Lots and lots of big figs, suggesting relatively recent conversion and heavy fragmentation. The third stopping point (roughly 300 meters) was moderately disturbed lowland forest, lots of weedy species present. *Castanopsis* was present at both of these lower sites, not sure why.

The following day, we traveled to the southern edge of the Cagar Alam to enter the swamp forest. An actively growing village is found on this margin of the park, with a large number of relatively newly established chocolate plantations. Getting into boats and traveling upriver, swamp forest is fairly quickly reached. In general, this swamp forest is very dense and dominated by a relatively few number of species – one notable *Elaeocarpus* was quite frequent, as well as a *Horsfieldia*, *Polyalthia*. Some *Nepenthes* were present although not abundant. These intact patches of swamp forest were rather isolated and small while much of the area has been completely converted. Apparently the local people keep some areas free of trees because they can fish very effectively when the water is high. This swamp forest seems to be the only intact and diverse forest of its type on the entire island and should be rated quite highly on any list of priority areas.

Road trip from Malili to Kolaka (western shore of Sulawesi Tenggara)



The road trip between Malili and Kolaka followed the west coast over very rugged, forested highlands. In the most severe terrain, the forest appeared to be in good condition, resembling forests around the Soroako area. Much of the land along the margins of villages and right along the coast had been converted to chocolate plantation, extending in some cases to the top of the coastal slopes. Several new logging roads were also seen being cut inland from coastal roads.

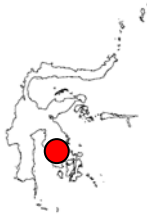
Kolaka area



We spent a short half-day hiking through forests in the Taman Wisata Alam Tirta Rimba just outside of Kolaka. Forests were generally in good condition within the park, however, chocolate plantation abutted the coastal side of the park. Geologically, this area is limestone with some thermal activity. Bubbling hot springs are a local attraction within the park, although it appears

few visitors go beyond the main river and trails. The forest appeared well-structured where it was within deep, rocky ravines; however, much of the surrounding forests had been disturbed by local agricultural practices.

Alaaha area



We hired a motorcycle in the small village of Mowewe just north of Kolaka in order to get to the last desa near the source of Sungai Iwoi (kecamatan Ulu iwoi, formerly part of kecamatan Mowewe). This long and tortuous journey went through large tracts of apparently undamaged forest. The hills to either side of the road were covered with well-structured forest interspersed with patches of open grass, presumably these were areas with mafic soils.

Local officials in Alaaha were helpful, guiding us through highland forests surrounding the area. Much of the forest appeared to have been moderately disturbed primarily as a consequence of rattan extraction. The canopy and upper storey of the forest was in excellent condition with many old-growth trees, but the under-storey had been mostly cleared by rattan laborers. The kepala desa from Alaaha informed us that recently a group of prospectors had visited the area looking for a suitable site for an oil-palm plantation. However, land use in the area is apparently regulated by Kendari because Alaaha is at the headwaters of the watershed for the city, and therefore the fate of the forest was unclear.

We returned from Alaaha via riverboat to Onaaha, where we could catch a kijang to Kendari. The river was clear and fast, flowing through what appeared to be good quality forest on the upper slopes of the surrounding hills. Along the river banks, local residents had converted much of the land to small palm and/or chocolate plantations. As we approached Onaaha, the land leveled out somewhat and many of the hills were almost completely denuded of trees with newly-planted chocolate plantations beginning to grow.

Tana Toraja

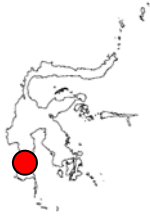


The bus ride from Mangkutana, which served as our base for several days while exploring Faruhumpenai, to Palopo passed through intensive agricultural lands near the coast but good views of the more remote and jagged mountains to the distant north gave convincing evidence that very good and intact forests are found on this central mountain range, just above the alluvial plains on the northern end of Teluk Bone. While in Palopo, tried to arrange a trip down to Gunung Latimojong but discovered that the local office in charge of this area is in the western city of Polewali. I decided instead to make an attempt to travel into the intact upland and montane forests to the west of Makale and Rantepao. The bus ride up to Makale passed through several areas of pine and clove plantations but also large and intact upland forests, heavily dominated by *Castanopsis*. The *Castanopsis* trees were all flowering in this region at this time (early August 2004), a phenomenon that became generally apparent across the southeastern part of the island as well.

Up into highlands of Tana Toraja proper, the forests have almost completely been converted to intensive agriculture and plantation forestry. A hired car drove me far up until the hills, from where the distant limestone formations could be seen. The surrounding areas were almost completely denuded of forests. The forests visible on the satellite images would have still been two days journey to the west and further north, beyond the reach of the roads.

The rich cultural heritage and carefully tended upland padi fields of the Torajans was very impressive.

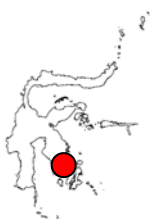
Karaenta



With the great assistance of Nenny Babo, the karst limestone formations in the Karaenta protected area were visited. These impressive formations rise suddenly out of the flat alluvial plains surrounding Ujung Pandang. The hills are quite jagged in their formations and deep divisions between the flat-topped hills are visible as we begin to drive up into the higher elevations. Most of the vegetation appears to be secondary, stunted and quite open. The pristine communities are very similar to these secondary communities and knowing the degree of disturbance is much more difficult on karst formations. We obtained a guide in a small village inside the cagar alam. This man is capable of “calling the macaques” with a little help from a tasty reward. A fairly large group of macaques soon appeared. These animals looked quite healthy and quite a few females were carrying infants.

Overall, the forests here appear typical of karst forests – low levels of diversity, open structure, abundant pioneer and weedy species. These forests are quite fragile and the soils erode quickly once exposed. Their unique qualities and potentially high number of endemic taxa make these forests interesting.

Rawa Aopa



This National Park is quite an interesting juxtaposition of habitats, with the open, frequently burnt grasslands on the heavy mafic soils in the area just south of a small range of hills, which border a large wetland area (which previously supported a peat swamp forest). This is probably the most heavily managed National Park I have ever visited. A large number of fires were burning during our visit. The area is used widely for hunting wild game. There are narrow gallery forests crossing the grasslands. Whether or not these vegetation communities are historical or recent products of human activity is unclear.

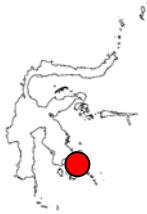
The hills just north of the grassland are covered with forests, which is obviously very seasonal and verges on being a monsoon forest but this element is also caused by the heavy mafic soils and the great heterogeneity in the distribution of nutrients and properties. These forests are fairly diverse, with abundant *Metrosideros* individuals. A legume shrub with a single leaflet was quite common. The two genera, *Vitex* and *Glochidion*, were abundant as well. Both of these are weedy plant groups, common to disturbed landscapes. An *Anacardiaceae* was also abundant upslope. *Tabernaemontana* (*Apocynaceae*) was a common small tree in the forest proper.

The ‘peat swamp’ forest in the northern part of the park has been completely converted into a large wetland, probably because of a past fire during a drought. Forest cover has been completely removed from most of the area. There is potentially a small fringe of forest on the southwestern margin of the swamp area but we were unable to reach it.

The wetlands are heavy in organic matter, as they are sitting on top of a large peat deposit, and the waters are black and acidic. Vast populations of lotus (*Nelumbo*), water lilies (*Nymphaea*), and menyanths (*Menyanthes*) grow intermixed with sedges, providing excellent waterfowl and aquatic wildlife. After returning to the park station, we were taken

around to the northern margin of the park and hiked into some heavily disturbed lowland forests. The structure and composition of these forests strongly indicated continued low levels of disturbance. While hiking into the park with two park rangers (jaga wana), a large group of men hauling freshly harvested rattan emerged from the forest. The jaga wana did nothing.

Buton



The boat trip from Kendari to Maligano on Buton Island rounded the southeastern tip of the island, allowing a close inspection of the Peropa protected area. The forest on these coastal hills looked in excellent condition and *Castanopsis* was flowering heavily across the hills. It was obviously the dominant taxa of tree in these low elevation forests. The aspect of the hills, exposed and seasonal, are perfect for *Castanopsis*. The narrow separation between Peropa and the northern end of Buton, both of which are well-forested, should not be a major biogeographic barrier to management of the two as a single unit. During my flight to Kendari, a young man described a large island off the coast of Kendari, to the east, which was completely covered by forest, this was probably Wawoni. These forests are in slightly worse condition than the other two areas. The composite area of these three forests are quite impressive.

A fairly large mangrove fringes the western coast of Buton island, although the forest behind the fringe has almost entirely been converted. This mangrove forest is typical for the region. The small species of *Nipa* palm noticed in the inlet to Tambiyoli, near Morowali, was present here as well. Given enough time, it would have been quite interesting to visit the small bay on the northeastern side of the island where a large mangrove forests appears to still be intact. The center of the island rises sharply along a limestone ridge while the northern end has a more gentle plateau of more mixed soils.

In the lower elevations of the northern protected area, a large, diverse forest is present. This forest appears to be sheltered and supplied with abundant groundwater. A large number of tall big trees are found here and the overall diversity approached the upper end observed across the island. The upper elevation forests (600-900 m elevation) on the northern end of Buton island were similar in structure and composition to the hill forests on the southeastern margin of the Lore Lindu national park. Because of increased seasonality of rainfall and the apparent lowering of elevational boundaries of upland forest, many upland species, like *Castanopsis*, *Podocarpus*, *Tristania*, and *Calophyllum*. Overall, these forests have experienced relatively limited amounts of disturbance and represent a valuable natural resource.

CONSERVATION PORTFOLIO

The Conservation Portfolio contains 85 separate units, scattered across all biogeographic regions recognized in this analysis. Including sub-units, fourteen of these portfolio units span two different biogeographic regions: 04, 04a, 04b, 05, 08a, 13, 20, 21, 22, 23, 29, 31, 52b, 68. West Central Sulawesi has the most units with 21 while Central North and Southeast Sulawesi have 11 and 13, respectively.

Table 2. Major forest classes within the conservation portfolio. The data columns show the total amount of area for each forest class, percentage of portfolio area represented by each forest class, percentage of each forest class within portfolio area, total amount of Great to Good forests present, and percentage of each forest class in the portfolio in Great to Good condition.

Class	Portfolio area (ha)	% Portfolio	% Class	G2G forest	% G2G of portfolio	% G2G of class
Open area / poor forest	2,402,953	24	26	0	0	0
Lowland Alluvium	430,570	4	28	46,562	11	95
Lowland Intermediate	4,395,686	43	50	1,882,234	43	97
Lowland Limestone	952,472	9	53	331,943	35	97
Lowland Mafic	926,797	9	78	543,376	59	95
Upland Intermediate	1,560,630	15	64	1,117,556	72	91
Upland Limestone	275,469	3	78	205,456	75	94
Upland Mafic	268,361	3	86	228,178	85	93
Montane Intermediate	709,543	7	67	575,265	81	79
Montane Limestone	52,136	1	79	47,369	91	83
Montane Mafic	69,531	1	95	65,061	94	97
Tropalpine	127,813	1	79	107,627	84	86
Karst	144,110	1	96	80,821	56	98
Wetlands	141,726	1	25	1,814	1	100
Mangrove	53,224	1	70	2,780	5	80

The most abundant forest class within the conservation portfolio, Lowland forest on Intermediate soils, is represented in roughly the same proportions as its overall distribution across the island. Lowland Intermediate forests cover 47% of the island while it constitutes 43% of the portfolio area. Several forest classes are almost entirely included within the portfolio, such as Karst Forests (96%), Montane Mafic (95%), and Upland Mafic (86%). Several others have more than three quarters of their area in the portfolio: Tropalpine (79%), Montane Limestone (79%), Upland Limestone (78%), and Lowland Mafic (78%). The most poorly represented forest classes in the portfolio are Wetlands (25%), Open and Poor Forests (26%), and Lowland Alluvium (28%). Because of the large amount of open area and poor forest cover on the island, a small percentage of this forest class still constitutes almost a quarter of the total portfolio area.

In general, the relative percentages of G2G forest have been substantially enriched within the portfolio. Over 90% of the available G2G forest in a majority of the forest classes has been incorporated into the conservation portfolio, with Karst forests leading all classes with 98% but both Lowland Intermediate and Lowland Limestone both have 97% of

available G2G forest in the portfolio. Mangrove and Montane Limestone forests have the lowest percentages of G2G forest in the portfolio.

Table 3. Major forest classes across biogeographic regions of Sulawesi. The first three ranking regions are shown for each forest class, including total amount of area within that region.

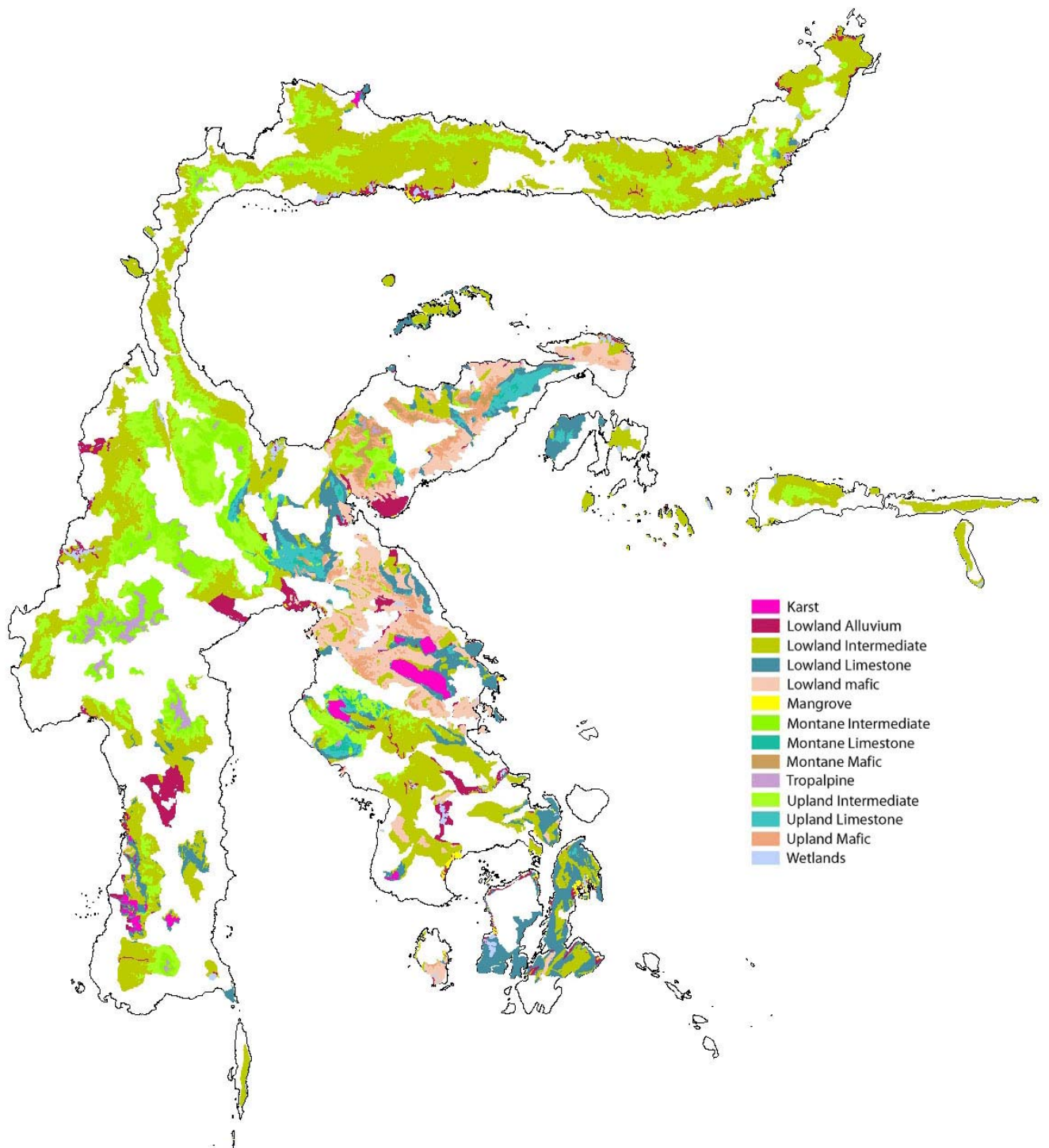
Class	Most area (ha)	2 nd Rank	3 rd Rank
Open area / poor forest	WCS (475,059)	SWS (455,797)	ECS (241,297)
Lowland Alluvium	SWS (102,120)	WCS (73,723)	SES (60,550)
Lowland Intermediate	CNS (917,755)	WCS (826,204)	WNS (645,889)
Lowland Limestone	ECS (278,253)	MBK (274,130)	SES (105,693)
Lowland Mafic	ECS (547,323)	LM (301,653)	SES (40,534)
Upland Intermediate	WCS (741,690)	CNS (246,722)	WNS (202,608)
Upland Limestone	ECS (103,497)	LM (87,652)	SES (45,502)
Upland Mafic	LM (149,050)	ECS (114,155)	SES (2,543)
Montane Intermediate	WCS (575,335)	WNS (42,631)	SES (30,990)
Montane Limestone	SES (20,403)	LM (13,646)	ECS (9,996)
Montane Mafic	LM (66,538)	ECS (2,946)	WCS (32)
Tropalpine	WCS (111,069)	LM (7,758)	WNS (3,598)
Karst	ECS (81,867)	SWS (31,253)	SES (25,205)
Wetlands	WCS (21,317)	WNS (20,553)	ECS (18,265)
Mangrove	MBK (16,043)	SES (10,253)	SL (7,169)

Table 4. Major forest classes across sites of the conservation portfolio. Numbers are in hectares.																
Sites	Open/ Poor	Lowland Alluv	Lowland Interm	Lowland Lime	Lowland Mafic	Upland Interm	Upland Lime	Upland Mafic	Montane Interm	Montane Lime	Montane Mafic	Tropalp	Karst	Wetland	Mangro	TOTAL
01	63,941	6,552	95,177	0	0	4,684	0	0	298	0	0	0	0	0	1,799	172,451
01a	3,072	31	2,319	0	0	846	0	0	0	0	0	0	0	0	0	6,268
02	55,799	3,648	72,888	45	0	11,022	0	0	548	0	0	0	0	114	394	144,458
02a	4,238	0	3,699	0	0	119	0	0	0	0	0	0	0	2,631	0	10,687
03	0	0	1,639	0	0	66	0	0	0	0	0	0	0	0	0	1,705
04	25,061	2,260	34,866	5,443	0	29,153	2,679	0	799	140	0	0	0	3,108	89	103,598
04a	407	0	5,071	0	0	2,638	0	0	0	0	0	0	0	1	0	8,117
04b	21,654	2,194	29,094	660	0	6,879	0	0	0	0	0	0	0	970	2	61,453
05	70,764	11,620	480,430	3,211	0	159,398	800	0	7,108	3	0	0	0	7,869	347	741,550
06	1,133	0	1,133	0	0	0	0	0	0	0	0	0	0	0	0	2,266
07a	46	0	1,232	0	0	0	0	0	0	0	0	0	0	0	19	1,297
07b	31	0	86	410	0	0	0	0	0	0	0	0	0	0	101	628
07c	100	0	3,540	0	0	0	0	0	0	0	0	0	0	0	0	3,640
07d	584	0	10,690	0	0	0	0	0	0	0	0	0	0	0	0	11,274
07e	0	0	1,169	0	0	0	0	0	0	0	0	0	0	0	0	1,169
08a	112,947	23,650	546,319	0	0	97,686	0	0	12,189	0	0	0	0	15,991	6,724	815,506
08b	21,237	2,888	270,905	5,906	0	99,477	0	0	25,605	0	0	656	5,124	5,482	213	437,493
09	4,076	519	103,975	31	0	57,937	0	0	14,454	0	0	2,942	0	353	0	184,287
10	4,055	0	3,770	1,168	0	0	0	0	0	0	0	0	0	0	0	8,993
11	5,381	512	28,274	0	0	2,377	0	0	0	0	0	0	0	0	0	36,544
12	13,530	75	14,938	0	0	0	0	0	0	0	0	0	0	28	38	28,609
13	2,851	17	72,646	0	0	22,165	0	0	577	0	0	0	0	0	0	98,256
14	5,738	0	81,642	0	0	85,082	0	0	54,177	0	0	3,351	0	0	0	229,990
15	4,397	123	9,843	0	0	4,253	0	0	1,196	0	0	0	0	916	0	20,728
16	21,035	0	19,097	0	0	156,799	0	0	76,792	0	0	760	0	72	0	274,555
17a	47,627	21,060	216,204	0	0	99,999	0	0	20,783	0	0	141	0	5,918	0	411,732
17b	58,596	9,931	106,879	425	0	85,709	0	0	104,234	0	0	7,008	0	11,718	0	384,500
17c	5,605	0	13,476	0	0	1,831	0	0	0	0	0	0	0	0	0	20,912
18	40,859	248	95,505	823	0	87,607	42	0	149,101	0	0	65,068	0	0	0	439,253
19a	13,725	0	2,468	0	0	37,429	0	0	48,079	0	0	6,694	0	0	0	108,395
19b	60,253	35,447	70,629	0	190	26,427	0	387	3,717	0	0	63	0	1,112	0	198,225

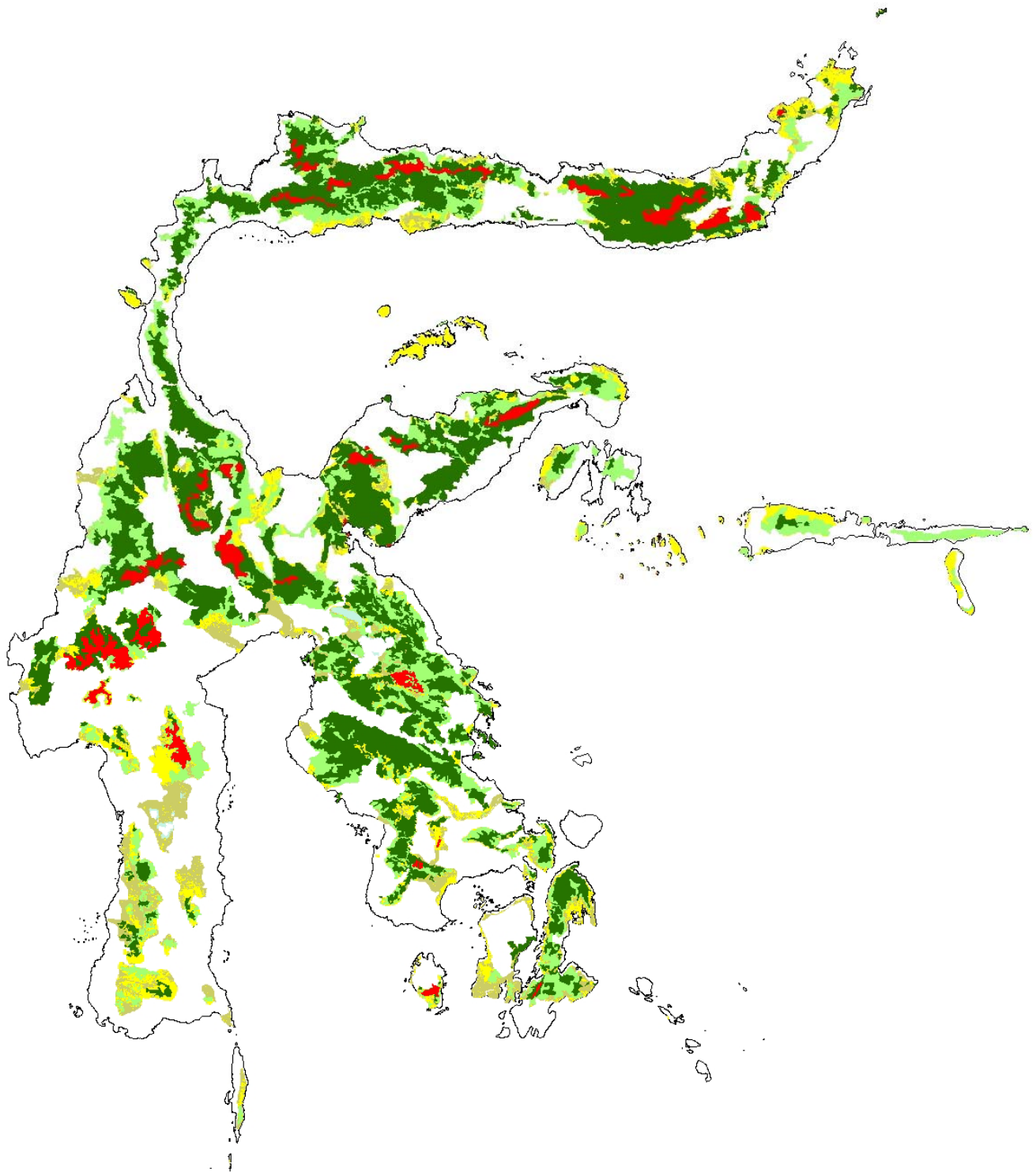
20	70,268	15,842	53,564	8,162	1,916	81,390	19,585	301	54,065	7,949	122	38	0	854	0	314,056
21	19,823	15,659	1,061	0	2,111	0	0	0	0	0	0	0	0	0	1,462	40,116
22	58,618	1,164	85,963	70,256	17,301	23,775	79,818	13,852	14	8,201	2,462	0	0	9,178	0	370,602
22a	4,450	0	417	4,533	0	0	189	0	0	0	0	0	0	0	0	9,589
23	72,774	48,250	64,070	52,991	86,060	66,387	20,508	49,237	26,107	6,587	35,326	6,579	0	1,194	1,662	537,732
24	16	425	0	2,296	239	0	0	0	0	0	0	0	0	4	0	2,980
25	5,351	0	39,261	6,574	18,795	3,063	250	27,255	10	0	10,557	157	0	0	0	111,273
26	27,513	3,064	24,842	60,405	74,875	3,937	76,338	42,098	5	8,853	19,789	1,021	272	2,405	175	345,592
27	31,684	4,046	18,141	726	74,731	0	0	9,452	0	0	20	0	0	7,714	223	146,737
28	1,937	1,422	1,198	4,981	61,841	303	7	21,109	0	0	845	0	0	0	0	93,643
29	124,562	24,090	110,582	154,942	477,478	3,832	14,175	102,115	0	0	410	0	81,867	6,863	1,823	1,102,739
30	3,552	1,289	636	3,580	32,012	0	0	276	0	0	0	0	0	1,205	39	42,589
31	33,613	6,571	226,998	44,911	5,404	104,035	45,295	0	27,204	19,987	0	2,327	21,163	763	0	538,271
31a	14,393	715	7,051	2,627	0	9,012	173	0	2,449	416	0	1	0	0	0	36,837
32	282	402	4	0	2,079	0	0	0	0	0	0	0	0	0	0	2,767
33a	36,876	4,013	179,572	0	17,696	9,808	0	0	1,336	0	0	0	0	2,187	0	251,488
33b	38,611	24,337	8,055	1,499	0	0	0	0	0	0	0	0	0	4,281	0	76,783
34	2,585	0	6,913	652	0	0	0	0	0	0	0	0	0	0	0	10,150
35	69,852	23,620	64,598	0	13,423	120	0	121	0	0	0	0	0	8,473	7,996	188,203
35a	6,755	0	11,864	10,067	0	0	0	0	0	0	0	0	4,043	15	0	32,744
36	730	0	84	0	0	0	0	0	0	0	0	0	0	678	0	1,492
37	6,996	0	43,814	3,634	0	0	0	0	0	0	0	0	0	22	0	54,466
38	27,248	803	33,801	40,951	3,548	66	31	0	0	0	0	0	0	491	1,279	108,218
39	4,583	745	6,925	0	0	0	0	0	0	0	0	0	0	0	978	13,231
40	21,756	9,086	0	6,812	0	0	0	0	0	0	0	0	0	1,534	4,353	43,541
41	67,673	859	0	70,402	0	0	0	0	0	0	0	0	0	7,431	290	146,655
42	3,654	0	0	20,178	0	0	0	0	0	0	0	0	0	0	0	23,832
43	51,886	5,957	49,745	86,550	344	24	2,661	0	0	0	0	0	0	2,720	9,654	209,541
44	10,659	457	11,429	34,246	0	0	0	0	0	0	0	0	0	0	465	57,256
45	33,194	8,634	45,458	54,778	8,647	0	0	0	0	0	0	0	0	0	796	151,507
46	3,737	88	2,874	251	317	0	0	0	0	0	0	0	0	0	211	7,478
47	12,683	775	2,298	912	21,200	30	41	2,147	0	0	0	0	0	1,766	274	42,126
48	10,169	0	0	0	0	2,383	0	0	21,090	0	0	6,797	0	0	0	40,439

49	1,886	0	0	0	0	1,922	0	0	2,862	0	0	0	0	0	0	6,670
50	163	6	157	0	0	0	0	0	0	0	0	0	0	0	0	326
50a	9,666	3,176	15,254	0	0	3,381	0	0	0	0	0	0	0	564	0	32,041
50b	39,518	354	44,790	1,297	0	20,758	0	0	2,911	0	0	0	0	0	0	109,628
51	0	0	4,822	0	0	3,654	0	0	0	0	0	0	0	0	0	8,476
52a	74,250	0	66,870	6,193	0	44,143	1,316	0	36,517	0	0	21,149	0	0	0	250,438
52b	113,570	82,567	37,157	3,194	0	0	0	0	0	0	0	0	0	18	0	236,506
53	158,356	17,322	139,338	48,845	6,130	31,751	740	12	291	0	0	0	24,289	123	0	427,197
54	75,144	0	56,611	31,198	0	0	0	0	0	0	0	0	0	322	0	163,275
55	7,673	0	3,726	3,191	0	0	0	0	0	0	0	0	6,964	0	0	21,554
56	105,208	1,854	94,584	520	0	35,166	0	0	14,874	0	0	3,060	0	0	0	255,266
57	11,281	698	11,845	0	0	0	0	0	0	0	0	0	0	3,137	0	26,961
58	7,576	0	39	7,537	0	0	0	0	0	0	0	0	0	0	0	15,152
59	18,065	0	22,220	457	0	0	0	0	0	0	0	0	0	0	0	40,742
60	15,635	1,070	8,435	5,843	287	0	0	0	0	0	0	0	0	0	0	31,270
61	427	0	0	283	0	0	0	0	0	0	0	0	0	0	144	854
63	23,865	0	2,373	54,237	0	0	10,819	0	0	0	0	0	0	960	136	92,390
64	337	0	0	3,506	0	0	0	0	0	0	0	0	0	0	88	3,931
65	1,308	0	31,034	0	0	0	0	0	0	0	0	0	0	3,143	0	35,485
66	6,397	0	10,145	0	0	0	0	0	0	0	0	0	0	732	195	17,469
67	658	0	677	0	0	0	0	0	0	0	0	0	0	0	35	1,370
68	26,134	0	25,370	0	0	0	0	0	0	0	0	0	390	2,862	2,112	56,868
69a	2,645	0	1,727	0	0	0	0	0	0	0	0	0	0	0	918	5,290
69b	3,848	0	3,600	0	0	0	0	0	0	0	0	0	0	0	251	7,699
70	43,497	0	85,171	0	0	30,042	0	0	0	0	0	0	0	1,754	4,651	165,115
71	1,063	0	3,910	0	0	0	0	0	0	0	0	0	0	1	0	4,974
72	1,592	0	57,872	0	0	596	0	0	0	0	0	0	0	903	0	60,963
73	299	0	2,889	0	0	0	0	0	0	0	0	0	0	0	0	3,188
74	655	0	655	0	0	0	0	0	0	0	0	0	0	0	0	1,310
75	22,232	0	25,762	0	0	0	0	0	0	0	0	0	0	2,143	0	50,137
76	3,407	0	4,215	0	0	0	0	0	0	0	0	0	0	1,341	0	8,963
77	64,847	164	44,770	17,556	0	0	0	0	0	0	0	0	0	0	3,288	130,625
78	563	0	1,956	0	0	0	0	0	0	0	0	0	0	0	0	2,519

79	956	0	6,152	0	0	0	0	0	0	0	0	0	0	0	0	7,108
80	827	0	9,437	0	0	1,259	0	0	149	0	0	0	0	0	0	11,672
81	1,071	273	27,779	0	0	212	0	0	0	0	0	0	0	0	0	29,335
82	1,841	0	0	0	0	0	0	0	0	0	0	0	0	1,841	0	3,682
83	682	0	2,458	667	0	0	0	0	0	0	0	0	0	19	0	3,826
84	1,798	0	8,184	699	170	0	0	0	0	0	0	0	0	1,126	0	11,977
85	6,789	0	32,885	1,212	0	0	0	0	0	0	0	0	0	4,678	0	45,564



Major Forest Classes in the Conservation Portfolio (map)



Forest Condition in the Conservation Portfolio (map)

CONCLUSIONS AND RECOMMENDATIONS

State of knowledge

The development of an effective strategy for conserving and managing the vegetation communities of Sulawesi is complicated by a number of issues. The first issue is our relative ignorance of the composition and structure of these communities. In terms of composition, collection densities on the island are some of the lowest in Indonesia. This ignorance obviously plays into the discrepancy between animals and plants in the level of observed endemism on the island. Many of the endemic plant species have simply not been described yet. From my experience with the stone oaks (*Lithocarpus*), this is certainly the case, and it is true for most other botanists with any experience on the island. That being said, botanists should not necessarily focus on the collection and description of rare and endemic species. The biological significance of these taxa is debatable, in terms of their value for conservation and ecosystem functioning, while the effort involved can be quite large. The existence of these taxa should simply be accepted, while unquantifiable, as a significant element of these vegetation communities.

The most important element of these vegetation communities that needs more detailed study is their ecological composition and structure from the single watershed up to major biogeographic units. Other than a few small scattered descriptions made in the context of vertebrate studies, primarily focused in the northern arm and around Lore Lindu National Park (LLNP), no substantial vegetation sampling at the community level has been accomplished on the island. From previous field experience, both in the LLNP and during the rapid survey performed as part of this ecoregional analysis, the relative levels of dominance and rate of species turnover can be quite complicated, both on the mesocommunity and landscape scales. The extremely complicated spatial distribution of land area, topography, and soil types has certainly played into the processes of community assembly and diversification. These communities are composed of populations which are probably substantially different in nature than those found on larger continental islands, like Borneo or Sumatra.

Given our general ignorance about the taxonomy and ecology of these forests, our complete ignorance of the geographic and taxonomic distribution of genetic diversity is obvious. We know nothing about the levels of genetic diversity on the island and how this relates to the overall diversity across Southeast Asia. The results from such a study could contribute to our understanding and ability to manage and conserve these forests. Estimates of the genetic distinctiveness of Sulawesi plants from closely related taxa found on Borneo would provide clues about the timing and frequency of immigration events. Further, these estimates would provide insight into the relative impact of previous climate change, particularly during the last few glacial cycles. Palynological evidence and the general structure of the forests suggests that the climate was more seasonal in the past in some areas.

The current coarse filter analysis provides a robust framework from which to develop effective strategies for improved sampling. Within the framework of the conservation portfolio and the nationally protected area network, key locations for long term study should be identified. Given the rather limited amount of resources available for these studies, the selection of these sites is quite important and could have a large impact on our overall

interpretation. These studies should focus on three things: the dominant taxa and how their dominance varies on both small and large scales; the comparison of dominant taxa across strong ecological gradients; and the impact of human-mediated disturbance on these forests. The vegetation studies initiated by STORMA provide some good examples for this latter issue.

Outside of the conservation and management concerns, a large number of basic biological questions can be addressed through ecological and evolutionary studies of the island's vegetation. Its biogeographic position and habitat complexity create a fascinating natural laboratory for understanding the processes of speciation and diversification in plants. The conversion and heavy fragmentation of these ancient communities will erase whatever historical patterns may have been established over very long periods of time. The description and analysis of these patterns before they are lost are essential for the proper understanding of fundamental biological processes. An understanding of speciation and gene flow would provide powerful tools for the conservation, management, and improvement of these forests.

Conservation portfolio

The portfolio includes over half (54%) of the island's land area and is broken up into 85 sites. Good and Old-Growth forests were obviously a major focus in the design of these sites, as the percentage of G2G forest is greatly enriched within the portfolio. In addition, large areas of critical and endangered forest classes were included, despite their relatively poor condition. The lowland classes, in general, are important because they contain high levels of species diversity and normally provide the most productive habitat for animals. These habitats, particularly the alluvial soils, are prone to conversion. The successful rehabilitation and management of these already disturbed sites would significantly improve the overall conservation value of the portfolio.

The interconnectedness of the portfolio, particularly through the central region and up into the northern arm, is an important aspect which should be carefully maintained. This interconnectedness of habitat will improve the chances of migration and gene flow between separate core areas. The integrity of populations across the island, not just individual populations, should be given a high priority in evaluating how to best manage the portfolio.

While a full analysis of the portfolio and the development of an objective set of criteria for prioritizing among sites will not be performed as part of this coarse filter analysis, a short list of suggestions about specific things to measure and rank each portfolio site in relation to others is provided below. These suggestions are given in no particular order.

1. Proximity of Old Growth forest next to Poor forest or Open areas. Given the premium placed on Old Growth forest, significant patches which are adjacent to heavily disturbed forests will be most vulnerable to future disturbance, either through direct conversion or through indirect effects that occur along edges. These juxtapositions of forests in very different conditions should be given a higher priority.
2. Integrity of G2G forest within a site. Given the probability that only a few concerted conservation efforts will be successfully implemented across the island, the conservation and protection of large intact patches of G2G forest, of the various major classes, should be given higher priority than sites which have scattered

islands of G2G forest. This perspective is only valid really from the ecoregional, top-down approach, while the opposite may be true for more local and small-scale conservation efforts. The two strategies should both be pursued.

3. Spatial position of G2G forests among neighboring sites. If adjacent sites are composed of roughly identical major forest classes, then the possibility of choosing one site over the others seems possible. If adjacent sites are quite different in their composition, then they should be protected equally.
4. The possibility of 'source/sink' relationships between portfolio sites. Given the range of forest conditions within the portfolio, it may be able to identify those sites which are most likely to function as sources for biodiversity (areas with large contiguous habitat and G2G forest) in comparison to sites which will likely be sinks for biodiversity over the foreseeable future. The spatial distribution of these sources and sinks should be taken into consideration as well.
5. Species diversity and composition. From the results of the fine filter analysis, some measure of the uniqueness and absolute value of plant species diversity could contribute to the prioritization of the portfolio.

General comments

Evidence from both temperate and tropical regions indicates that forests are fairly resilient as long as disturbance does not lead to complete conversion and is not sustained indefinitely. Small fragments of intact forest can harbor rich vegetation communities, relictual individuals of rare and endemic species, and provide important ecosystem functions, like migratory habitat for vertebrates or local forest product harvest. Substantial fragments of forest can generally be found in surrounding most villages and small cities. While these forests are sometimes modified in various ways, they may play a key role in the regeneration of forest in the future or in the persistence of gene flow between distant populations. Several studies have indicated that these small fragments can act as links between large populations which are separated by inappropriate habitat.

In general, while the creation of a conservation portfolio and the organization of strategies around the entire portfolio are necessary, the local protection and rehabilitation of even the smallest fragments of G2G forests should also be considered a priority. These forests are obviously of value to the people living nearby, in terms of water supply, forest products, and cultural meaning, and the promotion of these values should be emphasized strongly whenever possible. While the ecoregion approach will be effective at the provincial or national level, the small scale importance of these forests should not be lost or under-emphasized. The management and protection of these small fragments of forest are quite important.