NEGATIVE IMPACT OF FOREST DEGRADATION TO HERPETOFAUNA SPECIES RICHNESS IN KERINCISEBLAT NATIONAL PARK, SUMATRA[1]
[Dampak Negatif dari Degradasi Hutan Terhadap Kekayaan Jenis Herpetofauna di Taman Nasional Kerinci Seblat, Sumatra]

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ABSTRAK

Fragmentasi dan hilangnya habitat adalah penyebab utama ancaman pada keragaman herpetofauna di areal hutan hujan tropika termasuk hutan hujan tropika di Taman Nasional Kerinci Seblat, Sumatra. Untuk mengukur laju dampak negatif dari perubahan fungsi hutan terhadap keragaman jenis herpetofauna, 15 lokasi survei dengan berbagai derajat kerusakan hutan dipilih di areal Taman Nasional Kerinci Seblat. Berdasarkan analisa *cluster*, 15 lokasi survei terbagi menjadi 5 kelompok, yaitu kelompok hutan dataran rendah, kelompok hutan dataran tinggi, kelompok rawa, kelompok hutan terdegradasi dan kelompok perladangan. Hasil perhitungan regresi linier untuk empat kelompok besar (tidak termasuk kelompok rawa) menunjukkan bahwa laju penurunan keragaman herpetofauna terhadap perubahan fungsi hutan tinggi ($\mathbf{R^2} > 0,7$).

Kata kunci: degradasi hutan, dampak negatif, keragamanan herpetofauna, Taman Nasional Kerinci Seblat, Sumatra.

ABSTRACT

Habitat loss and fragmentation are among the largest threats to herpetofauna diversity in tropical rain forest areas, including the rain forest in Kerinci Seblat National Park (KSNP). To measure the rate of negative impact to the herpetofauna population, fifteen survey sites with several degree of habitat disturbance were selected. Based on cluster analysis, 15 survey sites were grouped into five distinct clusters, included low elevation forest group, high elevation group, swamp group, disturbed forest group and cultivated land group. Calculation of linier regression for four major (low elevation forest group, high elevation group, disturbed forest group and cultivated land group groups) showed that the rate of locally biodiversity losses were high ($\mathbf{R^2} > 0.7$).

Key words: Forest degradation, Negative impact, Herpetofauna, Species richness, Kerinci Seblat National Park, Sumatra.

INTRODUCTION

Habitat loss and fragmentation are among the most important threats to herpetofaunal diversity in tropical rain forest areas, including the rain forest in Kerinci Seblat National Park (KSNP). The park is the largest national park in Sumatra, spread over c. 1,400,000 hectares of tropical rain forest (Figure 1) that contains vegetation types including lowland tropical forest (50m - 600m), highland rain forest (600m - 1,500m), submontane vegetation (1,500m - 2,500m), shrub or fern (2,500m - 2,800m) and sub-alpine vegetation (above 2,300m) (Departemen Kehutanan Republik Indonesia 2007). However, the forest has been altered by human activities such as (illegal) logging, land clearing and cultivation. The KSNP cover 38,846 km^2 and contained 22,327 km^2 of forest in 1995, representing 57.5% of the region. Atotal of 1278 km^2 of forest was estimated to have been cleared between 1995 and 2001, as a result forest covered 21,048.7 km^2 in 2001, representing 54.2% of the region (Linkie, 2003).

Dessication of microhabitats within natural forests or wetlands, as well as alterations of the flow of natural water courses, followed by the development of monocultures have drastic negative impacts on herpetofauna populations (Gardner, 2001; Stuebing and Inger, 1999). To assess the degree of negative impact on herpetofaunal populations, fifteen survey sites with several degree of habitat modification were selected in KSNP (Figure 1) consisting of six sites in KSNP-Jambi Province (Gunung Tujuh, Rawa Bento, Tapan, Renah Kayu Embun, Lumayang, Sungai Durian); four sites in KSNP-West Sumatra Province (Muara Sako, Muara Kambang, Muara Labuh, Lubuk Selasih); four sites in KSNP-South Sumatra Province (Sulap Hills, Seloso Hills, Napal Licin and Upper Rupit River); and one site in Bengkulu Province (Ketenong). Altitude of the fifteen sites ranged from 50m to c. 2000m asl.

[1]*Diterima : 26 Agustus 2009 - Disetujui: 18 September 2009*

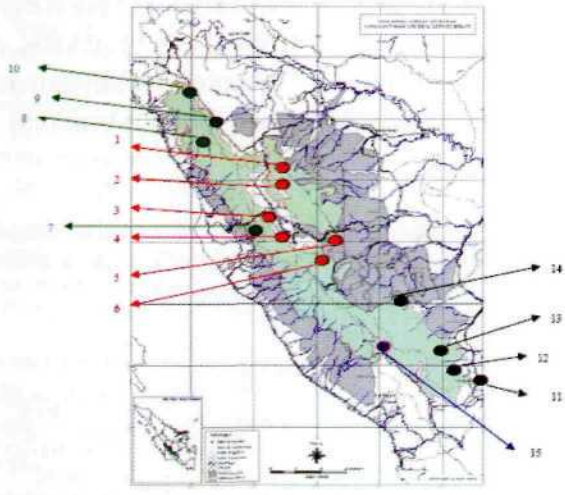

Figure 1. Study areas of amphibians and reptiles in Kerinci-Seblat National Park (red, green black and blue circles). Red circles: sites were located in Jambi Province. (1) Gunung Tujuh; (2) Rawa Bento; (3) Tapan; (4) Renah Kayu Embun; (5) Lumayang; (6) Sungai Durian. Green circles: sites were located in West Sumatra Provinve. (7) Muara Sako; (8) Muara Kambang; (9) Muara Labuh; (10) Lubuk Selasih. Black Circles: sites were located in South Sumatra Province. (11) Sulap Hills; (12) Seloso Hills; (13) Upper Rupit River: ,, ,,. (14)NapalLicin. Blue circle: site was located in Bengkulu Province. (15) Ketenong.

METHODOLOGY

A. Survey Sites

Amphibians and reptiles occupy a wide variety of habitats from subterranean cavities to the forest canopy. Consequently, survey sites were selected that sampled as many of the major habitat types as possible, while at the same time focusing effort on more common habitats. A brief description of 15 sampling sites surveyed:

1. Tapan (GPS position: S 2° 05'52.0"; E 101° 14'57.7" ; 550 meters asl).

Habitat at Tapan survey site consisted of lowland hill forest. Microhabitat types which are important to amphibians and reptiles included fast flowing streams, slow flowing streams, fallen logs and forest floor litter.

2. Lumayang (GPS position : S 2° 17'25.3" ; E 101° 42'13.6"; 700 meters asl).

Most habitats at Lumayang consisted of hilly lowland forest, where dipterocarps are the dominant tree species. Microhabitat types for amphibians and reptiles in this area included slow flowing streams, fast flowing stream, fallen logs, forest floor litter and water-filled holes in tree trunks.

3. Sungai Durian (GPS position: S 2° 19'0.8"; E 101° 44'6.4"; 700 meters asl).

Habitat types at Sungai Durian survey site are similar to Lumayang survey site. Microhabitat types for amphibians and reptiles include slow and fast flowing streams, fallen logs, forest floor litter, water-filled holes in tree trunks, and temporary and permanent pools (including animal wallows). Animal wallows are very important microhabitat for some tree frogs in the forest (Inger and Stuebing 1989).

4. Gunung Tujuh (GPS position: S 1°42'38.5" ;E 101° 22'18.0"; 1300-2000 meters asl).

Habitat type at Gunung Tujuh survey site is highland hill forest as described by Kurniati (2009). Microhabitat types for amphibians and reptiles in this area include grassy swamp, fast flowing streams, fallen logs and forest floor litter.

5. Rawa Bento (GPS position : S 1 ° 43 '46.4"; E 101[c] 20'52.2"; 1200 meters asl).

This wetland consists of grassy and weedy areas and scattered small trees. Microhabitat types

for amphibians and reptiles includes ditches, sloughs and swampy areas.

6. Renah Kayu Embun (GPS position: S 2° 09'3.4"; E 101°22'24.5"; 1200-1500 meters asl).

Habitat type is similar to that at Gunung Tujuh. Microhabitat types for amphibians and reptiles include grassy swamp, fast and slow flowing streams, fallen logs, temporary and permanent pools, and forest floor litter.

7. **Muara Kambang** (GPS position : S 1° 38' 14.1"; E 100° 49' 11.0"; 50-300 meters asl).

Habitat consists of edificarian, cultivation, secondary hill forest and heavily degraded forest as described by Kurniati (2009). Microhabitat types important to amphibians and reptiles included houses, fast flowing river, slow and fast flowing streams, standing water (permanent and temporary pools), tree trunks, fallen logs and forest floor litter.

8. Muara Sako (GPS position : S 2° 8'21.1"; E 101° 10'26.1"; 70-300 meters asl).

Most habitats at Muara Sako consist of edificarian, cultivation and secondary hill forest, heavily degraded forest. Microhabitat types for amphibians and reptiles in this area included habitation, fast flowing river, slow and fast flowing streams, standing water, tree trunks, fallen logs, and forest floor litter.

9. Muara Labuh (GPS position: S 1°22'34.2"; E 100° 58'35.5"; 700-1000 meters asl).

Habitat types comprised of edificarian, cultivation and secondary hill forest. Microhabitat types for amphibians and reptiles in this area included habitation, fast flowing river, slow and fast flowing streams, standing water, tree trunks, fallen logs, and forest floor litter.

10. Lubuk Selasih (GPS position: S 1° 10'38.5"; E100° 41'35.8"; 1000-1200 meters asl).

Habitat types consist of edificarian, cultivation and secondary hill forest. Microhabitat types for amphibians and reptiles in this area include house, fast flowing river, fast flowing streams, tree trunks, fallen logs, and forest floor litter.

11. Sulap Hills (GPS position : S 3° 16'42.1" ; E 102° 51'6.3"; 150-500 meters asl).

Habitat type at Sulap Hills is hilly cultivated land. Rubber plantations are the dominant vegetation at this site. Sulap Hills was a heavily degraded forest prior to 1992, when it was planted in 1992 by an initiative of the national park. Microhabitat types for amphibians and reptiles in this area include fast flowing streams, tree trunks and "forest" floor litter.

12. Seloso Hills (GPS position: S 3° 15'40.3"; E 102° 49'6.2"; 150-500 meters asl).

Habitat types observed at Seloso Hills survey site were heavily degraded forest, cultivated land and edificarian. Heavily degraded forest occurs about half way to the top of the hills. Rubber plantation is dominant vegetation in cultivated land. Microhabitat types for amphibians and reptiles include fast flowing streams, tree trunks, fallen logs, forest floor litter and temporary human shelter.

13. Napal Licin (GPS position : S 2°42'6.8"; E 102° 21'6.6"; 50-400 meters asl).

Napal Licin habitat consists of hilly selective-logged rain forest and cultivation, such as rubber plantation and dry paddy filed. Microhabitats available for amphibians and reptiles include slow and fast flowing streams, temporary pools, fallen logs, water-filled holes in tree trunks, and forest floor litter.

14. Upper Rupit River (GPS position: S 3° 01 '34.4"; E 102°36'58.7"; 100-700 meters asl).

Habitat type at Upper Rupit River consists of hilly rain forest as described by Kurniati (2009). Condition of the forest was still good. Microhabitat available for amphibians and reptiles included slow and fast moving streams, temporary pools, shallow rivers, fallen logs, and forest floor litter.

15. Ketenong (GPS position : S 1° 39'6.6" ; E 106° 14'41.4"; 550-800 meters asl).

Habitat type at Ketenong survey site was hilly primary forest, cultivation and edificarian. The forest was relatively intact, although in some areas we found loggers had stayed temporarily to conduct logging activities. Microhabitats available for amphibians and reptiles in Ketenong were temporary shelters, houses,

slow and fast moving streams, seasonal swamp, **permanent pool, paddy field,** gravelly shallow river, fallen logs, **tree trunks and** forest floor litter.

B. Survey Methods

Field surveys were conducted from January to March each year from 2005 to 2008. Due to rainfall is substantial for herpetofauna activities; wet season (January-March) is the best time for field survey. Sampling effort was varied among the fifteen sites (see Table 1) because of access and time constrains.

Counts of species were made by slowly walking through sites of selected habitat (estimation of searching site was 2 km^2) and recording individual encounters for each species. Collecting techniques are based on intensive searching in microhabitats. Techniques used to collect specimens included:

/. *Spotlighting*

This technique uses a bright flashlight to capture frogs at night. Individuals are temporarily blinded by light in their eyes, making them easy to catch.

2. Hand Collection

This technique is suitable for snakes and lizards by searching microhabitats including leaf litter, tree bark and buttresses, low-lying vegetation and in or under logs.

3. Trapping

Trapping was effective only for small lizards such as geckos (Gekkonidae) and skinks (Scincidae). Small rectangular pieces of wood (20 cm x 30 cm) were covered with rat glue and placed in suitable reptile habitats. Captured animals were removed from traps using cooking oil.

Based on life style and major habitat relationship, herpetofauna species that found in each survey site were classified into three groups (Inger and Stuebing 1989):

1. **Forest species:** None of the amphibians or reptiles can tolerate much habitat change.
2. **Non-forest species** : This species group closely associates with humans and is almost entirely dependent on human disturbance to create a preferred environment condition.
3. **Generalist** : This species group consists of amphibians and reptiles with broad ecological tolerance.

C. Analysis

Cluster analysis with complete linkage (Minitab version 13) was used to estimate similarities of amphibian and reptile diversity between survey sites based on species presence/absence (see Table 1 and 2). Linear regression was used to measure the rate of reducing species richness inside group of sites.

RESULTS AND DISCUSSION

Herpetofauna studies at 15 KSNP survey sites documented a substantial diversity of amphibians and reptiles. Atotal of 71 amphibians and 38 reptiles were

Table 1. Sampling effort in each survey site

Survey site	Number of effective day/night censuses	Number of person day/night in survey site
Tapan	7	3
Lumayang	6	4
Sungai Durian	8	5
Gunung Tujuh	10	4
Rawa Bento	4	3
Renah Kayu Embun	8	4
Muara Kambang	8	4
Muara Sako	8	3
Muara Labuh	9	4
Lubuk Selasih	8	4
Sulap Hill	7	3
Seloso Hill	7	3
Napal Licin	9	4
Upper Rupit River	12	4
Ketenong	10	4

recorded. A species list, habitat categories (forest species, generalist species and non-forest species) and taxonomic classification are presented in Tables 1 and 2. Number of species that were found in each survey site were counted below:

1. **Tapan:** 21 species observed (15 amphibians and 6 reptiles) which consisted of 10 forest species, 10 generalist species and 1 non-forest species.
2. **Lumayang:** 13 species were observed (9 amphibian and 4 reptiles) which consisted of 5 forest species, 5 generalist species and 3 non-forest species.
3. **Sungai Durian:** 32 species were observed (27 amphibians and 5 reptiles) which consisted of 19 forest species, 13 generalist species and 0 non-forest species.
4. **Gunung Tujuh:** 34 species were observed (27 amphibians and 7 reptiles) which consisted of 8 forest species, 17 generalist species and 9 non-forest species.
5. **Rawa Bento:** 6 species of amphibians were observed which consisted of 6 non-forest species.
6. **Renah Kayu Embun:** 16 species were observed (13 amphibians and 3 reptiles) which consisted of 3 forest species, 10 generalist species and 3 non-forest species
7. **Muara Kambang** : 29 species observed (17 amphibians and 12 reptiles) which consisted of 5 forest species, 10 generalist species and 14 non-forest species.
8. **Muara Sako** : 33 species observed (19 amphibians and 14 reptiles) which consisted of 5 forest species, 14 generalist species and 14 non-forest species.
9. **Muara Labuh** : 31 species observed (19 of amphibians and 12 reptiles) which consisted of 8 forest species, 12 generalist species and 11 non-forest species.
10. **Lubuk Selasih** : 18 species observed (15 of amphibians and 3 reptiles) which consisted of 5 forest species, 6 generalist species and 7 non-forest species.
11. **Sulap Hills** : 19 species were recorded (12 amphibians and 7 reptile) which consisted of 3 forest species, 5 generalist species and 11 non-forest species.
12. **Seloso Hills** : 17 species were recorded (11 amphibians and 6 reptiles) which consisted of 3 forest species, 4 generalist species and 10 non-forest species.
13. **Napal Licin** : 34 species were recorded (18 amphibians and 16 reptiles) which consisted of 10 forest species, 12 generalist species and 12 non-forest species.
14. **Upper Rupit River**: 29 species were recorded (16 amphibians and 13 reptiles) which consisted of 16 forest species, 13 generalist species and 0 non-forest species.
15. **Ketenong**: 35 species were recorded (23 amphibians and 12 reptiles) which consisted of 9 forest species, 15 generalist species and 11 non-forest species.

A dendrogram of species similarity among sites showed five distinct clusters (Figure 2). The sites where rainforest covered most of the areas at an altitude of 100-1000 meters asl (/. *e.*, Tapan, Lumayang, Upper Rupit River and Sungai Durian) clustered as one group and is referred to as the low elevation forest group. The second group included the sites of disturbed forest between 1200-2000 meters asl (/. *e.*, Gunung Tujuh and Renah Kayu Embun) that clustered as one group and is referred to as the high elevation group. The third group was Rawa Bento survey site, which has very a specific habitat and is located at a high elevation (1200m). At this site, grass was the major plant and covered most of the open area. The fourth group, included the sites of disturbed forest and is located at 50-1200 m (/. e., Muara Kambang, Muara Sako, Ketenong, Muara Labuh, Lubuk Selasih), and was named as the disturbed forest group. The fifth group included the sites of cultivated land at 100-300 m (/. *e.*, Sulap Hills, Seloso Hills and Napal Licin) and is referred to as cultivated land group.

The possible reasons for the grouping of the fifteen sites are explained below:

1. Low elevation forest group

Tapan, Lumayang, Upper Rupit River and Sungai Durian are hilly rain forest sites where the landscape is characterized by gentle and steep slopes. The forest at these sites are habitat for many forest species restricted to lowland forest. These forest

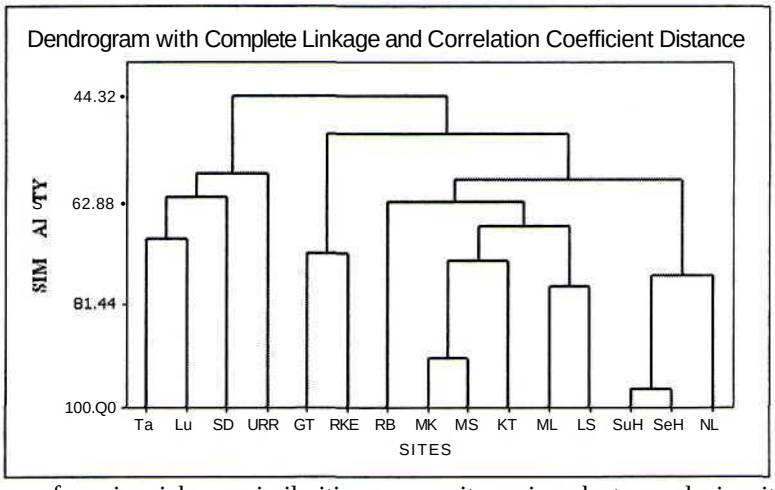

Figure 2. Dendrogram of species richness similarities among sites using cluster analysis with complete linkage Ta: Tapan; Lu: Lumayang; SD: Sungai Durian; GT: Gunung Tujuh; RB: Rawa Bento; RKE: Renah Kz>. Embun; MK: Muara Kambang; MS: Muara Sako; ML: Muara Labuh; LS: Lubuk Selasih; SuH: Sulit Hills; SeH: Seloso Hills; NL: Napal Licin; URR: Upper Rupit River; KT: Ketenong

species usually exhibit restricted ecological tolerance, meaning they do not tolerate serious habitat disturbance such as logging, deforestation and pollution from agricultural fertilize. Herpetofauna species that have restricted ecological tolerance at these sites are: *Ansonia glandulosa, Bufo divergens, Leptophryne borbonica, Kalophrynus pleurostigma, Phrynella pulchra, Metaphrynella sundana, Limnonectes microdiscus, Pelophryne brevipes, Nyctixalus pictus, Polypedates otilophus, Rhacophorus nigropalmatus, Aphaniotis acutirostris, Aplopeltura boa, Boiga cynodon* and *Gonocephalus grandis.*

Inside low elevation forest group, Sungai Durian (SD) was the richest site on herpetofauna diversity and Lumayang (Lu) was the poorest site. Most of species that inhabited the four survey sites were forest species. Species richness decreased sharply from Sungai Durian to Tapan. Richness was relatively stable from Tapan to Lumayang (gray line in Figure 3). Among these sites, forest threats in Tapan and Lumayang were higher compared to Sungai Durian and Upper Rupit River. The regression equation (y= -4.48x+36.8) of decreasing species richness for low elevation forest group shows a significant result with high R-square (0.923) (black line in Figure 3). This result indicated that forest threats such as logging have significantly impacted herpetofauna diversity at the four survr sites.

2. High elevation forest group

The landscape of Gunung Tujuh and Rena: Kayu Embun were very similar to Tapan, Lumayani and Sungai Durian; however, these two sites art located at high elevation. Species that inhabit these sites have variable tolerance to their habitats. Some species are restricted to their habitat and elevation including *Philautus aurifasciatus, P. cornutus,* anc *Megophrys aceras, M. paralella.* Others have greater ecological tolerance or generalist species (e. g., *Bufc juxtasper, Rana crassiovis, Rhacophorus catamitns Dendragama boulengeri* and *Lophocalotes ludekingi*\ and non-forest species (e.g., *B. melanostictus* and *Microhyla heymonsi).* Basically, most of the species can tolerate the cool temperatures that prevail above 1000 m.

In the high elevation forest group, decreasing species richness between Gunung Tujuh and Renah Kayu Embun is very sharp (Figure 4). The threat habitat conversion (forest to cultivated land) in Renah Kayu Embun was higher compared to Gunung Tujuh. The regression equation (y= -18x+52) resulted in a perfect R-square (R=l .00). This indicates that forest threat in Renah Kayu Embun has a highly significant negative impact on species that inhabit high elevation forest.

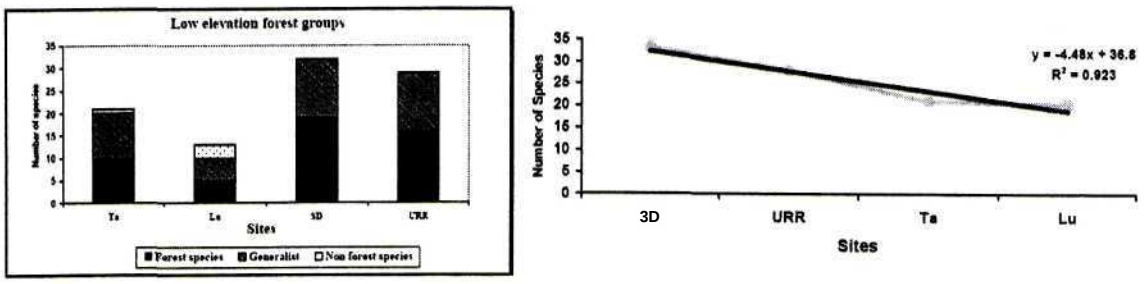

Figure 3. Linear regression of decreasing species richness in the low elevation forest group. Black line indicates a significant trend of decreasing species richness. SD: Sungai Durian; URR: Upper Rupit River; Ta: Tapan; Lu: Lumayang.

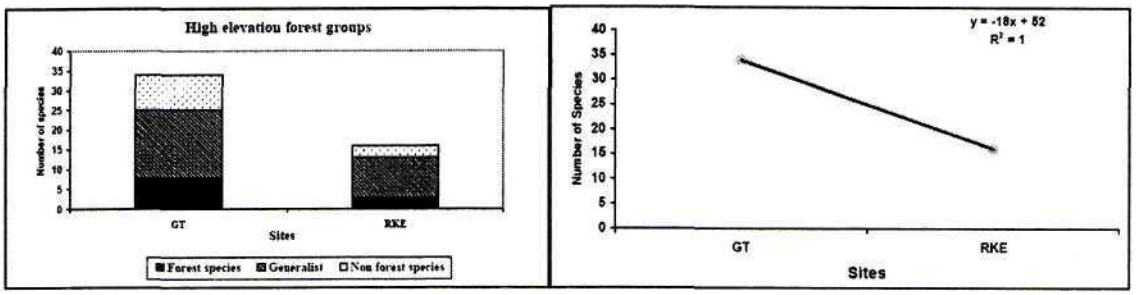

Figure 4. Linear regression of decreasing species richness in the high elevation forest group. Black line indicates the significant trend of decreasing species richness. GT: Gunung Tujuh, RKE: Renah Kayu Embun.

3. Marshland group

Rawa Bento has a specific habitat. Grasses are the major plants in the area. In the analysis, Rawa Bento clustered as a specific group that was relatively close to disturbed forest group. *Rhacophorus bifasciatus*, frog species that is restricted to marshland was found in this site, and was abundant. The frog was also found in marshland at Gunung Tujuh but was not common.

4. Disturbed forest group

In the disturbed forest group, sites clustered into three groups; low elevation group (Muara Kambang and Muara Sako), sub-middle elevation (Ketenong) and middle elevation group (Muara Labuh and Lubuk Selasih). Muara Kambang and Muara Sako are located at low elevation (50-300 m). At these sites habitat conversion from forest to cultivated land was very high. Most of the herpetofauna at these sites were non-forest species that inhabit low elevation forests such as *Limnonectes shompenorum* and *Rana erythraea*. Muara Labuh and Lubuk Selasih are located at middle elevations (700-1200 m). Habitat conversion at these sites was also high. Widely ecological tolerant species or generalist inhabit most of the available microhabitats, including *Bufo asper*, *Rana hosii* and *Limnonectes crybetus*. Based on cluster analysis, Ketenong site was closest to Muara Kambang and Muara Sako. At these sites, similarity of non-forest species that inhabited cultivated land was very high, including *Fejervarya cancrivora, F. limnocharis, Rana nicobariensis* and *R. erythraea.*

In the disturbed forest group, decrease in species richness among the five sites was quite sharp (Figure 5). Decrease in species richness from Ketenong to Muara Kambang was relatively low and very sharp compared to Lubuk Selasih (gray line; Figure 5). The regression showed that available habitats for non-forest species at four sites (KT, MS, ML, MK) was similar. Species that inhabited man-made habitat including plantation and paddy fields were dominant. However in Lubuk Selasih, degraded forest was

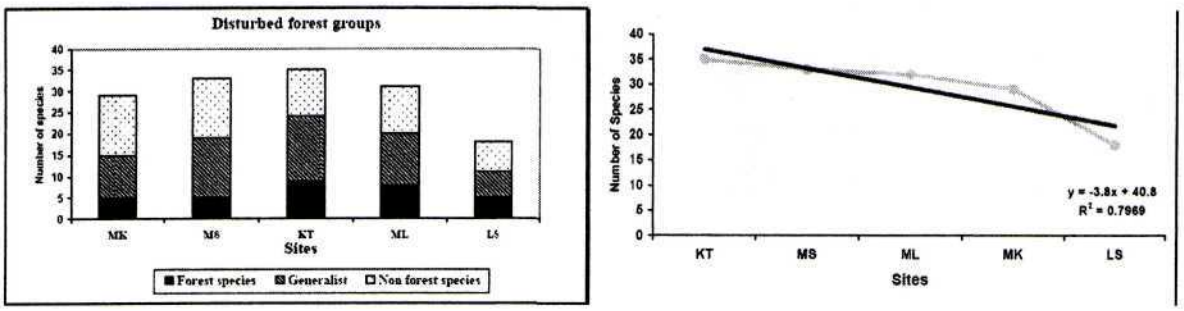

Figure 5. Linier regression of decreasing species richness in the disturbed forest group. Black line indicates a significant trend of decreasing species richness. KT: Ketenong; MS: Muara Sako; ML: Muara Labuh; MK: Muara Kambang; LS: Lubuk Selasih.

habitable for herpetofauna, but under human threat. The regression equation (y= -3.8x+40.8) resulted in a high R-square (R=0.7969) (black line; Figure 5), indicating that threats to forest in Lubuk Selasih has a significant negative impact on species that inhabit degraded forest at middle elevations.

5. Cultivated land group

Napal Licin, Sulap Hills and Seloso Hills clustered as one group. Sulap Hills and Seloso Hills are the most closely related with a high similarity, followed by Napal Licin (Figure 6). Most of the species identified in Sulap Hills and Seloso Hills were non-forest species, usually found in heavily degraded forests. However, Napal Licin stands as ab outlier group among the three sites. Napal Licin can be categorized as semi-cultivated land; plantations can be found in the forest. In some species were found only in this area, including *Metaphrynella pollicaris* and *Limnonectes macrodon.*

In the cultivated land group, decrease in species richness among the sites was sharp (Figure 6). Species richness decreased sharply from Napal Licin to Sulap Hills and was relatively stable from Sulap Hills to Seloso Hills (gray line; Figure 6). This phenomenon can be explained by habitat changing from degraded forest to plantation. Almost all habitats in Sulap and Seloso Hills were rubber plantation. However, in Napal Licin forest was still available even though it has been interrupted by plantation in selected areas. The regression equation (y= -8.5x+40.333) resulted in a high R-square (R=0.8369) (black line; Figure 6), indicating that changes in species richness in Napal Licin parallels that in Sulap and Seloso Hills.

Usually proximal factors such as habitat destruction or modification are easily identified as the responsible cause of local losses of biodiversity. Like most terrestrial species, amphibians and reptiles are threatened foremost by habitat destruction. The destruction or direct modification of ecological systems is widely held as a primary cause for the loss of amphibian species together with reductions in their population size (Gardner 2001). In forestry area where directly affected by human disturbance such as illegal logging in the Kerinci Seblat National Park can usually be attributed as the cause of population decline of the herpetofauna species. Activities of forestry modifications can produce changes in microclimate, soil moisture and habitat complexity that can drastically affect the livelihoods of reptile and amphibian species. Of particular importance is land drainage for reservoirs and other developments, frequently resulting in removal of breeding sites and fragmentation of populations (Gardner 2001). According to Gillespie *et al.* (2005), species richness was higher in minimally disturbed forest and forest habitats with only moderate disturbance levels than in highly disturbed habitat, such as secondary forest and plantation; disturbed habitats was characterized by species that widespread, habitat generalist and human commensalisms. Forest clearing in and around the four sites groups in Kerinci Seblat National Park has been beneficial to forest-dwelling species intolerant of open areas. Herpetofauna habitat loss from logging by local

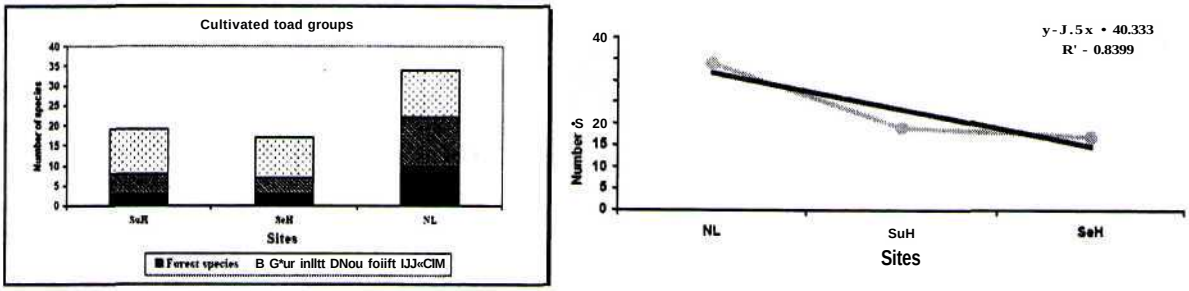

Figure 6. Linear regression of decreasing species richness in the cultivated land group. The black line indicates the significant trend of decreasing species richness.
NL: Napal Licin; SuH: Sulap Hills; SeH: Seloso Hills.

habitants in these areas is likely the main cause of observed decreases in herpetofauna diversity. In order to establish the herpetofauna population, it will take time to recover the condition by minimizing loss and fragmentation of habitats. Habitat connectivity appears to play a key role in regional viability of amphibian populations (Inger and Voris 1993). In amphibians, population connectivity is predominantly affected through juvenile dispersal. The preponderance of evidence suggests that the short-term impact of habitat loss and fragmentation increases with dispersal ability. However, species with limited dispersal abilities are likely to be equally imperiled by habitat loss and fragmentation over longer time periods (Cushman2006).

Kerinci Seblat National Park occurs 16 frog and 2 agamid species that endemic to Sumatra (see Table 1 and Table 2); however population of the frogs are under threat by such habitat modifications as described above. To keep existence of the endemic species for the long run, several actions need to implement, include:

1. The marshland area in Rawa Bento is the main habitat for *Rhacophorus bifasciatus;* the area is the only *R. bifasciatus* habitat that occurs in Gunung Tujuh region; so far the frog has not been found yet in the other areas in Sumatra (Kurniati, personal observation; Jim McGuire, personal communication). However this area is outside the protected area of Kerinci Seblat National Park. Most activities by local people are negatively impacting *R. bifasciatus* habitat at Rawa Bento, such as modification of marshland for paddy field. The opportunity exists to save the marshland are : (a) To protect Rawa Bento as part of the national park; (b) To work with local communities to preserve this marshland.
2. To increase public awareness on herpetofauna conservation to minimalism forest degradation of core protected area in Kerinci Seblat National Park.
3. To provide the high quality aquatic and terrestrial habitats that amphibians require. For some ranid species require clean water for their breeding habitat. To keep the upland ecosystems from deforestation and water pollutant such potassium are not only important to amphibians by providing habitats, but also human activities at higher watershed levels affect both terrestrial and aquatic habitat quality at lower levels.

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A. Amphibians

Table 1. List of amphibian species recorded at ten survey sites in KSNP (Jambi, West Sumatra, South Sumatra and Bengkulu Provinces), Sumatra. (+) species found; (-) species not found; (*) species endemic to Sumatra; (**) species has been described by Djoko Iskandar. Ta: Tapan; Lu: Lumayang; SD: Sungai Durian; GT: Gunung Tujuh; RB: Rawa Bento; RKE: Renah Kayu Embun; MK: Muara Kambang; MS: Muara Sako; ML: Muara Labuh; LS: Lubuk Selasih; SuH: Sulap Hill; SeH: Seloso Hill; NL: Napal Licin; URK: Upper Rupit River; KT: Ketenong. F: Forest species; G: Generalist species; N: Non-forest species.

riucSfIratinn LHssnicauon Species list	SltW Jambi Province					SHeS West Sumatra Province					Sites South Sumatra Province				Site Ucngkulu Province	Species categor > by habitat
	Ta	1.u	SD	GT	RB	RKE	MK	MS	ML	LS	SuH	SeH	NL	LRR	KT	
Class Amphibia Order Anura																
Family Megophryidac																
Megophrys nasula	+	+	+	-	-	-	+	+	+	+	-	-	-	-	+	F
*Megophrys aceras**	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	F
*Megophrys paralella**	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	F
hamil\ Bufunidac																
Ansonia cf *glandulosa **	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	F
Ansonia leptopus	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	F
Bufo asper	+	+	+	-	-	-	+	+	+	-	+	+	+	+	+	G
*Bvfo claviger**	.	.	.	-	-	-	-	-	-	-	+	-	-	-	-	N
Bufo (Mvergen	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	F
Bufojuxasper	-	-	-	+	-	+	-	-	-	+	-	-	-	-	-	G
Bifo melanostictus	-	-	-	+	-	-	+	+	+	-	+	+	+	-	+	N
Bxfopanus	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	G
Pelophryne brevipes	-	-	+	-	-	-	-	-	-	-	-	-	+	+	-	F
Leptophryne ***borbonica***	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+	F
Family Microhylidae																
Kabphrynus pleumstigma	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	F
Kaloula baleata	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	G
Microhyla borneensis	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	G
Microhyla heymonsi	-	-	-	+	-	-	+	+	+	+	+	+	+	-	+	N
Microhyla palmipes	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	G
Microhyla superciliaris	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	G
Microhyla sp	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	F
Melaphrynella cfpollicaris	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	F

Metaphrynella sundana	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-	F
Phrynelb ptichra	-	+	+	-	-	-	-	-	-	-	-	-	-	+	-	F
Family Ranidae																
Fejervarya cancrivora	-	-	-	+	+	-	+	+	+	+	+	+	-	-	+	N
Fejervarya limnocharis	-	-	-	+	+	-	+	+	+	+	+	+	+	-	+	N
*Huia modiglianii**	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F
*Huia sumatrana**	+	+	+	+	-	+	-	-	+	+	-	-	-	+	+	G
*Limnonectes acuticeps **	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F
*Limnonectes barisani**	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	F
Limnonectes bfythii	+	-	-	-	-	-	+	-	*	*	+	+	+	+	-	F
*Limnonectes crybetus**	-	-	+	-	-	-	-	-	+	+	+	+	+	+	+	F
Limnonectes kuhlii	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	F
Limnonectes latteps	-	-	-	-	-	-	-	*	-	-	-	-	+	+	-	F
Limnonectes macrodon	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	G
Limnonectes microdiscus	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	F
Limnonectes paramacrodon	-	-	-	-	-	-	+	+	-	-	-	-	-	-	+	N
*Limnonectes prajatmoi**	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F
Limnonectes shompenorum	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	N
Occidozyga laevis	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	F
Occidozyga sumatrana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	G
Rana chalconota	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	G
*Rana crassiovis**	+	-	-	+	-	+	-	-	+	+	-	-	-	-	+	G
Rana erythraea	-	-	-	-	-	-	+	+	-	-	-	-	+	-	+	N
Rana hosii	+	+	+	+	-	+	+	+	+	+	-	-	+	+	+	G
*Rana kampeni**	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	G
Rana nicobariensis	-	-	-	+	+	+	+	+	+	+	+	+	+	-	+	N
Rana nigrovittata	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	F
Rana picturata	-	+	-	-	-	-	+	+	-	-	-	-	-	-	+	F
Rana raniceps	-	-	-	-	-	-	+	+	+	+	-	-	+	+	+	F
*Rana sibcru**	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F
iriiiiii) Ithacnplioridac																
Nyctixahis pictus	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	F
PUlautus aurifasciatus	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	F
*Phtlautus comutus**	–	–	-	+	-	-	-	-	-	–	-	-	-	-	-	F

Polypedates leucomystax	-	-	-	+	+	+	+	+	+	-	+	+	+	-	+	G
Polypedates macrotis	-	-	+	+	-	+	-	+	-	-	-	-	-	-	+	G
Polypedates otilophus	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	F
*Rhacophorus achantharrhena**	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	N
Rhacophorus anguttrostris	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	N
Rhacophorus appendiculatus	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	F
*Rhacophorus barisani**	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	F
*Rhacophorus bifasciatus**	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	N
*Rhacophorus calami tus**	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	N
Rhacophorus cyanopimctatus	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	F
*Rhacophorus modestus**	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	F
Rhacophorus nigropalmatus	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-	F
Rhacophorus pardalis	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	G
*Rhacophorus poecibnotus**	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	N
Rhacophorus prominanus	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	G
Rhacophorus reinwardtii	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	G
Rhacophorus **spl**	-	-	+	-	-	-	-	-		-	-	-	-	-	-	F
Theloderma licin	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	F
Number of ♂ pecks	**15**	**9**	**27**	**2»**	**6**	**13**	**P**	**19**	**19**	**IS**	**12**	**11**	**18**	**16**	**23**	

B. Reptiles

Table 2. Total list of reptiles species found in at ten survey sites in KSNP (Jambi, West Sumatra, South Sumatra *SCL* Bengkulu Provinces), Sumatra. (+) species found; (-) species not found; (*) species endemic to Sumam (**) species has been described by Djoko Iskandar. Ta: Tapan; Lu: Lumayang; SD: Sungai Durian; G~ Gunung Tujuh; RB: Rawa Bento; RKE: Renah Kayu Embun; MK: Muara Kambang; MS: Muara Sak: ML: Muara Labuh; LS: Lubuk Selasih; SuH: Sulap Hill; SeH: Seloso Hill; NL: Napal Licin; URK: Uppr **Rupit** River; KT: Ketenong. F: Forest species; G: Generalist species; N: Non-forest species.

Qassiricaliun niid S penes list	Sites Jambi I'rnvi						Site West Sumatra Province				Sites South Sunntrn I'rovincc				Site Bengkulu Province	Species categjt} by habit*
	Tfl	Lu	Si)	Cr	Rli	KM:	MK	MS	ML	LS	SuH	Sell	M .	UKK	KT	
Class Kcptilia OrdirOphidia (Snakes)																
lamil) Colubridae																
Ahaetulla *prasina*	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	G
Aplopeltura boa	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	F
Asthenodipsas maheccanus	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	F
Boiga dendrophila	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	G
Boiga cynodon	-	-	+	-	-	-	-	-	-	-	-	-	+	+	-	F
Chrysopelea paradisii	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	N
Dendrelaphis pictus	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	G
Lepturophis bomeensis	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	F
Liopeltis baliodeirus	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	G
Ptyashorros	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	G
Ptyas mucosus	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	G
Rhabdophis chrysirgus	+	-	+	-	-	-	+	+	+	-	-	-	-	-	-	G
Rhabdophis 1 rianguligens	-	-	-	-	-	-	+	+	+	-	-	-	-	-	+	N
Family Ebpkbc																
Ophüiphagu ***hannah***	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	(':
Order Liccrtilia (1 i?anis)																
Family Varanidie																
Varanus sal valor	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	G
Family Agamidae																
Aphaniotis acutirostris	+	-	+	-	-	-	-	-	+	-	-	-	+	+	-	G
Bronchocela cristatetia	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	N
*Dendragatna boulengeri**	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	G
Draco melanopogcn	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	G
*Draco sumatranus**	+	+	-	-	-	-	+	+	+	-	+	+	+	-	+	N
Draco sp	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	F
Gonocephalus grandis	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	F
*Lophocalotes ludekingi**	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	G

Famllj Lacritidae																
l'ait\Jromui <&\lincatu	-	-	-	-	-	-	+	+	.	.	+	+	+	-	-	N
Fansl} Geldiomdee																
Cyrtodactylus marmoratus	+	–	+	+	-	-	-	.	.	.	.		-	+	+	-	-	**G**
Cyrtodactylus **spl**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	**G**
Cyrtodactylus **sp2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	**G**
Gekko gecko	-	+	-	-	-	-	+	+	+	-	+	+	+	-	-	-	-	**N**
Gekko monarchus	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	+	-	**G**
Gehyra mutilata		.	.	.	-	-	-	+	+	+	+	+	+	+	-	+	-	**N**
Hemáactylus	-	+	-	-	-	-	+	+	+	+	+	+	+	-	-	+	-	**N**
1 smilj Vindilar																
Dasia olivacea	-	-	-	+	-	-	+	+	+	.	-	-	+	+	-	-	-	**G**
Mabuya multifasdata	+	+	-	+	-	+	+	+	+	+	+	+	+	+	+	+	-	**G**
Mabuya rudis	-	-	-	-	-	+	+	+	+	-	-	-	+	+	-	-	-	**G**
Mabuya rugifera	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	**F**
Sphenomorphus sanctus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	**G**
Order Tetudiiuta (turtles) Fttnly Trkupchidae																		
Amvla caniliqwea	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	**G**
Family Gwenwdidae																		
Siebeircckidla erasucollis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	**G**
NwnBerof SDKWS	6	4	5	7	a	3	12	14	13	3	7	6	16	13	12			