A JOURNAL ON TAXONOMIC BOTANY,
PLANT SOCIOLOGY AND ECOLOGY

REINWARDTIA

Editors
KUSWATA KARTAWINATA
MIEN A. RIFAI

Published by
HERBARIUM BOGORIENSE
LEMBAGA BIOLOGI NASIONAL — LIPI
BOGOR, INDONESIA

Reinwardtia Vol. 10, Part 2, 107 — 270 23 July 1985

IO ISSN 0034 — 365X

REINWARDTIA
Published by Herbarium Bogoriense — LBN, Bogor
Vol. 10, Part 2, pp. 131 — 138 (19-85)

NITROGEN CONTENT OF TOPSOIL IN LOWLAND TROPICAL FOREST IN EAST KALIMANTAN (INDONESIA), BEFORE AND AFTER CLEAR-CUTTING AND BURNING

SOEDARSONO RISWAN
Herbarium Bogoriense, Lembaga Biologi Nasional-LIPI, Bogor

ABSTRACT

In order to study the changes in nitrogen content of forest soils after clear-cutting and burning over a period of time, two plots of 0.5 ha in the primary mixed dipterocarp and kerangas forests were established and clear-cut. Thereafter, all felled vegetation in one plot of each forest type was burnt, while in the other plot the vegetation was removed from the plot without burning. Soil samples were collected along the transect line 1 x 100 m in each of plots at intervals of 20 m. The preliminary results of the data collected over 6 and 12 weeks after felling with or without burning showed a decline of total N and organic C contents of topsoil and an increase in soil pH.

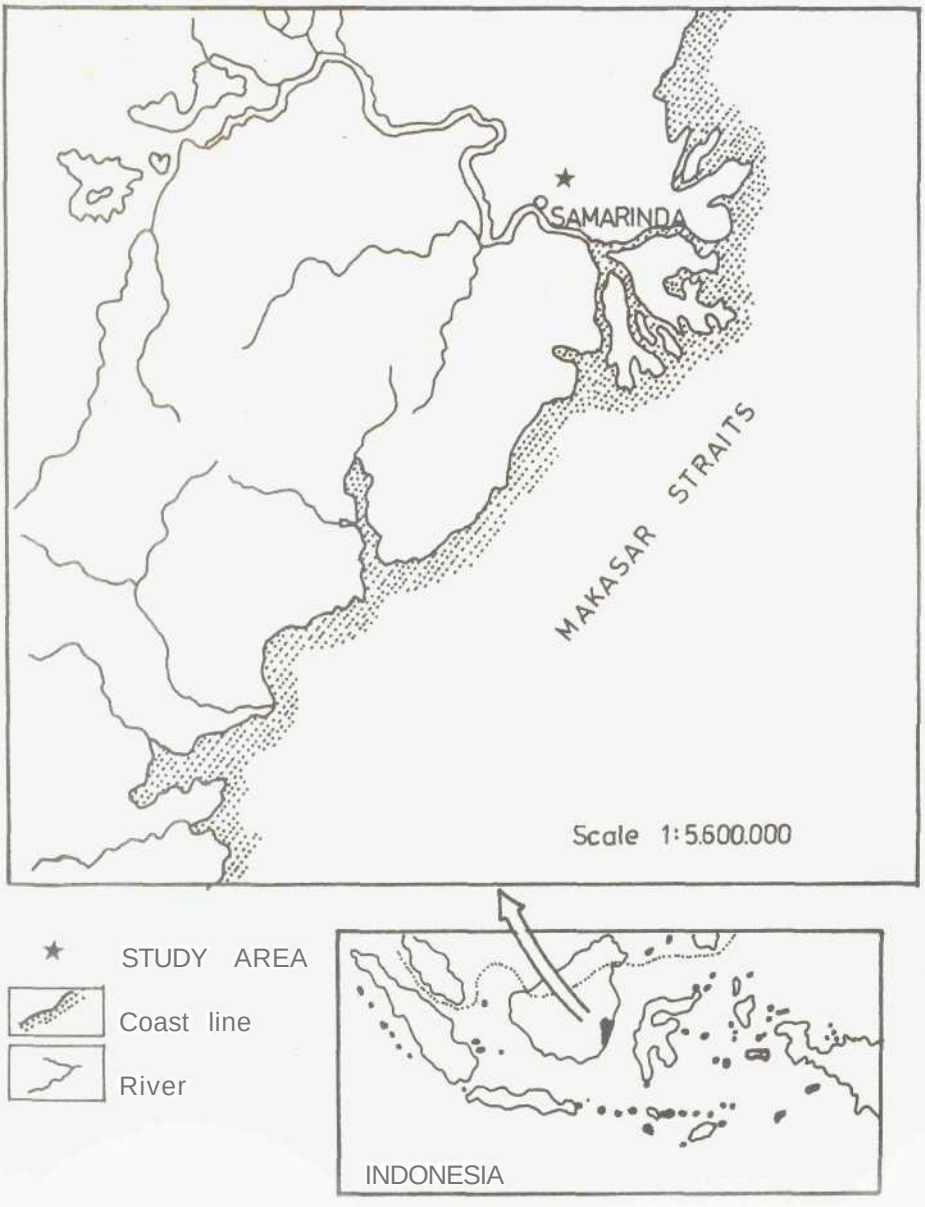
ABSTRAK

Perubahan kandungan nitrog'en tanah setelah hutan ditebang habis dengan atau tanpa dibakar telah diamati pada 2 tipe hutan yang berbeda di Kalimantan Timur, yaitu hutan campuran Dipterocarpaceae dan hutan kerangas. Contoh tanah diambil pada jarak interval 20 m sepanjang jalur pengamatan 1 X 100 m, pada masing-masing petak percobaan di kedua tipe hutan tersebut. Hasil sementara menunjukkan bahwa total nitrogen menurun, sedang karbon organik dan pH naik pada periode 0 dan 12 minggu setelah hutan ditebang dengan atau tanpa dibakar.

INTRODUCTION

Shifting cultivation is a primitive type of agricultural practice in many tropical areas, and has a severe effect on mineral element cycles. Odum (1971) mentioned that a large proportion of the nutrients in primary tropical forest is held in the vegetation, particularly trees. The nutrients can recycle directly from litter of the trees into the roots via mycorrhiza (Went & Stark, 1968) and indirectly through the decomposition process.

When the forest is cut and burnt, not only are nutrients released from the vegetation, but the recycling mechanisms, involving litter, mycorrhiza and other microorganisms are also destroyed. Nitrogen and sulphur are released into the atmosphere as gases. Other nutrient


SAMARINDA
MAKASAR STRAITS
Scale 1:5.600.000
STUDY AREA
Coast line
River
INDONESIA

elements are deposited on the soil surface as ash and are washed into the soil by the first rain.

A study was carried out to assess the effect of clear-cutting and burning on the movement of nutrients. This paper attempts to discuss the movement of nitrogen during- the early stage after clear-cutting, with of without burning, over a period of 6 and 12 weeks.

DESCRIPTION OF THE STUDY AREAS

The lowland mixed dipterocarp forest (MDF)

The study area is located at Tan ah Merah, Lempake, about 12 km northeast of Samarinda, the capital city of East Kalimantan Province (Fig. 1). It lies within a 300 ha forest, which belongs to the Mulawarman University and is utilized as a teaching and research forest. The area has an undulating to hilly topography with altitudes of 40 to 80 m. The soils belong to the Red-Yellow Podzolic Group (Hardjono, 1967), derived from the sedimentary rocks of the Upper Miocene Formation. The climate is humid. The mean annual rainfall is 1935 mm, and the mean monthly rainfall ranges from 97 mm in August to 20(5 mm in December (Berlage 1949). The vegetation of this area has been studied by Riswan (1976) and Riswan & Hadrijanto (in press). Twelve species of dipterocarps were found. The common species are *Sliorea polyandro, S. parvifolia, S. johorensis* and *Hopea rudiformis.* Non-dipteroearps are dominated by the iron wood *(Emideroxylov swageri), Baccam'ea inacrocarpa., Chistanthus myriamthiiH* and *Pentace laxiflora.*

The kcrangas forest (KF)

The study area is located at Gunung Pasir, Samboja, on the low and. flat hill on the eastern side of the main road from Ealikpapan to HandiI II. about 57 km from Balikpapan (Fig. 1). The elevation ranges from 20 to 40 m above sea level. The soils of this area belong to the podzols, being derived from sedimentary rocks of the Upper Miocene Formation. The climate, here is also humid. The mean annual rainfall is 2347 mm, and the mean monthly rainfall ranges from 129 mm in October to 273 mm in April (Berlage 1949). The prevalent species in this forest are *Ti'istuiiJa obovala, Coli/lciobitint flwvuni, Brackeii-rldyea liookeri, Eugenia claviflora* and *Cotijlelobuim inalaymuiin* (Riswan 1979).

AIMS AND METHODS

Our aim was to study the movement of nutrients through the soil profile after burning and ultimately their recovery into the vegetation

Table 1. Mean of total nitrogen and organic carbon in 0 - 10 cm soil depth at two forest types, before and after clear-cutting with or without burning (Values are means of six soil samples)

Site	Total N* (%)			Organic C (%)			C : N Ratio		
	A**	B	C	A	B	C	A	B	C
1. Removed and unburnt									
KF***	0.34±0.14	0.13±0.09	0.10±0.06	14.03±7.44	5.04±4.11	3.53±1.18	41.26	38.77	35.30
MDF	0.18±0.05	0.19±0.06	0.17±0.03	2.10±0.77	1.47±0.65	2.22±0.99	11.11	7.74	13.06
2. Burnt									
KF	0.37±0.18	0.13±0.05	0.13±0.05	12.51±9.07	4.54±1.26	5.64±1.68	31.81	34.92	43.38
MDF	0.18±0.05	0.16±0.07	0.18±0.09	2.00±0.77	1.72±0.50	1.48±0.65	11.11	10.75	8.22

* Values ± standard deviation

** A — before clear-cutting
B — six weeks after clear-cutting
C — twelve weeks after clear-cutting

*** KF — kerangas forest, Gunung Pasir, Samboja
MDF — mixed dipterocarp forest, Gunung Kapur, Lempake, Samarinda

of a woody fallow, which would allow identification of those woody pioneers which are principally involved in re-establishing fertility.

Two plots, 0.5 ha each, were established both in primary MDF and KF as experimental plots. All vegetation in these plots was clear-cut and kept in the respective plots. In one of the plots on each forest type, felled vegetation was burnt while in the other plot the vegetation was removed from the plot wihout being burnt. In each plot an experimental transect line of 1 X 100 m was established and divided into 100 sub-plots of 1 x 1 m. Soil samples were collected along the transect line at intervals of 20 m as a block of 10 x 10 x 10 cm^3; they were mixed and about 1 kg of sample was collected and put in a polythene bag to be treated further. Soil samples were collected before clearing and subsequently at 6 weeks. Total N and organic C were estimated by a Kjeldahl and combustion methods respectively (Jackson 1958) ; pH was measured with a glass electrode using a H_2O: soil ratio of 1: 1.

This paper only discusses the results of observations at 6 and 12 weeks after clear-cutting, with or without burning, on total N, total C and pH changes in the soil.

RESULTS AND DISCUSSION

Total nitrogen and organic carbon

Before clear-cutting. Field observation showed that the humus layer in the KF (6 -10 cm) was thicker than that of the MDF (2 - 3 cm). This means that compared to MDF, the organic C content in the KF is higher (Table 1). Brunig (1974) also showed that the C :N ratio in the KF was high.

Compared to the C: N ratio of other Kerangas forests as in Padang Luwai, East Kalimantan and Bangka island (Hardon 1937), the C : N ratio in Samboja is the lowest, the values being 57, 77 and 41 (unburnt) or 32 (burnt) respectively. The difference is possibly caused by the pH, which is the highest at Samboja compared to the pH in Padang Luwai and Bangka (Table 2). According to Nye & Greenland (1960) the higher

Table 2. Comparison of soil pH at different sites of Kerangas Forest

Site	pH *	Source
Gunung Pasir, Samboja, East Kalimantan	3.68 ± 0.40	This paper (from control plot)
Padang Luwai, East Kalimantan	2.80	Hardon (1937)
Bangka island, East of South Sumatra	2.70	Hardon (1937)

* lvalue ± standard deviation

the pH the greater will be the production of nitrate and also the concentration of bicarbonate ion. Similarly, Hardon (1936) has shown clearly the relationship between pH and C: N ratio beneath old secondary or primary forests in the lowland areas of Sumatra.

After clear-cutting. In general the results show that clear-cutting, with or without burning, on both forest types causes declines in total N and organic C contents. Exceptions, view at 12 weeks after clear-cutting and burning, in total N at MDF and in organic C at KF. Both of these values showed an increase. The increase in total N might be caused by symbiotic N_3 fixation with the re-sprouting of leguminous trees and shrubs *(Fordia gibbsiae, Sindora velutina, Koompasia* sp., *Bauhinia* sp. and *Spatholobus* sp.), and by non-symbiotic N_2 fixation, due to legumes do not contribute to the soil N status during their growth. Jenny (1950) suggested that the probable reason for the high level of N in the highly leached forest soil was the large number of legumes occuring on it. Nye & Greenland (1960) reported that the high rate of No fixation may be influenced by temperature and moisture and also by a very high rate of production of carbonaceous material providing the necessary energy source for N_2 fixation. The probable reasons of the increasing organic C after clear-cutting and burning of the KF over 12 weeks are. the presence of ash, the residue of charcoal, incomplete humification and the presence of undecomposed organic material. We know that all the nutrient elements except N and part of the S are preserved and added to the soil in the ash and that charcoal was derived from the less readily combustable parts of the vegetation. The immediate heating of the soil surface could effect the microorganism population and the physical and chemical properties of the topsoil, thus reducing the microbial activities such as humification and mineralization.

Within a period of 6 weeks the KF soil showed a marked decrease in organic C for both treatments (burnt and unburnt). The total N in the burnt treatment decreased also substantially, while on the unburnt treatment it showed a markedly decrease. We know that burning emits large amounts of smoke into the atmosphere, containing especially N, C and S. The residue of ash on the soil surface would be leached into the soil by the first rain, or washed away in run-off, and then to the river.

On the clear-cut, removed and unburnt treatment, the result shows that there was a decrease of total N and organic C on both forest types. These results are similar to those of Cunningham (1963), which showed the rate of decline in organic matter when forest is removed and no

other type of vegetation is introduced. Riquier (1958) also showed that the topsoil samples provide a marked loss of organic matter and total N after clearing.

Soil pH

Clear-cutting, burnt or unburnt treatments have increased the soil pH on both forest types (Table 8). This increase is associated with a

Table 3. Soil pH of burnt and unburnt kerangas and mixed dipterocarp forests before and after clear-cutting[1] (Values are moans of G soil samples)

Site	pH (H_30)*		
	A**	B	C
Removed and unburnt			
KF***	3.58 ± 0.02	3.82 i 0.43	3.83 x 0.37
MDF	3.59 ± 0.46	4.11 ± 0.29	3.80 ± 0.22
Burnt			
KF	3.05 ± 0.22	4.14 ± 0.19	4.14 :c 0.50
MDF	3.59 ± 0.46	5.50 ± 0.95	4.01 ± 0.48

* Values ± standard deviation
** & *** see Table 1

decrease of the C : N ratio. Hardon (1936) has shown a similar relationship. Nye & Greenland (1960) showed that when forest is cleared, the large quatities of cations released from vegetation raise the percentage cation saturation and the pH in the soil to levels which depending on the cation exchange capacity. The cation exchange capacity in turn depends largely on the organic matter content.

CONCLUSIONS

The preliminary study suggests that the effects of clear-cutting with or without burning of the forest vegetation, lead to a decline of soil organic C and total N in the topsoil. They also lead to an increase in soil pH. Therefore it confirms earlier research on similar forests.

ACKNOWLEDGEMENTS

This study forms part of the Indonesian contribution to the Man and the Biosphere (MAB) Programme, within the framework of the MAB East Kalimantan Project. The work was supported in part by funds provided by UNESCO (MAB Project No. 1) and UNEP (UNEP Project No. 1102-76-01). The author is indebted to Dr. S. **Sastrapradja,**

Director of Lembaga Biologi Nasional (Bogor), Dr. K. Kartawinata, Head of Herbarium Bogoriense, Lembaga Biologi Nasional and Mr. R.S. Wirakusumah, them Rector of Miilawarman University (Samarinda), for making this study possible to be carried out. The author is also grateful for the assistance of Department of Natural Sciences, Bogor Agricultural University in undertaking the physical and chemical soil analyses.

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