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Impact of Land Use on Soil Nutrient at Doi Pui and Tung Jaw, Chiangmai

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ABSTRACT

The change of land use practices from the hill evergreen forest to other land use types deteriorated the physical properties of soil. The bulk density of the top soil, 0 – 50 cm in depths was increased and soil porosity was decreased especially in the shifting cultivation and agroculture areas, but there was no difference at the depth of 50 – 100 cm in all types of land use.

The amount of organic matter and sulfer in the soil was decreased in all types of land use except in the agroculture area that the amount of sulfur was increased due to the use of chemical fertilizers. In all types of land use, the organic matter content decreased with increasing soil depth, but in the contrary, the amount of sulfur increased with increasing soil depth. The pH was slightly increased in all depths and types of land use. The amount of phosphorus, potassium and magnesium was increased and mostly accumulated at the top soil and decreased with increasing soil depth. However, the amount of phosphorus was increased in agroculture and forest plantation areas and decreased in areas of shifting cultivation and enrichment planting. The potassium and magnesium content were highest in forest plantation areas and lowest in the hill evergreen forest, while the amount of calcium was highest in agroculture area and lowest in the hill evergreen forest. All of the phenomena mentioned above may be due to the influence of fire and chemical treatments.

It was revealed that the change of the hill evergreen forest to other land use practices would impact the balance of nutrients in the system as well as the amount and rate of nutrient cycling. Most of the nutrients were moved and accumulated in the soil instead of storing in the form of plant biomass, Therefore, if the land were not properly used, the nutrients could be easily leached and lost from the system.

INTRODUCTION

As the country forested land, the primary resources, decreased tremendously within the last three decades. The highland on the upstream watershed of the North also have such a serious problem of shifting cultivation which is considered as one of the illegal forest destruction processes. Since the upstream watershed in the North are mainly mountainous with a very steep slope complex, the deforestation will cause a very severe changes in the ecosystem. Soil is one of the most important components of the system. The deforestation will affect the soil greatly and inturn will alter other ecosystem's components as well (Herrena *et al.*, 1981).

The research focus has been on a comparison of the soil nutrients in the hill evergreen forest with those in the disturbed forests which modified by man through reforestation, shifting cultivation, and other agricultural practices. The investigation of soil nutrient variation under various land use practices was carried out by collecting soil samples at different sites in Chiangmai from June, 1980 to March, 1981. The sampling sites were as follows : the hill evergreen forest at Kog-Ma watershed, Doi

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Pui, which was considered as control watershed; the enrichment planting, forest plantation, shifting cultivation and agroculture areas at Tung-Jaw watershed were considered as the representative areas of those land use practices.

MATERIALS AND METHODS

Soil samples from five different representative land use types of the study sites were collected at four depth levels, i.e., 0 – 25, 25 – 50, 50 – 75 and 75 – 100 cm from the surface. In each site, on each sampling date, six soil pits were randomly dug from the three assigned sampling strips, 20 meters apart, of each sample plot. A total of 30 soil pits were dug on each sampling date. There was a total of four sampling dates through out the study period, at approximately three-month intervals from June, 1980 to March, 1981. Therefore, a total of 480 soil samples were then collected for chemical analysis and an equal amount of undisturbed samples at the same site were also taken by the core method for physical analysis. The soil samples for chemical analysis from the six soil pits at the same depth of each sampling site on each sampling date were mixed to make up one composite sample.

The soil samples were analysed for some of their physical and chemical properties. The former ones included bulk density, particle density, porosity, and texture of soil. Bulk density was found by the core method described by Black (1965). Particle density and soil porosity were determined by using pycnometer method. The method of hydrometer was employed for soil texture analysis.

The chemical properties included pH, organic matter, available phophorus content, and exchangeable potassium, calcium and magnesium as well as sulfur content. The pH was measured by a pH meter with 1 : 1 soil water suspension. The organic matter content was done by the Walkly and Black's Titration method. The Bray II method was used for phosphorus determination. Potassium, calcium and magnesium were extracted by 1.0 N ammonium acetate at pH 7.0. The amount of potassium in the filtrate was determined by using a flame photometer. A known volume of calcium and magnesium in the filtrate were measured by atomic absorption spectrophotometer. Sulfur content was extracted with acetate – acetic solution. A turbidimetric method was employed for measurement of sulfur concentration. More details of these methods are referred to those in Black (1965) and Jackson (1967).

Statistical treatments used in this study included the calculation of means, standard error of the means for the chemical properties of soil at different depth of various land use pattern. Analysis of variance was also employed. The main effects considered in these analysis were land use pattern and soil depths. The calculated F-values were tested at one and five percent levels of significance. Duncan's new multiple range test also applied in case of significantly differences.

RESULTS AND DISCUSSION

Physical and chemical properties of soil are explained under separate headings. Results indicate that these properties were somewhat changed due to different land use practices.

Physical Properties :

Some physical properties of soil from different land use types are presented in Table 1. The bulk density of soil samples within 0 – 50 cm from the hill evergreen forest, enrichment planting and forest plantation sites are relatively low ranging from 0.53 to 1.06 gm/cc. The bulk density of the top soil of shifting cultivation and agroculture are ranging from 1.09 to 1.33 gm/cc. The values of bulk density increased

Table 1 Soil properties of various land use at different soil depth at Doi Pui and Tung Jaw Chiangmai

Type of land use	Soil Depth cm	Physical properties: Bulk density gm/cc	Particle density gm/cc	Porosity %	Mechanical composition: Sand %	Coarse silt %	Fine silt %	Clay %	Textural class
Hill–evergreen forest	0–25	0.73	2.33	68.67	35.42	21.67	3.56	39.25	Sandy clay loam
	25–50	0.96	2.45	60.82	35.34	19.24	3.20	42.22	Sandy clay loam
	50–75	1.21	2.50	51.60	33.95	17.21	2.38	46.46	Sandy clay loam
	75–100	1.22	2.52	51.59	29.41	22.74	4.11	43.74	Sandy clay loam
Enrichment planting	0–25	0.53	2.33	77.25	46.77	7.56	1.85	43.82	Sandy clay
	25–50	1.06	2.48	57.25	42.21	6.85	3.49	47.45	Sandy clay
	50–75	1.10	2.45	55.10	38.94	11.07	0.00	49.19	Sandy clay
	75–100	1.11	2.49	55.42	16.96	34.44	0.00	49.90	Clay loam
Forest plantation	0–25	0.89	2.29	61.14	52.64	22.96	3.40	21.00	Sandy loam
	25–50	0.88	2.38	63.03	45.03	21.40	4.91	23.66	Sandy loam
	50–75	1.04	2.43	57.20	41.76	19.96	4.48	33.80	Sandy loam
	75–100	1.17	2.49	53.01	47.25	17.42	8.92	26.41	Sandy loam
Shifting cultivation area	0–25	1.24	2.42	48.76	46.57	17.98	6.25	29.20	Sandy loam
	25–50	1.33	2.75	51.64	47.56	15.59	3.97	32.88	Sandy loam
	50–75	1.39	2.45	43.26	44.91	15.39	4.05	35.65	Sandy clay loam
	75–100	1.25	2.53	50.59	46.55	12.97	3.93	36.55	Sandy clay loam
Agroculture site	0–25	1.09	2.44	55.33	43.19	13.54	3.83	39.44	Sandy clay loam
	25–50	1.13	2.49	54.62	37.62	13.42	4.35	44.61	Sandy clay loam
	50–75	1.21	2.51	51.79	38.39	12.66	3.43	45.52	Sandy clay loam
	75–100	1.27	2.53	49.90	38.09	14.63	3.55	43.73	Sandy clay loam

with increasing in soil depth. However the highest bulk density which occurs in the shifting cultivation area does not exceed 1.39 gm/cc which is of the normal soil (Buckman and Brady, 1962). The bulk density of the top soil, 0 – 25 to 25 – 50 cm in depth is increased and soil porosity is decreased especially in the shifting cultivation and agroculture areas but there is no difference at the depth of 50 – 75 and 75 – 100 cm in all types of land use. There is also no difference of particle density at each depth in all types of land use. Most soil are light texture soils with their texture varies from sandy loam soil to sandy clay loam and clay loam. The change of land use practice from the hill evergreen forest to other land use types will increase percent of sand in the top soil. The small soil particles may easily washed away from the surface soil by raindrop impact and surface runoff due to the changing of cover condition. The results were comparable to those studied by Santudgarn (1974).

Chemical Properties :

The chemical properties of soil from different land use types are presented in Table 2.

pH of soil : pH of soil is an important characteristic which controls availability of plant nutrients and activities of soil microorganisms. It gives an indication of the base saturation and leads to possible toxicity or deficiency of certain elements.

The pH of soil is acid to slightly acid and ranges between 4.81 in the hill evergreen forest to 5.53 in the forest plantation area (Table 2 and Figure 1). The change of the hill evergreen forest to other land use practices would slightly increased of soil pH. There is no significant difference among depths either in the same or different land use types. But there is highly significant difference in pH among land use types.

Organic Matter Content : The amount of organic matter in the soil was decreased if the forest was cleared for other land use practices. In all types of land use, the organic matter content decreased with increasing soil depth. At the 0 – 25 cm in depth, the highest organic mater content of 10.82 percent was found in the hill evergreen forest and the lowest organic matter content was 3.71 percent in the shifting cultivation (Table 2, Figure 2). The change of the hill evergreen forest to other land use practices would decreased organic matter content in soil. Although there is no significant difference of organic matter content among land use but there is highly significant among depths.

Numerous experiments have shown that the organic matter content has an important role in crop production. Normally, organic matter in a fertile soil should be higher than 2.5 percent (Rosjanasoonthon and Moorman, 1972). The deforestation will cause a great reduction of organic matter by 40 – 50 percent particularly that in the top soil (Watters and Bascones, 1971; Sahunalu *et al.*, 1980). When a forest land was changed to a cultivated land, its organic matter content will gradually decrease, and after the land was abandoned under natural regrowth, its organic matter content will be recuperated within 7 years (Sabhasri, 1978; Khemnark *et al.*, 1972).

Phosphorus Content : The phosphorus content differ greatly, at the 0 – 25 cm in depth, their content vary from 4.21 ppm in the enrichment planting to 68.12 ppm in the agroculture area. If comparing to the original hill evergreen forest, the phosphorus content was increased in agroculture and forest plantation and decreased in areas of shifting cultivation and enrichment planting. The soil under hill evergreen forest was generally found to be low in phosphorus content. The phosphorus content in the studied sites are relatively low when comparing to those of other forest areas (Sahunalu *et al.* 1980; Khemnark *et al.*, 1972). In all type of land use, the phosphorus content was accumulated at the top soil and decreased with increasing soil depth (Table 2, Figure 3). Sahunalu *et al.* (1980) also showed a good tendency in the decreasing of phosphorus content with the soil depth.

There is a significant difference of phosphorus content among land use and there is highly significant among depth/land use. Khemnark *et al.* (1972) and Zinke *et al.* (1970) concluded that phosphorus content of soil are affected by their pH. The optimum pH range is 5.5 to 7. The phosphorus content decrease whenever the soil pH drops below 5.5 or goes above 7.

Potassium Content : The amount of potassium was increased, after changing of land use practices, and mostly accumulated at the soil surface and decreased with increasing soil depth. The values of potassium at the 0 – 25 cm in depth are ranging from 77.60 ppm in the hill evergreen forest to as high as 239.84 ppm in the forest plantation site. (Table 2, Figure 4). All of the deforested areas, their potassium contents in the top soils are higher than those in the

Table 2 Variation of pH, Organic matter, Phosphorus, Potassium, Calcium, Magnesium and Sulfur (Unit ± SE) at different soil depths (cm) of various land use pattern, Doi Pui and Tung Jaw, Chiangmai (June, 1980 to March, 1981)

Land use Pattern	pH				OM (%)				P(ppm)			
	0—25	25—50	50—75	75—100	0—25	25—50	50—75	75—100	0—25	25—50	50—75	75—100
Hill - evergreen forest	4.81 ±0.07	4.95 ±0.14	4.82 ±0.06	4.94 ±0.06	10.82 ±0.59	4.40 ±0.49	1.69 ±0.23	1.15 ±0.21	8.58 ±0.70	4.17 ±0.86	2.08 ±0.22	2.00 ±0.19
Enrichment planting	5.02 ±0.07	4.96 ±0.07	4.90 ±0.06	4.96 ±0.06	5.27 ±0.21	3.11 ±0.16	1.80 ±0.06	1.26 ±0.05	4.21 ±0.22	3.83 ±1.62	2.04 ±0.19	2.04 ±0.31
Forest plantation	5.53 ±0.05	5.50 ±0.05	5.43 ±0.05	5.37 ±0.06	4.98 ±0.39	2.82 ±0.26	1.95 ±0.17	1.50 ±0.11	19.84 ±1.58	9.46 ±0.99	7.83 ±0.81	8.09 ±0.98
Shifting cultivation	5.39 ±0.05	5.31 ±0.05	5.35 ±0.06	5.33 ±0.06	3.71 ±0.10	1.64 ±0.05	1.17 ±0.05	0.86 ±0.05	5.29 ±0.44	2.79 ±0.20	3.04 ±0.19	2.71 ±0.24
Agroculture	5.79 ±0.09	5.23 ±0.07	5.28 ±0.07	5.23 ±0.08	4.26 ±0.25	2.47 ±0.20	1.66 ±0.18	1.01 ±0.07	68.12 ±18.24	30.79 ±10.44	19.12 ±6.88	7.67 ±2.89

Land use Pattern	K(ppm)				Ca(ppm)			
	0—25	25—50	50—75	75—100	0—25	25—50	50—75	75—100
Hill—evergreen forest	77.63 ±4.12	47.25 ±3.05	45.21 ±4.02	38.46 ±3.76	11.33 ±8.82	3.33 ±1.38	3.67 ±1.50	3.00 ±1.50
Enrichment planting	188.09 ±14.13	94.29 ±8.18	68.42 ±6.50	54.79 ±4.91	156.17 ±19.51	46.42 ±5.48	41.25 ±7.22	33.33 ±6.39
Forest plantation	239.84 ±12.90	156.33 ±12.94	144.88 ±10.91	139.29 ±13.38	1088.42 ±96.14	540.83 ±70.42	325.25 ±32.59	241.17 ±28.38
Shifting cultivation	186.63 ±11.60	137.24 ±11.66	116.00 ±8.85	103.79 ±8.43	776.84 ±85.09	505.16 ±55.66	390.92 ±49.75	310.00 ±47.51
Agroculture	192.17 ±21.50	148.00 ±14.34	95.09 ±12.01	73.96 ±7.73	1021.25 ±111.07	552.75 ±63.86	375.17 ±34.55	288.17 ±24.87

Land use Pattern	Mg(ppm)				S(ppm)			
	0—25	25—50	50—75	75—100	0—25	25—50	50—75	75—100
Hill—evergreen forest	46.48 ±13.5	17.07 ±4.18	8.90 ±2.27	5.74 ±1.95	7.81 ±3.24	6.48 ±2.59	12.45 ±3.58	11.85 ±4.03
Enrichment planting	87.96 ±8.92	28.10 ±2.88	24.80 ±2.52	22.70 ±2.53	3.28 ±0.62	2.99 ±0.52	2.98 ±0.59	13.74 ±3.10
Forest plantation	254.71 ±79.01	130.42 ±10.35	135.56 ±24.92	90.43 ±7.15	0.91 ±0.19	1.33 ±0.24	1.03 ±0.27	1.27 ±40.39
Shifting cultivation	180.65 ±14.60	129.27 ±7.64	114.69 ±10.91	111.60 ±8.90	2.46 ±0.47	2.57 ±0.47	2.38 ±0.42	2.42 ±0.51
Agroculture	115.40 ±6.94	101.21 ±5.83	103.44 ±7.26	109.46 ±10.05	4.23 ±1.66	16.28 ±4.28	8.72 ±3.46	32.09 ±15.72

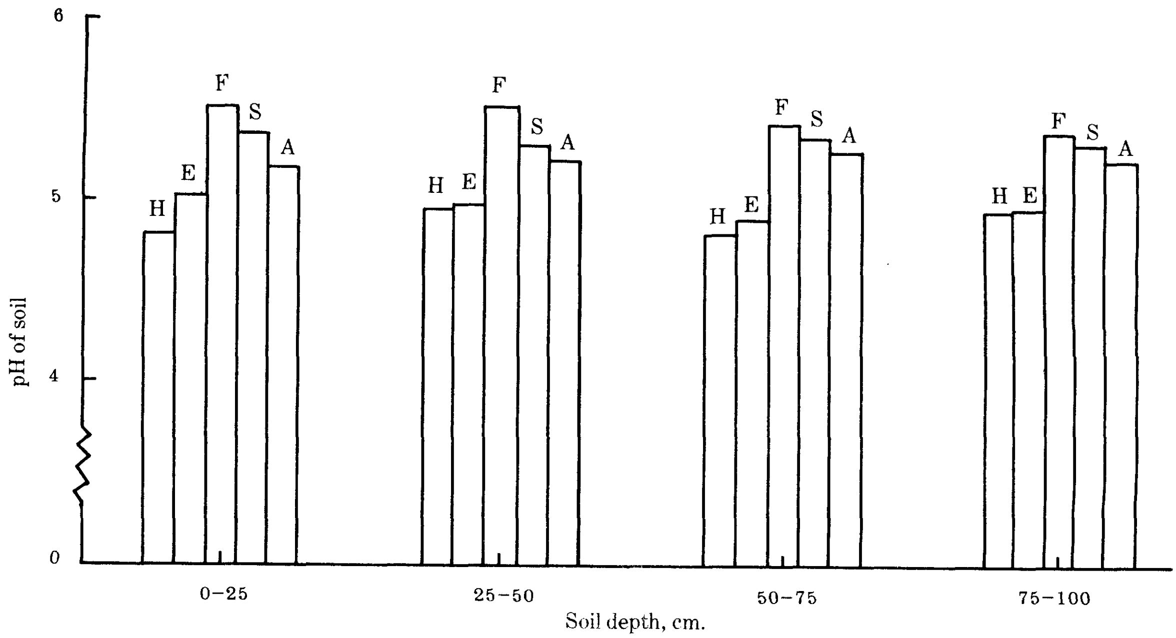

Figure 1. pH of soil in the hill–evergreen forest (H), Doi Pui, and in the enrichment planting (E), the forest plantation (F), the shifting cultivation area (S), and the agroculture area (A), Tung Jaw, Chiangmai. (June, 1980 to March, 1981)

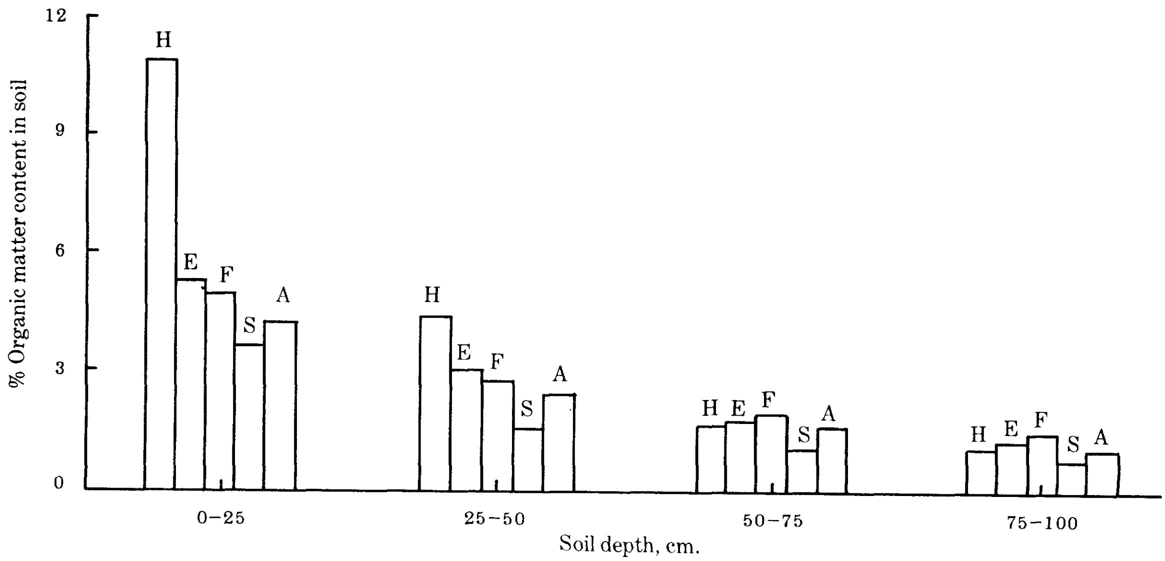

Figure 2. Soil of organic matter in the hill–evergreen forest (H), Doi Pui, and in the enrichment planting (E), the forest plantation (F), the shifting cultivation area (S), and the agroculture area (A), Tung Jaw, Chiangmai. (June, 1980 to March, 1981)

forest areas. This might be the result of burning. Zinke *et al.* (1970) found that during the early stages of the burn and first year regrowth of the cycle, the potassium contents were higher in the surface soils and less in amount as the forest regrows. Nye and Greenland (1960) also con-

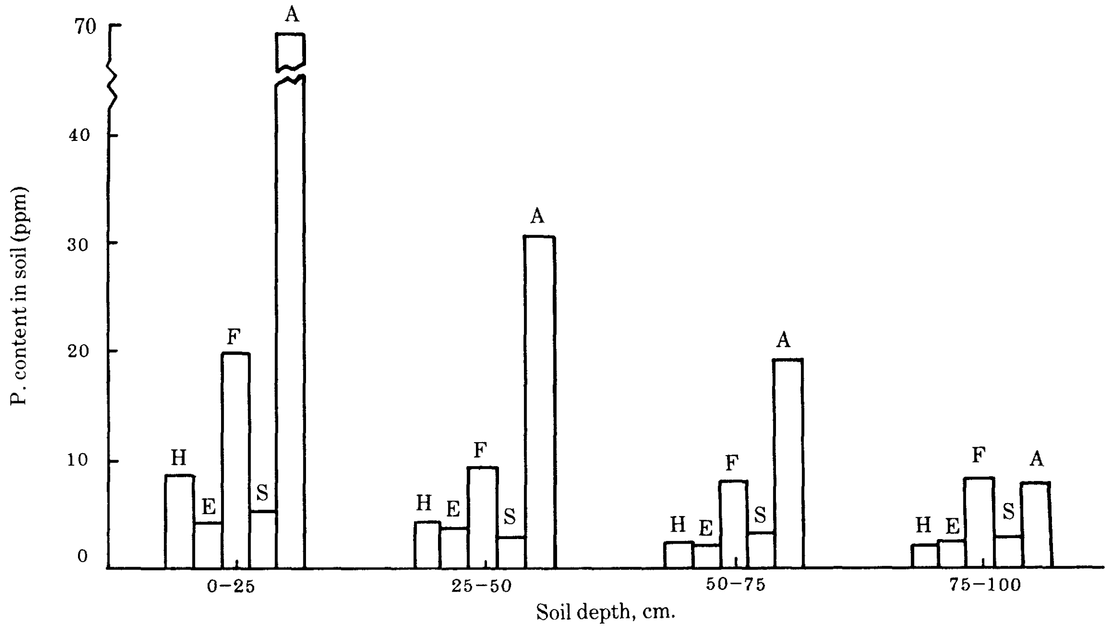

Figure 3. Phosphorus content of soil in the hill—evergreen forest (H), Doi Pui, and in the enrichment planting (E), the forest plantation (F), the shifting cultivation area (S). and the agroculture area (A), Tung Jaw, Chiangmai. (June, 1980 to March, 1981)

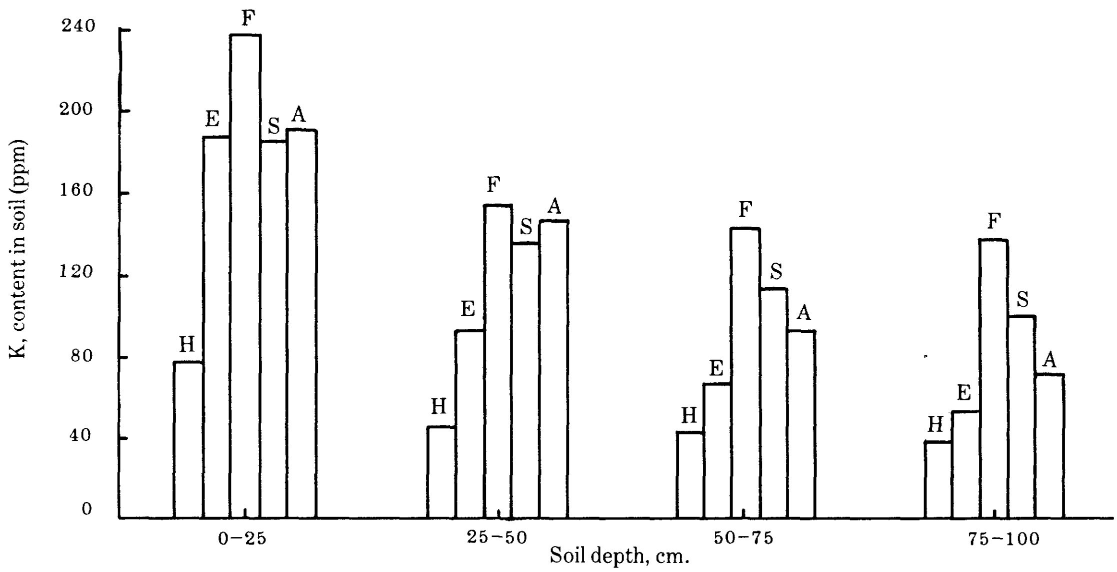

Figure 4. Potassium content of soil in the hill—evergreen forest (H), Doi Pui, and in the enrichment planting (E), the forest plantation (F), the shifting cultivation area (S), and the agroculture area (A), Tung Jaw, Chiangmai. (June, 1980 to March, 1981).

cluded that the soil potassium contents increased sharply after deforestation and burn, the contents declined gradually after planting.

There is a significant difference of potassium contents among land uses and highly significant among depth either in the same or different land use types. The change of hill evergreen forest to other land use practices would increased potassium content in soil especially in the surface soil. The results agreed with those studied by Nye and Greenland (1960), Zinke et al. (1970) and Santudgarn (1974).

Calcium Content : Results showed that the soil in all of the land use types have relatively high calcium content on their surface and the values trended to decrease with the soil depth. The calcium content at the 0 – 25 cm in depth ranged from 11.33 ppm in the hill evergreen forest, 156.17 ppm in the enrichment planting, 776.84 ppm in shifting cultivation area, 1,021.25 ppm in the agroculture with the highest value of 1,088.42 ppm found in the forest plantation site. (Table 2, Figure 5). The soil under hill evergreen forest was generally found to be low in calcium content. The calcium content in the deforested area trended to be higher than those in their original hill evergreen forest. The change of the hill evergreen forest to other land use practices would therefore increased calcium content in the soil. Results from statistical analysis indicated that there is a highly significant difference of calcium content among land use as well as among soil depth.

Magnesium Content : The magnesium content was increased, after changing of land use practice, in a manner similar to potassium and calcium. The magnesium content was mostly accumulated at the top soil and decreased with increasing soil depth. The values of magnesium at the 0 – 25 cm in depth ranged from the lowest 46.48 ppm in the hill evergreen forest to the highest 254.71 ppm in the forest plantation area. In all types of land use the magnesium content decreased with increasing soil depth (Table 2, Figure 6). The change of the hill evergreen forest to other land use practices would increased magnesium content at every level of soil depth. There is a highly significance difference of magnesium content among land use and among depths/land use.

Sulfur Content : The sulfur content in all of the land use types has the same pattern of variation. In all types of land use the sulfur content increased with increasing soil depth. At the 0 – 25 cm in depth, the highest sulfur content of 7.81 ppm was found in the hill evergreen forest and the lowest sulfur content of 0.91 ppm in the forest plantation area (Table 2, Figure 7). Gulimor and Mukhanova (1976) reported that there was 14 – 56 percent of the total amount of sulfur accumulated at the 0 – 100 cm level of soil depth. The amount of sulfur in mobile form was increased with increasing soil depth. The change of the hill evergreen forest to other land use practices would decreases sulfur content in soil. There is a significant different of sulfure among land use and among depths/land use.

The results indicate that the change of land use practices from the hill evergreen forest to other land use types deteriorated some physical and chemical properties of soil. The relative sand content on the surface soil trends to increase. The bulk density of the top soil was increased and soil porosity was decreased particularly in the shifting cultivation and agroculture area. The pH, phosphorus, potassium, calcium and magnesium contents increases at all depth levels and in all type of land use. The amount increased were mostly accumulated on the top soil and decreased with increasing soil depth. The organic matter and sulfur contents were decreased in all types of land use except the sulfur content in the agroculture area that was increased due to the use of chemical fertilizer.

The nutrient contents in the original hill evergreen forest trended to be lower than those in the deforested areas or under other land use practices. This might be the result of burning and also because of the different land use practices. Nye and Greenland (1960) and Zinke et al. (1970) found that the nutrient contents increases sharply after deforestation

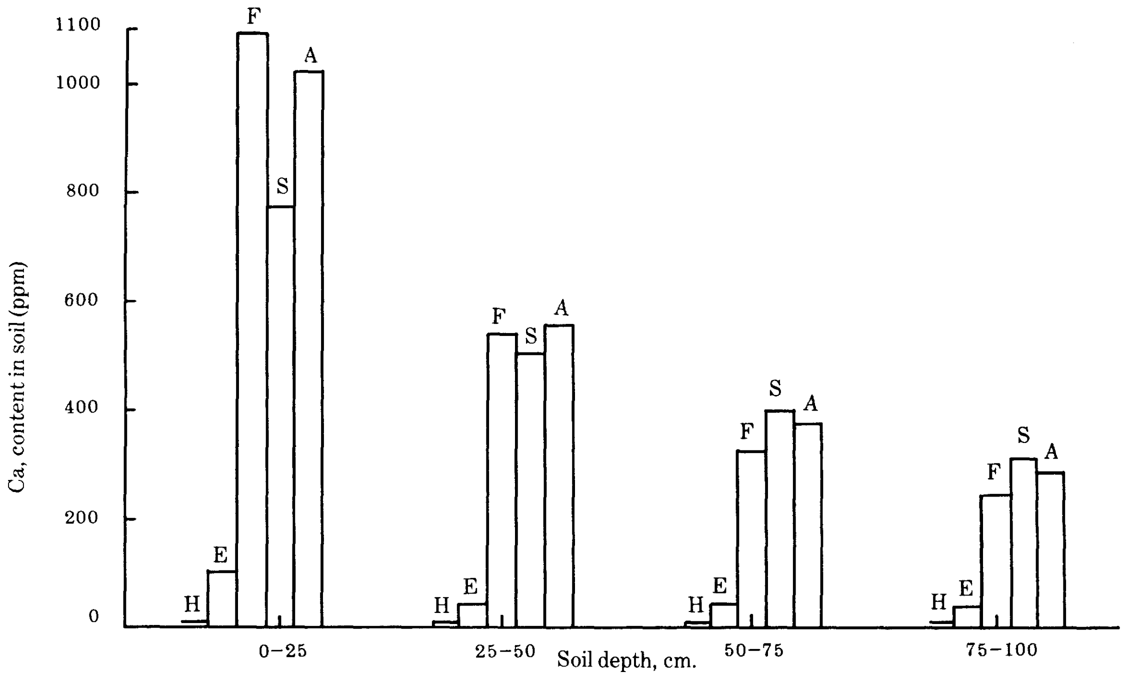

Figure 5. **Calcium content of soil in the hill−evergreen forest (H), Doi Pui, and in the enrichment planting (E), the forest plantation (F), the shifting cultivation area (S), and the agroculture area (A), Tung Jaw, Chiangmai. (June, 1980 to March, 1981)**

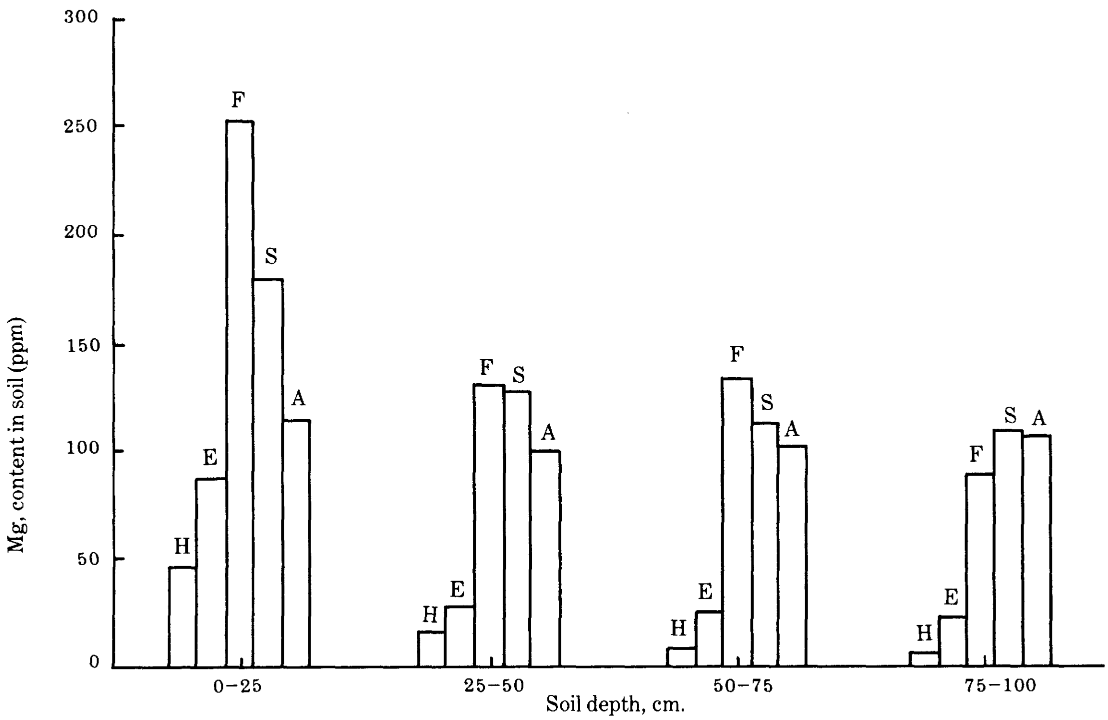

Figure 6. **Magnesium content of soil in the hill−evergreen forest (H), Doi Pui, and in the enrichment planting (E), the forest plantation (F), the shifting cultivation area (S), and the agroculture area (A), Tung Jaw, Chiangmai. (June, 1980 to March, 1981)**

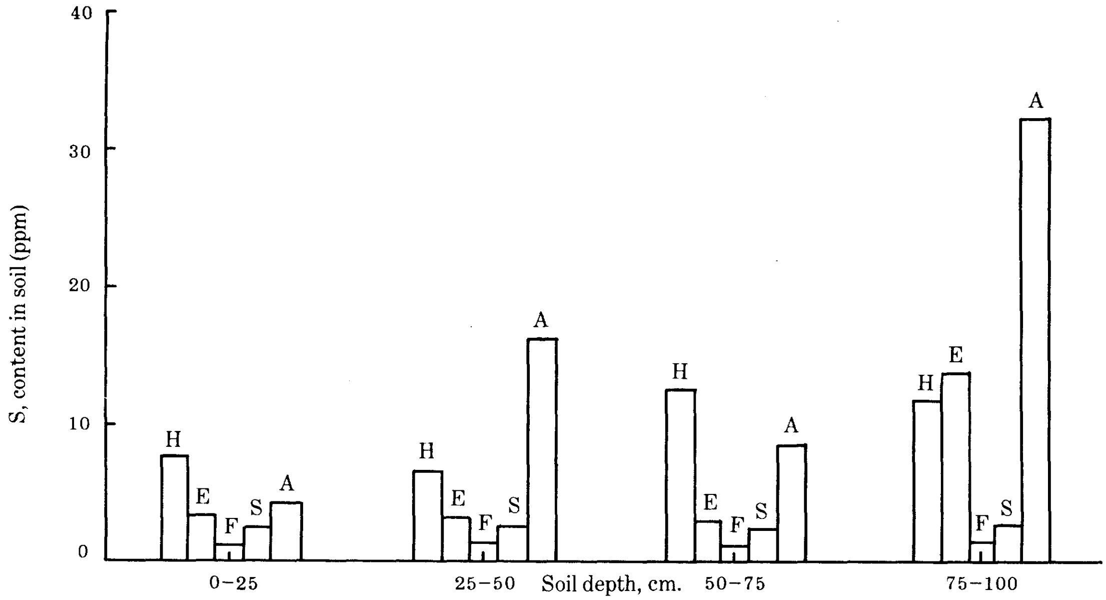

Figure 7. **Sulfur (SO_4) content of soil in the hill—evergreen forest (H), Doi Pui, and in the enrichment planting (E), the forest plantation (F), the shifting cultivation area (S), and the agroculture area (A), Tung Jaw, Chiangmai, (June, 1980 to March, 1981)**

and burn, the contents declined gradually after planting or follow forest regrowth. The forest shows very well developed mechanisms for efficient recycling of nutrients and storing it in biomass so that losses are minimal. The nutrients in the tropical forest depends largely on input by rain and the ability of the forest plants to use this source of nutrition. However, the nutrient conserving mechanisms are very fragile and when the forest is disturbed such as burning and cultivation they cease the function. The sudden release of nutrients from biomass and stored in the soil after deforestation are the reason that why the deforested areas have higher nutrients content than the original undisturbed forest. Herrera et al. (1981) conclude that the nutrients cycle of the tropical forest is more dependent on rainfall and internal cycling for its nutrition than on supply by the soil.

SUMMARY AND CONCLUSION

Impact studies on soil deterioration of various land use practices has been investigated at Tung Jaw and Doi Pui Chiangmai during June, 1980 to March, 1981. The sampling sites were as follows : the hill evergreen forest at Kog-Ma watershed, Doi Pui which was considered as control. the enrichment planting, forest plantation, shifting cultivation and agroculture at Tung Jaw, were considered as the representative areas of those land use practices.

The results indicated that the change of land use practices from the hill evergreen forest to other land use types deteriorated some physical properties of soil. The percent sand content trend to increase in the surface soil. The bulk density of the top soil was increased and soil porosity was decreased especially in the shifting cultivation and agroculture areas, but there was no difference at the depth of 50 – 75 and 75 – 100 cm in all types of land use. There was no difference of particle density at each depth in all types of land use.

The pH was relatively low and slightly increased in all depths and types of land use.

The amount of organic matter was decreased if the forest was cleared for other land use practices. In all types of land uses, the organic matter content decreased with increasing soil depth. The phosphorus, calcium and magnesium content was increased and mostly accumulated at the top soil and decreased with increasing soil depth. However, the phosphorus content was slightly increased in agroculture and forest plantation areas and decreased in areas of shifting cultivation and enrichment planting. The potassium and magnesium content were highest in forest plantation and lowest in the hill evergreen forest, while the calcium content was highest in agroculture area and lowest in the hill evergreen forest. The sulfur content was decreased in all type of land use except in the agroculture area that the amount of sulfur was increased because of the use of chemical fertilizers. In all types of land use, the sulfur content increased with increasing soil depth.

Besides the organic matter, the nutrient contents in the original hill evergreen forest trended to be lower than those under other land use practices. This might be the result of burning and the sudden release of nutrients in the biomass to the soil after deforestation. Besides that the forest shows very well developed machanisms for efficient recycling of nutrients and storing of nutrients in its biomass so that losses are minimal. This is may be one of the reason that why the deforested areas have high nutrient contents than the original undisturbed forest.

It was revealed that the change of the hill evergreen forest to other land use practices would impact the balance of nutrient in the system as well as the amount and rate of nutrient cycling. Most of the nutrients were moved and accumulated in the soil instead of storing in the form of plant biomass. Therefore, if the land use were not practiced properly, the nutrients could be easily leached and lost from the system. Therefore, serious effort should be directed to asses the impact of large scale disturbances of forest land in the highland and to investigate alternative management practices that could assure sustanined yield agriculture with appropriate technologies.

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