Thai J. For. 35 (3) : 72-85 (2016)

Original article

Some Morphology of Forest Soils in Two Community Forests, Mae Wang District, Chiang Mai Province

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Received: Jul 3, 2015 Accepted: Sep 17, 2016

ABSTRACT

Some morphology of forest soils in HKL and HT community forests, Mae Wang, Chiang Mai province was studied. Three soil pits (1.5×2×2 m) were dug in each community forest. Soil samples were collected along soil profiles for analysis of physical and chemical properties and forest soil morphology. The results showed that (for 2 m soil depth) in HKL, soil bulk density was very low to medium; soil reaction (pH) was very strong to slightly acidic, organic matter was moderately low to very high, total N was very low to medium, available P was very low to moderately high, extractable K was very high, extractable Ca and Na were very low, extractable Mg was very low to low, the CEC was very low to high and %BS was very low to low. For HT, soil bulk density was very low to moderately low, soil pH was very strong to slightly acidic, organic matter was very low to moderately high, total N was very low to very high, available P was very low to moderately high, extractable K and Ca were very low to very high, extractable Mg was very low to medium, extractable Na was very low, the CEC was low to very high and %BS was very low. Soil development in both forests was classified in the order Ultisols, suborder Humults, great group Palehumults and the soil profiles were developed as A-AB/BA-Bt-Bt, and the parent rock was granite. Soil color in HKL was gray, reddish yellow, yellow red in dry form and gray, black, yellowish red in moist form. Soil texture was sandy loam and sandy clay loam, with granular and blocky structures, tubular pores and many fine and common medium roots in the topsoil with none found in subsoils. For HT, the soil color was gray, red, reddish yellow in dry form and dark gray, black, yellowish red, dark red in moist form, soil texture was sandy clay loam, sandy clay, clay loam and clay, with granular and blocky structures, tubular and irregular pores and many fine and common medium roots in the topsoil with none found in subsoils. The characteristics and morphology of the soils in both forests showed similar tendencies.

Keywords: Soil morphology, community forest, Karen tribe, soil properties, forest soils

INTRODUCTION

Soil morphology is the area of soil science that deals with the form, structure and organization of the soil material. Soil morphology is ordinarily observed, described and studied in the field but can be continued in the laboratory using optical and electron microscopy. Field observations with the unaided eye are considered micromorphology, while observations utilizing a microscope are considered micromorphology (Buol *et al*., 2003). The composition of soil includes chemical, physical and mineralogical measurements of soil material removed from defined positions within identified pedons. New methods for analyzing soil are constantly being developed and tested. The study should be done systematically, from the fresh soil appearance to its final dried state in the following manner: (1) soil color as well as the background color and points (mottles), (2) soil texture, (3) soil structure, (4) soil consistency or strength, (5) soil cementation, (6) soil pores, (7) cutans or coats in soil, (8) plant roots, (9) other characteristics, such as gravels or cobbles, pans, concretions or nodules, (10) soil reaction, pH 1:1 and (11) soil horizon boundary (Kheoruenromne, 1984; Potican, 2009). Fisher and Binkley (2000) reported that soil in many parts of the world may be described as red and yellow podzolics, brown earths, brown forest soils, and Chernozens (black soils). Knowledge of the soil morphology will help soil survey staff to understand the environment and is a key factor in soils at the local level. Soil correlation will use data on the soil depth in the profile for fundamental classification in the field (Buol *et al.*, 1989; Dent and Changprai, 1973; Soil Survey Division Staff, 1993, Soil Survey Staff, 1951, 1962, 1998).

Information on plant species diversity, forest management by villagers and on the physical and chemical soil properties has been sufficient, but most research has only been conducted in government or private areas such as national parks, botanical gardens, forest plantations, parks, government project areas and private project areas.

In Thailand, there is less published data of the soil morphology in pine-montane and montane forests. In most cases, it is only university thesis research and is not published in scientific journals. This makes accessing soil information in Thailand difficult. Thus, the objective of this research was to disseminate morphological data of forest soils in Thailand under community forests managed by Karen villagers. These data will be important for comparison of forest soil types.

MATERIALS AND METHODS

Study areas

The research areas were in community forests in Mae Win sub-district, Wae Wang district, Chiang Mai province, about 70 kg to the southwest of Chiang Mai and northeast of Inthanon Mountain. Two contiguous community forests were divided by administration into two villages Huay Khao Leeb (HKL) and Huay Tong (HT) villages. In both areas, the altitude range varied between 800 and 1,600 m msl, and villagers belonged to the Karen tribe. The mean air temperature was about 22 ^{o}C. The parent rock in the community forests was granite. The community forests of HKL and HT cover about 4.80 and 4.12 kg^2, respectively.

Research methods

Forest vegetation surveys were conducted in the community forests in August-December 2013 using 12 plots (40x40 m) for ecological parameters (Krebs, 1985).

The soil was studied in three plots in forest vegetation located on the ridge; break and foot of the hill. All plots were located using a global point system (GPS). Soil properties were determined to a depth of 2 m in each pit and soil samples were collected along the profiles at 13 depths; 0-5, 5-10, 10-20, 20-30, 30-40, 40-60, 60-80, 80-100, 100-120, 120-140, 140-160, 160-180 and 180-200 cm. Soil composite samples were obtained from the same layers at three soil depths. They were later analyzed for physical and chemical properties in the laboratory.

Soil physical analysis measured: (1) soil texture and particle size distribution using a hydrometer method and (2) bulk density using a core method. Chemical analysis involved: (1) soil reaction using a pH meter; pH (H_2O) (soil : water = 1 : 1) (Mclean, 1982); (2) total N using the Micro Kjedahl method (Bremner and Mulvaney, 1982); (3) extractable phosphorus using Bray II and the Colorimetric method and an atomic absorption spectophotometer (Bray and Kunzt, 1945; Olsen and Sommers, 1982); (4) extractable bases consisted of potassium, calcium, magnesium and sodium extracted using ammonium acetate solution 1N, pH 7.0 and determined using an atomic absorption spectophotometer (Peech, 1945; Lanyon and Heald, 1982); (5) cation exchange capacity (CEC) extracted by ammonium acetate solution 1 N, pH 7.0 (Summer and Miller, 1996) and (6) base saturation percentage (BS%) defined as the amount of basic cation that occupies cation exchange sites, divided by the total cation exchange capacity (CEC) (Coleman and Thomas, 1964; Soil Survey Staff, 1972).

Soil morphology analysis was determined from soil pits (1.5x2x2 m). Analysis involved: (1) classifying soils according to soil taxonomy methods, using: (2) soil color and mottles (3) soil texture (4) soil structure (5) soil pores and (6) plant roots, following the methods of Kheoruenromne (1984).

RESULTS AND DISCUSSION

In each community forest, three soil pits were dug to determine physical and chemical properties and to undertake morphology studies, in the HKL community forest (pedon 1, pedon 2 and pedon 3) and in the HT community forest (pedon 4, pedon 5 and pedon 6).

1. Species composition and richness

HKL community forest:

This community forest was pine-montane forest. Within the 12 sampling plots (40x40 m), 125 species (99 genera and 53 families) were measured. The dominant trees in the forest were mainly *Pinus kesiya* Royle ex Gordon, *Quercus brandisiana* Kurz and *Castanopsis acuminatissima* (Blume) A.DC. The remaining species were in lower numbers.

HT community forest:

Pine-montane and montane forest were the forest types in the HT community forest where 109 species (86 genera and 49 families) were measured. The dominant trees in the forest were mainly *Castanopsis acuminatissima* (Blume) A.DC., and *Castanopsis diversifolia* (Kurz) King. The remaining species were in lower numbers.

For more detail of plant species diversity see Seeloy-ounkaew (2014).

2. Physical and chemical properties

2.1 Physical properties

HKL community forest:

Pedon 1: The bulk density was moderately low to low (1.20-1.40 Mg m^{-3}) at 0-60 cm soil depth and medium to moderately high (1.43-1.66 Mg m^{-3}) in deeper soils, except at depth 160-180 cm where it was moderately low. The gravel content to 2 m soil depth varied between 2.95-10.64%. The soil texture was sandy loam and sandy clay loam.

Pedon 2: The soil density of this pedon within the 2 m soil profile was very low to medium (0.70-1.41 Mg m^{-3}) and the gravel content varied in the range 3.28-6.19%. The soil texture was sandy loam and sandy clay loam.

Pedon 3: The density of soil within the 2 m soil profile was very low to medium (0.63-1.56 Mg m^{-3}) and the gravel content varied in the range 2.57-13.11%. The soil texture in this pedon was sandy loam and sandy clay loam.

HT community forest:

Pedon 4: The bulk density was very low to low (0.68-1.10 Mg m^{-3}) and the gravel content to 2 m soil depth varied in the range 9.28-14.78%. The soil texture was sandy loam, sandy clay loam, sandy clay and clay.

Pedon 5: The soil density within the 2 m soil profile was very low to moderately low (0.65-1.31 Mg m^{-3}) and the gravel content varied in the range 9.24-16.68%. The soil texture was sandy loam and sandy clay loam.

Pedon 6: The density of this soil within the 2 m soil profile was very low to low (0.53-1.10 Mg m^{-3}) and the gravel content varied in the range 11.77-18.77%. The soil texture was sandy loam and sandy clay loam.

2.2 Chemical properties

HKL community forest:

Pedon 1: The soil reaction (pH) throughout the soil profile depth to 2 m depth was very strongly to moderately acidic (pH = 5.65-6.07), organic matter content (OM) was very high to moderately high in surface soil (4.73-3.14%) and medium to very low in subsoils (0.29-1.93%), it was same trend for organic carbon (OC) (about half of OM was OC). Total nitrogen (N) was medium to very low (0.02-0.23%). The C/N ratio varied in the range 8.41-16.43. The available phosphorus (P) was moderately high to high in surface soil and moderately low to very low in subsoils (0.43-31.91 mg ha^{-1}), extractable potassium (K) was very high throughout the soil profile (177.97-275.42 mg ha^{-1}), whereas extractable calcium (Ca) was very low throughout the soil profile (11.43-190.48 mg ha^{-1}), extractable magnesium (Mg) was very low to low (12.18-81-98 mg ha^{-1}) and extractable sodium (Na) was very low throughout (5.86-20.86 mg ha^{-1}).

The cation exchange capacity (CEC) was moderately low to low (4.20-9.70 cmol kg^{-1}) and base saturation (BS) was low (11.80-35.00%).

Pedon 2: The soil was very strong to slightly acidic to 2 m soil depth (pH: 4.97-6.23). The OM content was medium to very high (1.81-7.36%) as was the OC content. Total N was medium to very low (0.09-0.36%), with the C/N ratio in the range 11.07-12.01. Available P was low to moderately high (4.69-15.13 mg kg^{-1}), extractable K was very high

throughout the soil depth (182.20-305.08 mg kg^{-1}), extractable Ca was very low (12.86-357.14 mg kg^{-1}) throughout the soil profile except at 0-5 cm soil depth where it was low (797.62 mg kg^{-1}). Extractable Mg was very low to low (12.99-64.94 mg kg^{-1}) and extractable Na was very low throughout (3.13-15.31 mg kg^{-1}).

The CEC value was moderately low to moderately high (8.20-19.15 cmol kg^{-1}) and the BS content was low (9.11-26.92%).

Pedon 3: The soil pH was moderately to slightly acidic (pH: 5.63-6.01). The OM content was moderately low to very high (1.22-9.99%) and a similar trend was evident with the OC content. Total N was very low to medium (0.06-0.49%), the C/N ratio was 10.86-12.37. Available P was very low to moderately high (0.43-18.17 mg kg^{-1}), extractable K was very high throughout the soil depth (169.49-283.90 mg kg^{-1}), extractable Ca was very low (8.10-285.17 mg kg^{-1}), extractable Mg was very low to low (7.36-116.07 mg kg^{-1}) and extractable Na was very low too (10.70-16.88 mg kg^{-1}).

The CEC value was very low to high (1.90-23.95 cmol kg^{-1}) and the BS content was very low (8.93-32.10%).

HT community forest:

Pedon 4: The soil was very strongly to slightly acidic (pH: 4.93-6.45), the OM content was high but varied from very low to very high (0.10-10.45%), with the same trend for the OC content. Total N was very low to high (0.01-0.52%) and the C/N ratio was 5.80-12.63. Available P was very low to medium (0.72-14.24 mg kg^{-1}), extractable K was very low to low (30.02-576.28 mg kg^{-1}), extractable Ca was very low throughout the soil depth (9.42-291.87 mg kg^{-1}), extractable Mg was very low to medium (11.96-141.09 mg kg^{-1}) and extractable Na was very low throughout the soil depth too (3.36-16.16 mg kg^{-1}).

The CEC value was moderately low to high (7.62-22.48 mg kg^{-1}) and the BS content was low (1.82-14.30%).

Pedon 5: The soil was strongly to moderately acidic (pH: 5.18-5.79). The OM content was very low to very high (0.49-12.79%), with a similar trend for the OC content. Total N was very low to high (0.02-0.66%), the C/N ratio range was 5.80-12.63 and available P was very low to medium (1.20-13.36 mg kg^{-1}). Extractable K was varied from very low to very high (25.10-531.99 mg kg^{-1}), extractable Ca was very low throughout the soil depth (19.40-312.00 mg kg^{-1}), extractable Mg was very low to medium (8.41-155.70 mg kg^{-1}) and extractable Na was low (4.68-18.21 mg kg^{-1}).

The CEC value was moderately low to high (5.56-23.44 cmol kg^{-1}) and the BS content was very low (3.06-21.13%).

Pedon 6: The soil was strongly to moderately acidic (pH: 5.15-5.90). The content of OM was ranged from low to very high (0.52-25.84%), and the same trend was evident for the OC content. The total N was very low to very high (0.03-1.35%) and the C/N ratio was 8.99-12.04. Available P in this pedon was very low to moderately high (1.36-22.16 mg kg^{-1}). Extractable K ranged from very low to very high (27.51-538.55 mg kg^{-1}), extractable Ca in the top soil of this pedon (0-10 cm soil depth) was medium to high (1,745-17-2,332.92 mg kg^{-1} and very low in deeper soils (10-200 cm) at 25.36-50.48 mg kg^{-1}, and similarly extractable Mg ranged from medium to high

at 0-10 cm depth (270.57-376.40 mg kg^{-1}) and in deeper soil was very low (4.36-23.02 mg kg^{-1}). Extractable Na was very low throughout the soil profile (7.59-16.09 mg kg^{-1}).

The CEC value was low to very high (4.00-52.56 cmol kg^{-1} and the BS content was low (1.63-30.92%)

3. Soil types and profile development

Table 1 shows the soil profile development. The two community forests were classified in the order Ultisols, suborder Humults, great group Palehumults, subgroup Typic Palehumults. The soils were more than 200 cm in depth with highly weathered granitic rock. The soils were well developed with low base saturation (<35%). The soil profiles were developed as A-AB/BA-Bt-BC with a 2-4 cm thick organic layer and had high clay accumulation in subsoils. The parent rock in this forest was granite.

Table 1 Topographical features and soil profiles in two community forests.

Pedon	Topography			Forest type	Profile Development
	Altitude (m)	Slope (%)	Aspect		
A. HKL community forest					
1	1,102	17	N 60^0 E	Utilization forest	A-BA-Bt1-Bt2-Bt3-Bt4-Bt5-BC
2	1,231	20	S 20^0 W	Utilization forest	A-AB-Bt1-Bt2-Bt3-Bt4-Bt5
3	1,473	5	N 20^0 E	Community forest	A-BA- Bt1-Bt2-Bt3-Bt4-Bt5
B. HT community forest					
4	1,194	13	N 60^0 W	Utilization forest	A-BA- Bt1-Bt2-Bt3-Bt4-Bt5-Bt6
5	1,279	10	N 30^0 W	Community forest	A- AB-Bt1-Bt2-Bt3-Bt4-Bt5
6	1,585	8	N 25^0 E	Community forest	A1-A2-AB- Bt1-Bt2-Bt3-Bt4-Bt5

4. Information on the site and general information on the soils

4.1 Information on the site

HKL community forest:

Pedon 1: This pedon was located at 18º 43′ 46″ N; 98º 32′ 00″ E, at an elevation of 1,102 m (MSL). Regarding the land form, the physiographic position was high on the slope, the surrounding land form was hill and the profile site as nearly level (17%), N 60^0 E aspect. Vegetation and land use were consistent with a pine-montane forest community with local utilization of forest products. The dominant trees were *Pinus kesiya* Royle ex Gordon, *Quercus brandisiana* Kurz and *Castanopsis acuminatissima* (Blume) A.DC. Annual rainfall was approximately 1,330 mm/yr and the mean temperature was approximately 22^0C.

Pedon 2: The pedon was located at 18º 42′ 48″ N; 98º 31′ 44″ E, at an elevation of 1,231 m (MSL). Regarding the land form, the physiographic position was high on the slope, the surrounding land form was hill and slope on which profile site as nearly level (20%), S 20^0 W aspect. Vegetation and land use were consistent with a montane forest community which was used for conservation and forest product utilization. The dominant tree was

Castanopsis acuminatissima (Blume) A.DC. Annual rainfall was approximately 1,330 mm/yr and mean temperature was approximately 22^0C.

Pedon 3: The pedon was located at 18º 42′ 33″ N; 98º 31′ 09″ E, at an elevation of 1,473 m (MSL). Regarding the land form, the physiographic position was high on the slope, the surrounding land form was hill and slope on which profile site as nearly level (5%), N 20^0 E aspect. The vegetation and land use were consistent with a montane forest community which was also used for conservation and forest product utilization. The dominant trees were *Pinus kesiya* Royle ex Gordon and *Castanopsis acuminatissima* (Blume) A.DC. Annual rainfall was approximately 1,330 mm/yr and mean temperature was approximately 22^0C.

HT community forest:

Pedon 4: This pedon was classified as Typic Paleustults and located at 18º 42′ 27″ N; 98º 31′ 59″ E, at an elevation of 1,194 m (MSL). Regarding the land form, the physiographic position was high on the slope, the surrounding land form was hill and slope on which profile site as nearly level (13%), N 60^0 E aspect. Vegetation and land use were consistent with a pine-montane forest community which was being used for forest product utilization. The dominant trees were *Pinus kesiya* Royle ex Gordon, *Quercus brandisiana* Kurz and *Castanopsis acuminatissima* (Blume) A.DC. The annual rainfall was about 1,330 mm/yr and the mean temperature was 22^0C.

Pedon 5: This pedon was classified as Typic Paleustults and located at 18º 42′ 26″ N; 98º 31′ 30″ E, at an elevation of 1,279 m (MSL). Regarding the land form, the physiographic position was high on the slope, the surrounding land form was hill and slope on which profile site as nearly level (20%), S 20^0 W aspect. Vegetation and land use were consistent with a montane forest community which was also used for conservation and forest product utilization. The dominant trees were *Schima wallichii* (DC.) Korth and *Castanopsis acuminatissima* (Blume) A.DC. Annual rainfall was approximately 1,330 mm/yr and the mean temperature was approximately 22^0C.

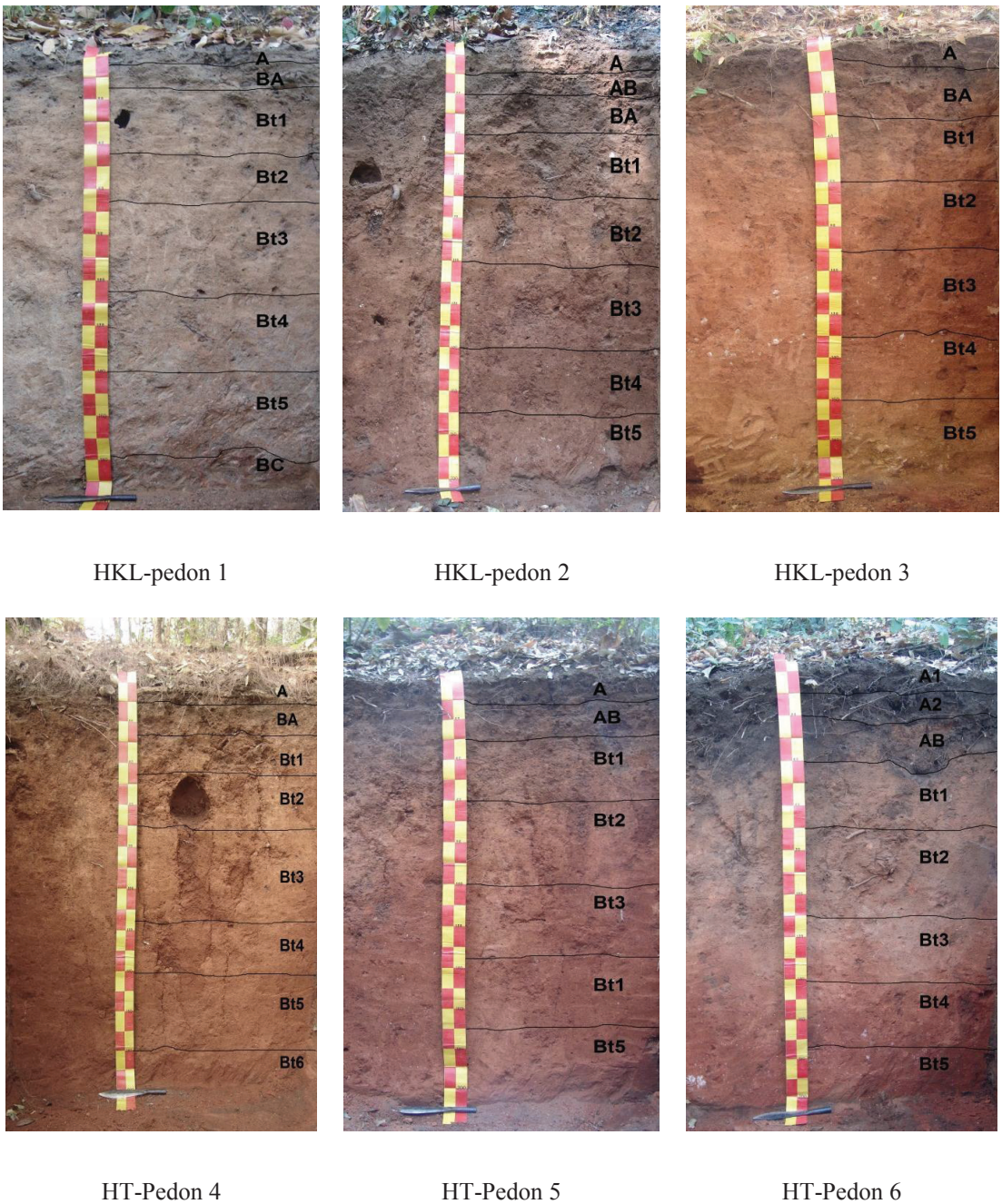
Pedon 6: The pedon was classified as Typic Paleustults, located at 18º 42′ 05″ N; 98º 30′ 59″ E, at an elevation of 1,585 m (MSL). Regarding the land form, the physiographic position was high on the slope, the surrounding land form was hill and slope on which profile site as nearly level (8%), N 25^0 E aspect. Vegetation and land use were consistent with a montane forest community which was used for conservation and forest product utilization. The dominant trees were *Castanopsis diversifolia* (Kurz) King, *Schima wallichii* (DC.) Korth and *Castanopsis acuminatissima* (Blume) A.DC. Annual rainfall was approximately 1,330 mm/yr and the mean temperature was approximately 22^0C.

4.2 General information on the soils

In the two community forests, the soil parent material was derived "*in situ*" from granite in the Precambrian period; the sites were well drained, with moisture conditions in the profile being dry throughout, the depth of the ground water table was nil, there no stones and no rocks and there was evidence of slight sheet erosion.

5. Morphology of soils

Soil morphology was evaluated using (1) soil color and mottles (2) texture (3) structure and (4) plant roots. Some soil profile descriptions are provided below throughout each profile depth (see also Figure 1).



HKL-pedon 1 HKL-pedon 2 HKL-pedon 3

HT-Pedon 4 HT-Pedon 5 HT-Pedon 6

Figure 1 Soil profiles of Pedons 1, 2, 3, 4, 5 and 6 in two community forests.

5.1 Soil color and mottling

Soil samples were measured in dry and moist forms.

HKL community forest:

Pedon 1: *Dry soil form*; 0-17 cm soil depth, soil color light gray (5YR7/1), pinkish white (5YR8/2) at 17-45 cm depth, pink (5YR8/3) at 45-105 cm, pinkish white (5YR8/2) at 105-140 cm and reddish yellow (5YR7/8) at 140-200+ cm soil depth. *Moist soil form*; dark gray (5YR4/1) at 0-5 cm, gray (5YR6/1) at 5-17 cm, yellowish red (5YR5/6) at14-45 cm, pink (5YR7/3) at 45-65 cm, yellowish red (5YR5/6) at 65-105 cm and reddish yellow (5YR6/6) at depth 105-200+ cm.

Pedon 2: *Dry soil form*; gray (5YR5/1) at 0-10 cm soil depth, reddish brown (5YR4/4) at 10-20 cm, dark gray (5YR4/1) at 20-40 cm, reddish brown (5YR5/4) at 40-70 cm and at 70-200+ cm depth as yellowish red (5YR5/6). *Moist soil form*; black color (5YR2.5/1) at 0-40 cm, dark reddish brown (5YR3/2) at 40-100 cm and reddish brown (5YR4/4) at 100-200+ cm soil profile depth.

Pedon 3: *Dry soil form*; soil color at 0-5/10 cm depth was gray (5YR5/1), reddish brown (5YR5/6) at 5/10-30 cm, yellowish red (5YR5/6, 5YR5/8) at 30-130 cm and reddish yellow (5YR7/8) at 130-200+ cm depth. *Moist soil form*; dark reddish brown (5YR3/2) at 0-30 cm, yellowish red (5YR4/6, 5YR5/6, 5YR5/8) at throughout 30-160 cm depth and reddish yellow (5YR6/6) at 160-200+ cm depth.

The soil color of the HKL community forest was light gray, gray, pinkish white, pink, pinkish white, reddish yellow, reddish brown, dark gray, yellowish red and reddish yellow in dry form. Moist soil color was dark gray, gray, yellowish red, pink, reddish yellow, black, dark reddish brown and reddish brown.

HT community forest:

Pedon 5: *Dry soil form*; dark gray (2.5YR4/0) at depth 0-10 cm, weak red (2.5YR5/2) at 10-25 cm and deeper soils (25-200+ cm) red (2.5YR4/6, 2.5YR4/8, 2.5YR5/8). *Moist soil form*; soil depth 0-10 cm very dark gray (2.5YR3/0), dusky red (2.5YR3/2 at 10-25 cm, reddish brown (2.5YR4/4) at 25/70 cm, red (2.5YR4/6) at 70-110 cm and dark red (2.5YR3/6) in deeper soils (110-200+ cm).

Pedon 5: *Dry soil form*; soil depth at 0-30 cm dark gray (2.5YR4/0) color, 30-100 cm soil depth as reddish brown (2.5YR4/4) and red (2.5YR5/8) at 100-200+ cm soil depth. *Moist soil form*; at 0-10 cm soil depth the soil color was black (2.5YR2.5/0), very dark gray (2.5YR3/0) at 10-30 cm, light red (2.5YR6/8) at 30-60 cm, red (2.5YR4/6) at 60-100 cm, dark red (2.5YR3/6) at 100-135 cm, reddish brown (2.5YR4/4) at 135-170 cm and dark red (2.5YR3/6) at 170-200+ cm soil depth.

Pedon 6: *Dry soil form*; depth 0-20 cm dark gray (5YR4/1), gray (5YR6/1) at 20-40 cm, yellowish red (5YR4/8, 5YR5/6) at 40-110 cm and in 110-200+ cm reddish yellow (5YR6/6, 5YR6/8). *Moist soil form*; black (5YR2.5/1) at 0-20 cm soil depth, dark reddish brown (5YR2.5/3, 5YR3/3, 5YR3/4) at 20-110 cm and yellowish red (5YR4/8, 5YR5/8) in deeper soils.

The soil color in these pedons of the HT community forest differed throughout the soil profile; in dry soil form it was dark gray,

weak red, red, reddish brown, yellowish red and reddish yellow, whereas in moist soil form it was very dark gray, dusky red, reddish brown, red, dark red, black, light red, dark reddish brown and yellowish red.

5.2 Soil texture

HKL community forest:

Pedon 1: The soil at 0-30 cm depth was moderately coarse-textured sandy loam. The deeper horizons (30-200 cm) had moderately fine-textured sandy clay loam.

Pedon 2: The soil at 0-40 cm depth was moderately coarse-textured sandy loam. The deeper horizons (40-200 cm) had moderately fine-textured sandy clay loam.

Pedon 3: The soil at 0-20 cm depth was moderately coarse-textured sandy loam. The deeper soil (20-180 cm depth) had moderately fine-textured sandy clay loam and moderately coarse-textured sandy loam at 180-200 cm.

The surface soils in the HKL community forest were moderately coarse-textured, whereas the subsoil was moderately fine-textured.

HT community forest:

Pedon 4: The soil at 0-5 cm depth was moderately coarse-textured sandy loam. The deeper horizons had different textures: at 5-20 cm, moderately fine-textured sandy clay loam; at 20-200 cm, fine-textured sandy clay and clay.

Pedon 5: The soil at 0-20 cm depth was moderately coarse-textured sandy loam. The deeper soil (20-200 cm) had moderately fine-textured clay loam and sandy clay loam.

Pedon 6: The soil at 0-80 cm depth was moderately coarse-textured sandy loam, whereas that in the deeper soil (80-200 cm depth) was moderately fine-textured sandy clay loam.

The surface soils in the HT forest was moderately coarse-textured, whereas the subsoil was moderately fine-textured and fine-textured.

5.3 Soil structures

HKL community forest:

Pedon 1: The structure of soils in this area was similar throughout the soil depth, being of strong medium granular structure at 0-45 cm depth and in the deeper soil (45-200+ cm), it had a strong coarse granular structure.

Pedon 2: The soil at 0-10 cm had a strong medium granular structure, a weak fine granular structure at 10-40 cm, a moderate medium granular structure at 40-100 cm, a strong medium granular structure at 10-400 cm and deeper soil had a moderate medium granular structure.

Pedon 3: This pedon had a moderate medium blocky structure at 0-90 cm, a strong medium blocky structure at 90-160 cm and a moderate medium blocky structure at 160-200+ cm.

HT community forest:

Pedon 4: The soils at 0-40 cm had a weak fine granular structure, at 40-110 cm a moderate medium granular structure and a strong medium granular structure at 110-200+ cm soil depth.

Pedon 5: This pedon had a weak-medium granular structure at 0-10 cm soil depth, at 10-100 cm depth a moderate-medium granular structure and deeper soil had a strong medium granular structure.

Pedon 6: This pedon had a moderate medium angular blocky structure at 0-10 cm soil depth, at 10-68 cm a weak medium angular blocky structure, at 68-110 cm a moderate medium angular blocky structure, a strong medium angular blocky structure at 110-143 cm and at 143-200+ cm soil depth a moderate medium angular blocky structure.

Most of the soil structure in the two community forests had an angular blocky and granular structure with different size classes and strengths or grades of structure.

5.4 Soil pores

HKL community forest:

Pedon 1: This community forest at 0-5 cm soil depth had common medium simple tubular pores, at 5-65 cm common medium tubular pores, a few medium tubular pores at 65-105 cm and common medium tubular pores in deeper soils (105-200+ cm).

Pedon 2: Throughout the soil profile of this pedon there were common medium tubular pores.

Pedon 3: This pedon at 0-130 cm soil depth had common medium tubular pores and a few fine tubular pores at 130-200+ cm.

HT community forest:

Pedon 4: Throughout the soil profile, this pedon had common medium tubular pores.

Pedon 5: At 0-30 cm soil depth there were a few medium irregular pores, with common medium irregular pores at 30-170 cm soil depth and at 170-200+ cm, there were many medium irregular pores.

Pedon 6: At 0-10 cm depth, there were common medium tubular pores, with many medium tubular pores at 10-20 cm whereas deeper soil had common medium tubular pores.

The two community forests had tubular and irregular pores but different vertical continuity, in amounts and size.

5.5 Plant roots

HKL community forest:

Pedon 1: The soil profile of this pedon at 0-5 cm had common fine and a few medium roots, a few fine and common medium roots at 5-17 cm, at 17-45 cm common medium roots, with a few medium roots at 45-140 cm, Deeper soils had no plant roots.

Pedon 2: At 0-10 cm soil depth there were common fine and common medium roots, a few medium and common medium roots at 10-20 cm, a few very fine and a few fine roots at 20-40 cm, at 40-100 cm there were common medium roots, with a few medium roots at 100-140 cm. Deeper soils had no plant roots.

Pedon 3: At 0-5/10 cm soil depth there were common very fine, many very fine and common medium roots; at 5-10-30 cm common fine, a few fine and common medium roots, with a few medium roots at 30-60 cm. Deeper soils had no plant roots.

HT community forest:

Pedon 4: At 0-10 cm soil depth there were a few common, common medium and common fine roots, with common medium roots at 10-25 cm, at 25-40 cm a few medium and few fine roots, at 40-40 cm common fine and a few medium roots and common medium, while at 70-110 cm there were a few medium roots and at 110-140 cm a few medium roots.

Pedon 5: There were many fine, common fine and common medium roots at

0-10 cm soil depth, with common fine and common medium roots at 10-30 cm, at 30-60 cm there were common medium and few fine roots, then a few medium roots at 60-100 cm, at 100-135 cm a few fine and a few medium roots, with a few medium roots at 135-170 cm and finally a coarse roots at 170-200+ cm.

Pedon 6: At 0-20 cm depth there were many very fine, many fine and many medium roots; with many medium and many fine roots at 20-40 cm, at 40-68 cm there were common medium roots, and below this there were common medium and a few coarse roots at 68-110 cm and finally at 110-143 cm a few medium roots. Deeper soils had no plant roots.

The highest amounts of plant roots were located in top soils and lower in deeper soils, with larger sizes of roots in top soils and smaller sizes in deeper soils.

CONCLUSION

The forest types of HKL and HT community forests were identified as pine-montane and montane forests with villages and adjoining community forests occupied by Karens. The villagers have to manage their community forest under the law with the cooperation of the government officers. The villagers can cut some trees for housing and agricultural equipment under the control of the head of the village, except in conservation forest where all cutting is forbidden. The physical and chemical properties in these forests differed depending on the location on the ridge, break or foot of the hill slope. There was high organic matter accumulation in the surface soil and high clay levels in deeper soils. Soil differences resulted from soil color, soil texture, soil structure, soil pores and plant roots by soil layers. Forest protection from fire and cutting of trees especially in the utilization forest helped to maintain the ecological balance in the soils. In addition, land management agency units must cooperate and support the implementation of protection areas by the community.

This data is important for basic information and to assess or track the future transition dynamics of the various properties of HKL and HT community forests.

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