Classification of Forest Soils in Japan

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Introduction

Basis of forest soil classification in Japan was established by Dr. M. Ohmasa. In the study of beech forest soils in the Tohoku region, he classified them into 13 unit-types on the basis of morphological characteristics of soil profiles, and compiled them into 3 groups: Podzolic soils (6 types), Brown forest soils (6 types), and Ground water soils (1 type)[5]. The basic principle of this classification was laid on morphological characteristics reflecting different moisture conditions mainly caused by microtopography of mountains. Accordingly, this classification offers a good indicator for physical and chemical properties as well as productivity of mountain soils, so that it is quite suitable for the soil grouping in such complicatedly dissected mountains as in Japan.

In two forest soil survey projects, i.e. Soil Survey of National Forests started in 1947, and subsequent Soil Survey of Private Forests started in 1954, the Ohmasa's unit-types, to which Red soils, Black soils, etc. were added, were employed as the mapping units. At present, up to 85% of the national forests and 50% of the private forests are shown by the large-scale soil maps, which are used effectively as the basic material for planning forest management such as determining suitability of sites for forestation, soil conservation, etc.

In the course of these forest soil surveys, researches on forest soils were carried out in addition to survey works. Major research achievements obtained in relation to genesis and classification are as follows: The Red soils in Japan were found to be palaeosols formed in Pleistocene interglacial epoch[2,3]. Among the Black soils, there are ones which have accumulated organic matter under immersed conditions, and become Black soil after drain[3]. Wet Podzolic soils have Iron-type and Humus-type[6]. Among the Brown forest soils, there are sub groups which show strong reddish or yellowish color[7].

After the return of Okinawa and Ogasawara, soils of subtropical forests have come to be a new research subject, and it was made clear that Yellow soils dominant in these islands are formations under recent bioclimatic condition, and Red soils there are palaeosols as the case in the mainland[4].

Based on the results of survey and research conducted for more than 20 years, the forest soil staffs of the Forestry and Forest Products Research Institute have improved classification system, and published a new one[1] (shown in Table 1), which will be briefly described below.

Categories of the classification

In the new classification, 4 categories starting from high order, soil group, to the low order, subtype, are set-up. Category higher than soil group order was not set-up, because there is no need to set-up in a hurry. On the other hand, category lower than subtype order was also not set-up, but the subtype is to be practically subdivided according to soil texture, parent material, compactness, etc., if necessary.

1) Soil group

An assemblage of the soils having the same sequence and characteristics of diagnostic horizons in soil profiles in common with each other. Conceptually, it nearly corresponds to "Soil type" in West Germany (FRG) and Soviet Union (U.S.S.R.).

Table 1. Classification of forest soils in Japan (1975)

Soil group	Subgroup
Podzolic soils	Dry podzolic soils Wet-iron podzolic soils Wet-humus podzolic soils
Brown forest soils	Brown forest soils (typical) Dark-brown forest soils Reddish-brown forest soils Yellowish-brown forest soils Surface-gleyed brown forest soils
Red and Yellow soils	Red soils Yellow soils Surface-gleyed red and yellow soils
Black soils	Black soils (typical) Light-colored black soils
Dark-red soils	Eutric dark-red soils Dystric dark-red soils Volcanogenus dark-red soils
Gley soils	Gley Pseudogley Podzolic gley
Peaty soils	Peat soil Muck soil Peat podzol
Immature soils	(Regosols) (Eroded soils)

2) Soil subgroup

Subdivision of soil group. In addition to typical subgroup which possesses typical characteristics of soil group, soils which are partially influenced by other soil formation process or possess intermediate nature from one soil group to other soil group are distinguished. The soil subgroup corresponds nearly to "Soil subtype" in West Germany and Soviet Union.

3) Soil type

It constitutes a unit member of soil subgroup, which is divided by differences in developing grade of diagnostic horizons and in soil structure, etc. These classifying criteria are morphological characteristics liable to reflect moisture conditions caused by microtopography of mountainous lands, and hence a succession of Ohmasa's unit-types. The soil type is very appropriate as the basic mapping unit for large-scale soil maps. It corresponds nearly to "Varietat" of West Germany and "Soil species" of Soviet Union.

4) Soil subtype

Soil types which need subdivision in practice due to wide variations of characteristics, are divided into subtypes according to minute differences in criteria for soil type.

General description of soil groups and subgroups

1) Podzolic soils

They are divided into three subgroups as shown in Table 1, and each of the subgroups are further divided into Podzol, Podzolic, and Slightly podzolised soils, according to the degree of development of the A_2 horizon.

Dry podzolic soils: Having well-developed A_0 horizon, especially F horizon, grey-white A_2 horizon, and ferruginous B horizon. Formed in places liable to suffer from dryness

Table 2. Characteristics of the soil types of Brown forest soils

Soil type	Morphological characteristics: Ao horizon	A horizon	B horizon	Productivity	Soil forming environment	Moisture condition
B_A	Thick	Thin, black, loose granular str. Mycorrhiza	Light brown, loose granular str.	Low	Ridge, top (steep)	Dry ↑
B_B	Thick	Thin, black, granular str. Mycorrhiza	Light brown, granular and nutty str.	Low	Ridge, top (gentle)	
B_C	Thin	Thin, dark brown, granular and nutty str.	Brown, nutty and hard blocky str.	Low ~ medium	Convex gentle slope of the upper part of mountainside (wind blows)	
B_D	Very thin	Thick, brownish black, crumb str.	Brown, soft blocky str.	High	Mountainside	
B_E	Very thin	Thick, brownish black, crumb str.	Dull brown, massive	High	Footslope (freely drained)	
B_F	Thin	Thick brownish black, crumb str. weakly	Dull brown ~ brownish gray, massive, orange spots rarely	Medium (wet damage)	Footslope (poorly drained)	↓ Wet

like mountain tops, ridges, or edges of uplands. In such places, podzolization proceeds easily due to slow litter decomposition, development of thick A_0 horizon, and production of strongly acidic organic compounds. Distributed widely in alpine zone and subalpine zone, but observed even in mountainous areas of temperate zone. Being strongly acidic, and lacking nutrients and water make artificial reforestation difficult.

Wet-iron podzolic soils: Having A_0 horizon, especially well-developed black greasy H horizon, grey-white or blue-grey $A_{2\text{-}g}$ horizon, orange-brown B_1 horizon or orange $B_{1\text{-}g}$ horizon, and light brown B_2 horizon. Generally, clayey and massive. Formed from heavy clayey parent materials at gentle slopes, such as flat ridges, elevated peneplains and volcanic mud-flows, in areas from upper temperate zone to subalpine zone. Such places are ill-drained, and top soil is affected by strong reduction. Sometimes, iron pan is formed in $B_{1\text{-}g}$ horizon, that inhibits root system development. Artificial reforestation is extremely difficult.

Wet-humus podzolic soils: Having black greasy H horizon, dark grey A_2 horizon, and dark red-brown B horizon. Soil layer is not necessarily compact, and humus accumulates down to deep layer. Distributed mainly in subalpine zone. As compared with the above-listed two subgroups, soil productivity is slightly high, permitting artificial reforestation, but natural reforestation is general.

The total area of these Podzolic soils is about 1.31 million ha, only 3.5% of the total land area of the country.

2) Brown forest soils

Acidic or slightly acidic soils having dark brown A horizon, and brown B horizon, without eluviation and illuviation of free sesqui oxides and clay. As given in Table 1, they are classified into 5 subgroups, which are further divided into soil types and subtypes

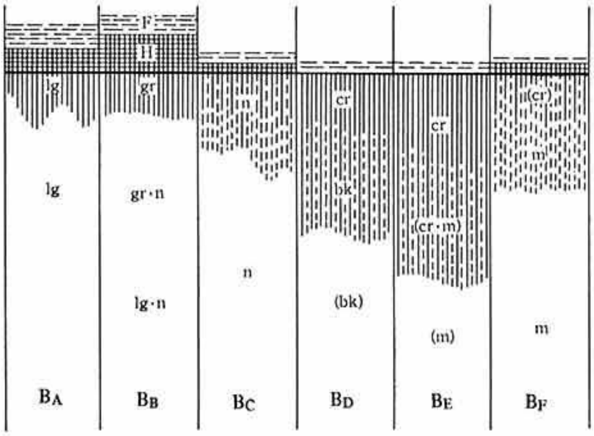

Fig. 1. Sub-division (soil types) of the Brown forest soils

lg : loose-granular structure. gr: granular structure.
n : nutty structure. bk: blocky structure.
Cr : crumb structure. m: massive. ( ) weak.
B_A : Dry brown forest soil (loose granular str. type)
B_B : Dry brown forest soil (granular & nutty str. type)
B_C : Weakly-dried brown forest soil
B_D : Moderately-moist brown forest soil
B_E : Slightly-wet brown forest soil
B_F : Wet brown forest soil

according to the developmental degree of A and A_0 horizons, nature of boundaries between horizons, features of soil structure, etc.

Brown forest soils (Typical subgroup): This subgroup has hardly been subjected to other soil forming process observed in the other subgroups described later. Hue of the soil color is usually 7.5YR. This subgroup is distributed mainly in temperate zone with the greatest area among 5 subgroups. As shown in Fig. 1 this subgroup is further classified into 6 soil types, of which B_D soil is most widely distributed.

Dark brown forest soils: Having black greasy H horizon or H-A horizon, brownish-black A horizon, and dark brown B horizon. Distributed in areas above the typical subgroup zone, showing vertical zonality in the transitional zone to the podzol-distribution zone. It is considered that in these areas a large amount of humus had accumulated because of slow decomposition of organic matter due to cool climate. Artificial reforestation is possible, but with poor result due to low temperature and deep snow. This subgroup is further divided into two soil types, following the subclassification of the typical subgroup.

Reddish-brown forest soils: Soil color is more reddish than the typical subgroup, and the A horizon is light-colored and generally thin. It is regarded that this subgroup was formed from parent materials exposed to red weathering. As compared with the typical subgroup, this subgroup is more deficient of nutrients, more acidic, and lower in productivity. Distributed on low mountains, hills, and terraces, frequently accompanying Red soils. This subgroup is divided into 4 soil types.

Yellowish-brown forest soils: As compared with the typical sub-group, the soil color is more yellowish, and A horizon is light-colored and thin. Formed from parent materials exposed to yellow weathering. This sub-group occurs mostly together with Reddish brown forest soils, and its property is like the latter.

It is divided into 5 soil types.

Surface-gleyed brown forest soils: This subgroup is Brown forest soils containing gley spots and/or iron mottles produced by reduction occurred due to temporary stagnant water. It is distributed on gentle slopes, terraces, etc. at the Japan Sea Side of Hokkaido and Eastern Japan. Subdivided into 4 soil types.

These Brown forest soils are distributed over a wide range from the northmost Hokkaido (45°N) to the Yakushima Island (30°N), covering an area of about 19.08 million ha, 51.3% of the total land area of Japan.

3) *Red and Yellow soils*

This soil group is classified into 3 subgroups according to soil color and presence or absence of surface-gleyzation. The Red soils and Yellow soils are originally zonal soils in humid subtropical zone. However, these soils in Japan were found recently to be palaeosols, except that Yellow soils in the Ryukyu islands are regarded to be recent formation. The both soils are well-weathered acidic soils and clayey in general, containing kaoline, and with low cation-exchange capacity and nutrient deficiency. Except soil color, they resemble closely each other. Their distribution is also quite similar, occurring on definite geomorphic surface with certain altitude such as low mountains, hills, terraces, etc. Both of them are poor in productivity. They are divided into 3 soil types, following the subdivision of Brown forest soils.

Red soils: Having light-colored, thin A horizon, and reddish-brown to bright-reddish brown (5 YR, 2.5 YR) B horizon. The C horizon also shows strong reddish color. Rich in hydrate iron oxide.

Yellow soils: Light-colored, thin A horizon, and yellowish-brown to bright-yellowish brown (10 YR, 2.5 Y) colored B horizon. The C horizon also strongly yellowish.

Surface gleyed red and yellow soils: This subgroup is Red and Yellow soils with gley A_2 horizon or bluish-gley $A_{2\text{-}g}$ horizon. Although the formation mechanism of A_2 horizon is not made clear enough, surface gleyzation is thought to be involved to a great extent. Distributed on flat to gently sloped areas of tableland and hills of the Ryukyu islands. Poor in productivity. Divided into soil types, based on developmental grade of A_2 horizon.

4) *Black soils*

This soil group has thick, black A horizon, which shows a clear border with B horizon. In general, it shows low bulk density and high exchange capacity and water-holding capacity. Internationally, it is called "Andosol", derived from Japanese name "Ando" ("an"=dark, "do"=soil). Based on the darkness of the A horizon, it is classified into typical subgroup and light-colored subgroup. Each subgroup is further divided into 5 soil types, following the subdivision of Brown forest soils. Almost all of the Black soils are formed from volanic ash. There is a view that allophane derived from volcanic ash maintains black humus, but it can not be said that volcanic ash is essential in the formation of Black soils, because there are Black soils hardly containing volcanic ash. On the other hand, Black soils are distributed mainly in grasslands or lands used as grassland before, but not in climax forests or areas covered by climax forests by recent years. This fact shows that effect of grassland on the formation of Black soil can not be neglected.

Distribution area of this soil group accounts for 5.75 million ha, 15.5% of the total land area of Japan, and is widely used as farmlands and grasslands in addition to forest land. Its productivity is generally high.

5) *Dark red soils*

They are chocolate-colored soils formed from carbonate rocks or ferrit-magnesian rocks. Having light-colored, thin A horizon, and B horizon with color slightly darker than Red soil. Those showing degree of base saturation of B horizon higher than 50% are taken as Eutric subgroup, while those with base saturation less than 50% as Dystric subgroup. Distribution area of both subgroups is not so wide: being not found in northern Japan. In the Ryukyu islands, Eutric dark red soils are found in terraces of elevated coral-reefs.

In addition to these subgroups, soils derived from red-colored material caused by volcanic hydrothermal alteration are included into this soil group as Volcanogenus subgroup. Volcanic area of the whole country is dotted with this subgroup.

These 3 subgroups are classified into respective soil types, following the subdivision of Brown forest soils. Eutric subgroup derived from serpentine has an extremely low productivity due to its heavy metal ions.

6) Gley soils

This soil group is classified into 3 subgroups, i.e. Gley which has bluish-gley G horizon formed under the effect of groundwater, Pseudogley which has G horizon formed by gleyzation under seasonal stagnation of excess soil water, and Podzolic gley which has G horizon in a lower layer, and an eluvial horizon formed by podzolization in an upper layer. Gley is distributed widely in lowland, mostly in paddy fields, while its distribution in mountains is less. Pseudogley, derived from heavy materials of flat to gently sloping area, is found in plenty on terraces in Hokkaido. Podzolic gley is found in subalpine zone, but quite scarcely.

7) Peaty soils

This group consists of 3 subgroups: Peat soil which have peat layer thicker than 30 cm at the top layer of the soil, Muck soil having muck layer thicker than 30 cm, and Peaty podzol which have orange illuvial horizon beneath the peat or muck layer. Peat soil are widely distributed in lowland of Hokkaido but scarcely in forests. Muck soil are found around Peat soil, and Peat podzol in coniferous forests in alpine zone, but both are rare.

8) Immature soils

They are difficult to be classified due to lacking genetic horizon. They are divided into Regosols and Eroded soils. In the former, genetic horizon has not differentiated or only slightly differentiated due to its new deposition, while in the latter, genetic horizon has been lost due to soil erosion. Representative Regosols are Volcanogenous regosol and Coastal sand dune regosol. In addition, there are Fluvial regosol and Mud flow regosol. Eroded soils are subdivided by the extent of soil erosion.

References

1) Forest Soil Division: Classification of forest soils in Japan (1975). *Bull. For. & For. Prod. Res. Inst.*, (280), 1–28 (1976) [In Japanese].
2) Kidachi, M. & Ohmasa, M.: Geological and mineralogical study on the formation of Red soils in Japan. *For. Soils of Jap.* (14), 1–126 (1963) [In Japanese].
3) Kurotori, T. & Ohmasa, M.: Red soil and their accompanying Black soils in Kyushu. *For. Soils of Jap.* (13), 1–88 (1963) [In Japanese].
4) Kurotori, T. & Kojima, T.: General remarks of forest soils in the Ryuyu Islands. *J. Jap. For. Soc.*, 51, 227–230 (1969) [In Japanese].
5) Ohmasa, M.: Studies on beech forest soils. *For. Soils of Jap.*, (1), 1–243 (1951) [In Japanese].
6) Takehara, H., Kubo, T. & Hosokawa, K.: Podsolic soils from quartz porphry in Kiso region (Central mountain region in Japan). *J. Jap. For. Soc.*, 39, 419–426 (1957) [In Japanese].
7) Yamaya, K.: Relationship between properties of the *Thujopsis* forest soils and forest growth in the Tsugaru and the Shimokita peninsulas. *For. Soils of Jap.*, (12), 1–155 (1962) [In Japanese].

(Received for publication, May 19, 1982)