# Soils of *Sasa* Bamboo-Growing Land and its Surface Treatments for Natural Regeneration of Trees*

By

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# ササ地の土壌と林木更新のための地表処理*

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## Introduction

It is said that the communities of *Sasa* species cover 89% of forest lands with a procreative power and an adaptability, corresponding to 5 million hectares in Hokkaido.[2,3,8,9] As shown in Fig. 1, the lands mainly covered with a gigantic *Sasa* bamboo (*Sasa kurilensis* MAKINO et SHIBATA) having a culm height of over 2 m occupy 17% of the forest land area, while those covered with a medium type *Sasa* bamboo (*Sasa senanensis* RHED.) amount to 58%, including its community mixed with *S. kurilensis*.[9] The gigantic *Sasa* bamboo distributes over such heavy snowfall regions as the side facing to the Sea of Japan and the high mountains that often result in the treeless land of a wide area. In these stands the

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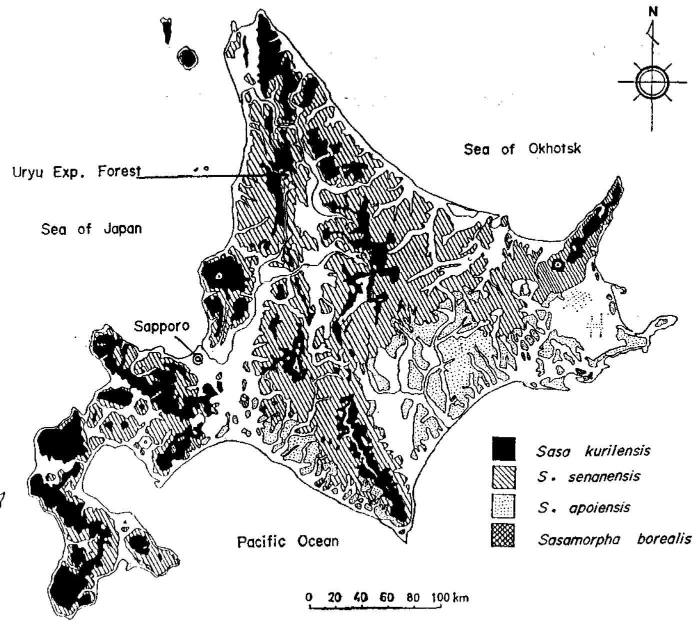


**Fig. 1.** Distribution of *Sasa* and *Sasamorpha* species in Hokkaido.[9]

seeds of trees are hardly able to germ owing to dense covering of *Sasa*, and might be nearly killed with a suppression of the upper *Sasa* and by insects and organisms living in the humus and topsoils even if they could germ. Accordingly, the large *Sasa*-growing lands have been formed and stabilized for a long time, unless the community of *Sasa* is withered up by widespread flowering.[6] The growing stock of *S. kurilensis* is shown to be 63 million tons, and when involving all *Sasa* species, that is estimated at 150 million tons, which are really a match for 28% of the tree stock in weight in Hokkaido. However, the industrial utilization of *Sasa* had scarcely been carried out with the exception of the production of hardboard and particleboard for a short period in the 1950's,[5] while the culms and juvenile sprouts of the gigantic *Sasa* bamboo are now only used for the vegetable supports in the farm and for food, respectively. The reason might be attributed to high harvesting cost, easy deterioration by organisms, though a lot of studies on the utilization of *Sasa* have been done, as summarized recently by KAWASE *et al.*[5]

On the contrary, *Sasa* has been hitherto cut down and removed as the hindrance of tree plantation and natural regeneration. As a subsidiary work of natural regeneration on the treeless land widely covered with *Sasa* bamboo, the surface treatment with a bulldozer was firstly practiced in Ohmu Prefectural Forest under Hokkaido Prefecture in 1967,[1] though the treatment had been tested on a small scale in national forests. Ecological studies on the *Sasa*-growing land[6,10,16] and practical works[1,2,7] on the forest regeneration of the land by various treatments such as herbicides, burning up and raking with bulldozers *etc.* have been now much reported. Recently, the detailed book of natural regeneration on *Sasa*-growing land including its ecology and distribution has been published by Hokkaido Regional

Forestry Office.[2] Yet, at the present time when forest resources are wanting throughout the country, *Sasa* should be again looked over for industrial materials or a new energy as a kind of biomass.

In this study, the author examined the soils of two plots covered densely with *S. kurilensis* or *S. senanensis* in Uryu Experiment Forest of Hokkaido University, and furthermore investigated the changes of the soils and floor plants as well as the regeneration of trees in the 14-year elapse after various surface treatments to the lands having removed *S. kurilensis,* which had been used for the raw material of particleboard. A part of the study has been announced in the Meetings of Hokkaido Branch of the Japanese Forestry Society[11] and IUFRO Symposium in Tokyo.[14]

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## Outlines of Uryu Experiment Forest[15]

Uryu Experiment Forest established in 1901 as the first College Forest is situated on 44°3′-29′ north latitude and 142°1′-20′ east longitude, and administratively belongs to Horokanai Town, the most northern part of Sorachi Province in Hokkaido. The experimental forest having an area of 21,600 ha spreads surrounding Lake Shumarinai, the land of which was transferred from Uryu Experiment Forest to Hokkaido Electric Power Co. for the reservoir of hydraulic power, as shown in Fig. 2. The topographical features are comparatively gentle, showing the elevations varying from 200 to 700 m above sea level. Widely distributing bedrocks are andesite and sedimentary rocks derived from Tertiary System, while serpentinite intruded into Lower Yezo Group is locally seen in the southern part of the Forest. As regards the climate, mean annual temperature is 3.5°C and the maximum and minimum temperatures are reported to be 34.2°C and −41.2°C in the last 10 years, respectively. It is shown that the difference between heat and cold is remarkably great, and that the indices of warmth and coldness are 46.7 and −66.0, respectively, calculated by the accumulation of mean monthly temperatures subtracted from a basis of +5°C. Meanwhile, annual precipitation is 1,410 mm mainly as snow which falls from late October to the end of April, holding the maximum snow depth of 2.75 m at the observatory site of Moshiri Branch Station. This district is said to be one of the heavy snow and coldest regions in Japan.

As the forests belong to pan mixed forest zone, coniferous trees consist mostly of *Abies sachalinensis* and *Picea glehnii* which sometimes forms pure forests on serpentine soils at the southern part and on peat soils at the northern part of Lake Shumarinai, and broad-leaved trees are *Quercus mongolica* var. *grosseserrata, Tilia japonica, Betula ermanii etc.* at the higher altitudes and *Fraxinus mandshurica* var. *japonica, Ulmus davidiana* var. *japonica, Alnus hirsuta etc.* at the lower altitudes. It may be characteristic that *Picea jezoensis* seen in a large extent in the northern mountains of Hokkaido is rare in this experimental forest.

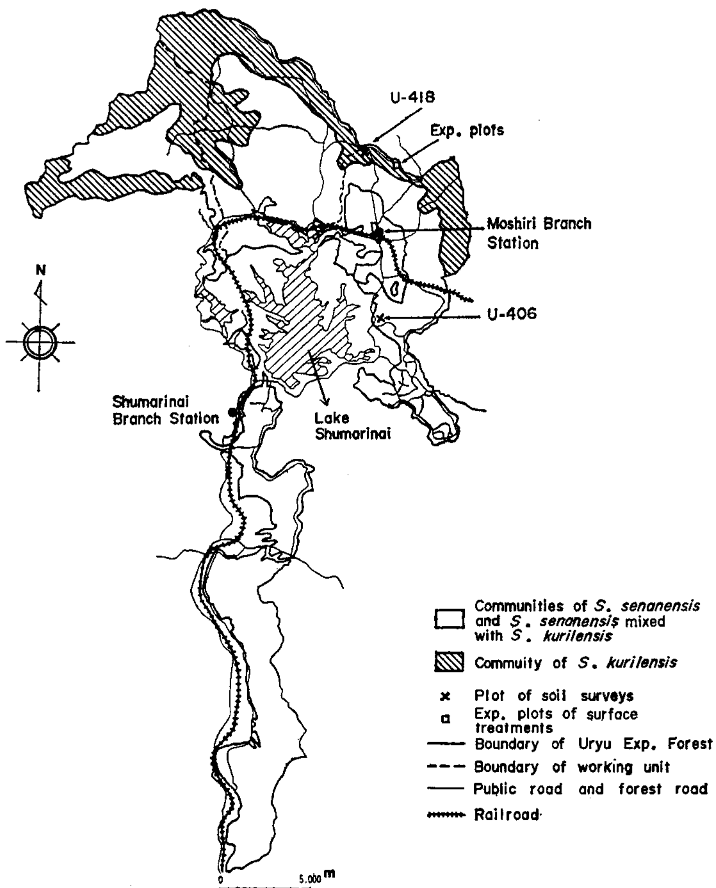


**Fig. 2.** Location of surveys and communities of *Sasa* in Uryu Experiment Forest.

However, the forests are on the whole sparse and are often changed to a wide treeless land covered densely with ***Sasa kurilensis*** in the high elevation or to an opened bare land composed of *S. senanensis* among the tree groups. The reason why such lands appear must be probably attributed to the fact of over-cutting during and after World War II and the damage caused by the Typhoon No. 15 occurring in 1954. The growing stock of trees is estimated at 2,055,000 $m^3$, corresponding to about 100 $m^3$ per hectare, and the area of unstocked land amounts to 3,346 ha. Accordingly, the working programs based on a new 10-year management plan in 1983 include continuously the following studies:

1) Structural analysis of natural forests in the heavy snow and cold region and the establishment of natural regeneration technique.
2) Systematic planning of mechanization in natural forest treatments.

As the serial works, surface treatments on the *Sasa*-growing land have been widely carried out for forest regeneration using bulldozers with raker-teeth since 1968. The experimental plots of the treatment were first set up to the land of the strip-cut *S. kurilensis* in 5, 10 and 20-m widths, the culms of which were sold out for the material of particleboard at the compartment No. 418 in 1968. The four different surface treatments designed on this land were as follows:

a. Removal of $A_0$ layer.
b. Raking of A horizon after a-treatment.
c. Removal of $A_0$ layer and A horizon.
d. Raking of B horizon after c-treatment.

These experimental plots have been since then observed in the relation between the treatments and tree growths.

## Experiments

1. Field Surveys

Surveys of *Sasa*-growing lands were carried out at 2 plots in Compartment No. 418 (U 418-I and U 418-II) covered widely with *S. kurilensis* and at 2 plots of an opened bare land covered with *S. senanensis* in Compartment No. 406 (U 406-I and U 406-II) in Uryu Experiment Forest in 1975 (Fig. 2). Environmental growing conditions of the 2 species of *Sasa* were investigated in an area of 10 m × 10 m on number, heights and basal diameters of the culms. Meanwhile, soil profiles were made till a 1-m depth, and the soils were observed and described by standard procedure.[12,13] The soils, furthermore, were taken for the measurement of apparent specific gravity, moisture and three phases under natural condition using a core sampler with a 100-ml cylinder. Those from each horizon and *Sasa* samples were also collected for the analyses in the laboratory.

Field surveys of the land treated in 1968 were carried out at the experimental plots a, b and c of the 20-m width together with non-treatment land (designated as Plot No. 1, 2, 3 and 4 in order) in 1982. In each plot, the area of 2 m × 2 m was selected and examined on all the vegetation including trees, each of which was felled, measured on the height and diameter, then weighed out in separation of the stem, branches and leaves. As to the roots, those of 5 typical trees were digged up and weighed for the application to all the trees by T-R weight ratios. At Plot No. 4 in the land untreated, *Sasa kurilensis* growing in the same area was similarly counted up and measured on the size and the weight, dividing into the culm, branches, leaves and rhizomes in which the soils adhered were removed.

After the moistures were determined using each part of trees and *Sasa* samples, the biomass was calculated as dry matters.[4] The properties of the soils at each experimental plot were examined by the above-mentioned procedures, after the profiles were made. The soil samples from each horizon were collected for the analysis.

2. Analysis of Soils

Soils brought from the *Sasa*-growing land into the laboratory, were air-dried and passed through a 2-mm sieve. Fine soils thus obtained were analyzed by standard methods,[12,13] in which following items were included: Real specific gravity with a Beckman air comparison pycnometer; Carbon and nitrogen with a Yanagimoto CN Corder (MT 500); Cation exchange capacity (CEC) with an ionmeter (Orion 407) using an ammonium electrode; Calcium, magnesium, potassium and sodium in exchangeable cations with an atomic absorption spectrophotometer (Seiko 721); Phosphate absorption by a vanado-molybdate method with a spectrophotometer at 440 nm. Moisture content at various pF values made with a Kokusan centrifuge was also determined.

As to the soils obtained from the experimental plots, the samples were analyzed on mechanical composition, maximum water holding capacity, moistures at various pF values and pH in water and 1 N-KCl solution. The mechanical composition was determined with a recording sedimeter (Shimadzu RS 1000) combined with sieving method.

3. Analysis of *Sasa* Bamboo

Inorganic components of the culms and leaves in both *S. kurilensis* and *S. senanensis* milled in the alumina vessels were determined on phosphorus, silicon, aluminum, iron, magnesium, calcium, potassium and sodium, after an aliquot of the sample were ignited and dissolved with *aqua regia* and hydrogen fluoride in a Tefron-lined acid-digestion bomb.[12,13] Nitrogen was also determined with the CN Corder.[12,13] For comparison, an Akaezomatsu spruce (*Picea glehnii*) and Todomatsu fir (*Abies sachalinensis*) collected in autumn in Uryu Experiment Forest were similarly analyzed, after divided into each organ including barks and woody part of the branch as well as needle leaves.

## Results and Discussion

1. Vegetation and Soils under Natural Condition

The results from the field surveys of the treeless land covered with *S. kurilensis* showed that the *Sasa* numbered 800 and 1,800 in a 10 m×10 m area of the two plots investigated, as well as green culm weights were estimated at 38 to 60 tons per hectare. The average length and diameter at butt were 260 cm and 1.45 cm, respectively. As the other vegetation, *Rhus ambigua, Euonymus oxyphyllus, Viburnum furcatum. Maianthemum dilatatum* and *Dryopteris* spp. were a little observed in the community of *S. kurilensis*. A few trees of *Betula ermanii, Quercus mongolica* var. *grosseserrata, Magnolia obovata, Sorbus commixta, Phellodendron amurense etc.* were seen in the circumstances of U 418-II plot. Meanwhile, in the surveys of the opened bare land covered with *S. senanensis* (U 406), the number was about 3,000 in the 10 m×10 m plot, the green and dried weights of which were estimated at 26 and 12 tons per hectare, respectively. The average length and diameter were calculated at 148 cm and 0.87 cm, respectively. As the other floor plants and shrub trees, there were observed *Dryopteris* spp., *Rubus idaeus* var. *aculeatissimus, Hydrangea paniculata, Viburnum furcatum, Vitis coignetiae etc.* The trees in the environments were *Picea glehnii, Abies sachalinensis, Betula ermanii, Phellodendron amurense* and *Tilia japonica*.

**Table 1.** Soil properties of *Sasa*-growing lands under natural condition

| Plot | Horizon | Depth (cm) | Thickness (cm) | Color | | | Hardness (mm) | Apparent specific gravity | | Moisture content based on | | Gravel (%) | Distribution of three phases (vol. %) | | | Porosity (vol. %) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Description of fresh soil with naked eye | Fresh soil by Munsell | Dried soil by Munsell | | Fresh soil | Dried soil | Fresh soil (%) | Dried soil (%) | | Solid | Liquid | Gas | |
| U-418-I | $A_0$ | | 4 | brownish black | 7.5YR2/2 | 7.5YR4/2 | — | — | — | 70.8 | 242.2 | 0 | — | — | — | — |
| | $A_1$ | 0-11 | 11 | dark brown | 10YR3/3 | 10YR3/2 | 14 | 1.12 | 0.58 | 48.1 | 92.7 | 0 | 27 | 54 | 19 | 73 |
| | $A_2$ | 11-25 | 14 | 〃 | 7.5YR3/3 | 7.5YR4/3 | 21 | 1.25 | 0.69 | 44.9 | 81.5 | 2 | 29 | 57 | 14 | 71 |
| | $B_1$ | 25-100 | 75 | brown | 10YR4/4 | 10YR6/4 | 23 | 1.37 | 0.94 | 30.8 | 44.4 | 0 | 41 | 42 | 17 | 59 |
| | $B_2$ | 100- | 30< | 〃 | 10YR4/6 | 10YR5/4 | 22 | 1.24 | 0.78 | 37.0 | 58.6 | 62 | 33 | 46 | 21 | 67 |
| U-418-II | $A_0$ | | 2 | brownish black | 7.5YR2/2 | 7.5YR4/2 | — | — | — | 75.7 | 311.6 | 0 | — | — | — | — |
| | $A_1$ | 0-16 | 16 | dark brown | 7.5YR3/4 | 7.5YR3/3 | 16 | 1.17 | 0.61 | 48.0 | 92.3 | 0 | 28 | 56 | 16 | 72 |
| | $A_2$ | 16-33 | 17 | 〃 | 〃 | 7.5YR4/3 | 19 | 1.16 | 0.66 | 43.1 | 75.6 | 4 | 28 | 50 | 22 | 72 |
| | B | 33- | 35< | brown | 10YR4/4 | 10YR5/4 | 25 | 1.41 | 0.97 | 31.4 | 45.9 | 42 | 41 | 45 | 14 | 59 |
| U-406-I | $A_0$ | | 2 | brownish black | 10YR2/3 | 10YR4/2 | — | — | — | 79.4 | 386.5 | 0 | — | — | — | — |
| | A | 0-7 | 7 | dark brown | 10YR3/3 | 10YR5/3 | 17 | 1.16 | 0.67 | 42.2 | 73.0 | 0 | 25 | 49 | 26 | 75 |
| | B | 7- | 42< | brown | 10YR4/4 | 10YR5/4 | 26 | 1.81 | 1.37 | 24.2 | 31.9 | 0 | 49 | 44 | 7 | 51 |
| U-406-II | $A_0$ | | 4 | brownish black | 10YR2/3 | 10YR3/2 | — | — | — | 77.7 | 347.7 | 0 | — | — | — | — |
| | A | 0-10 | 10 | dark brown | 7.5YR3/3 | 7.5YR4/2 | 8 | 1.17 | 0.79 | 32.5 | 48.2 | 0 | 33 | 38 | 29 | 67 |
| | $B_1$ | 10-26 | 16 | brown | 7.5YR4/4 | 7.5YR4/3 | 24 | 1.57 | 1.10 | 30.0 | 42.6 | 0 | 41 | 47 | 12 | 59 |
| | $B_2$ | 26- | 40< | reddish brown | 5YR4/6 | 5YR5/6 | 22 | 1.60 | 1.08 | 32.5 | 48.2 | 43 | 39 | 52 | 9 | 61 |

The soil properties of the *Sasa*-growing lands under natural condition are shown in Table 1. The thickness of $A_0$ layer in U 418 is as comparatively thin as 2 to 4 cm, while that of A horizon is as thick as 25～33 cm, combining $A_1$ with $A_2$. This means the components of litters are sufficiently decomposed and return to the topsoils. These soils forming crumby structure of a diameter of 0.1 to 0.3 cm, did not contain gravels and had a high moisture content. The solid ratio in the three-phase distribution shows below 30%. As for the B horizon colored in brown, however, the consistency belongs to "very hard" in the classification, showing 23 to 25 mm values measured with a Yamanaka's soil hardness gauge, and is proportional to the solid ratio. The content of gravels amounts to 62%. Putting together these features of the soils, the soil type can be said to be a typical and properly wet brown forest soils (Soil type $B_D$). As for the soils from U 406, the thickness of A horizon is as thin as 7 to 10 cm, though the $A_0$ layer is almost the same as that in U 418. The soil type at the 2 plots examined belongs also to the brown forest soils, but the difference between U 406-I and -II was indicated in the color, namely the subsoils of the latter exhibited a bright

**Table 2.** Physical and chemical properties of

| Plot | Horizon | Mechanical analysis (%) | | | | Soil class | Air-dried moisture (%) | Maximum water holding capacity (%) | Bulk density | Real specific gravity | pH | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Coarse sand | Fine sand | Silt | Clay | | | | | | $H_2O$ | N-KCl |
| U-418-I | $A_0$ | — | — | — | — | — | 9.78 | 335 | 0.32 | 1.90 | 4.2 | 3.7 |
| | $A_1$ | 6 | 13 | 29 | 52 | HC | 8.75 | 146 | 0.58 | 2.11 | 4.4 | 3.7 |
| | $A_2$ | 8 | 8 | 13 | 71 | HC | 8.45 | 99 | 0.81 | 2.36 | 4.6 | 3.9 |
| | $B_1$ | 14 | 47 | 19 | 19 | SCL | 11.82 | 72 | 0.92 | 2.28 | 5.2 | 4.0 |
| | $B_2$ | 24 | 42 | 15 | 19 | SCL | 12.29 | 79 | 0.86 | 2.33 | 5.0 | 3.9 |
| U-418-II | $A_0$ | — | — | — | — | — | 10.29 | 323 | 0.30 | 1.73 | 4.3 | 3.6 |
| | $A_1$ | 5 | 6 | 24 | 65 | HC | 8.96 | 119 | 0.76 | 2.18 | 4.5 | 3.7 |
| | $A_2$ | 5 | 7 | 21 | 67 | HC | 9.00 | 92 | 0.70 | 2.33 | 4.8 | 3.9 |
| | B | 19 | 34 | 23 | 24 | CL | 9.87 | 69 | 0.83 | 2.36 | 5.0 | 4.1 |
| U-406-I | $A_0$ | — | — | — | — | — | 9.27 | 471 | 0.26 | 1.60 | 4.7 | 4.2 |
| | A | 4 | 9 | 44 | 43 | LiC | 3.92 | 81 | 0.82 | 2.67 | 4.6 | 3.7 |
| | B | 3 | 6 | 44 | 47 | HC | 4.63 | 66 | 0.91 | 2.78 | 4.9 | 4.1 |
| U-406-II | $A_0$ | — | — | — | — | — | 10.55 | 439 | 0.25 | 1.58 | 4.3 | 3.8 |
| | A | 6 | 8 | 32 | 54 | HC | 6.06 | 102 | 0.70 | 2.43 | 4.1 | 3.4 |
| | $B_1$ | 8 | 3 | 27 | 62 | HC | 5.50 | 75 | 0.87 | 2.69 | 4.4 | 3.8 |
| | $B_2$ | 6 | 15 | 26 | 53 | HC | 7.74 | 81 | 0.82 | 2.77 | 4.9 | 3.9 |

reddish brown when air-drying, whereas those of the former did not so change. The moisture of the subsoils at the plot of U 406-I was extremely low, compared with those at U 406-II, U 418-I and -II.

2. Properties of Fine Soils

The properties of fine soils obtained from the *Sasa*-growing lands are shown in Table 2. At the plots of U 418, the soils of A horizon are classified into heavy clay for soil class, composed of 50 to 70% of clayey component by mechanical analysis, while those of B horizons are loamy, containing relatively equal amounts of sand, silt and clay. The real specific gravity is as low as the range from 2.1 to 2.4. From the results, the soils at the plot of U 418 can be said to have a good physical property.

In the case of a chemical property, however, it is not all superior, because the soils show in general low pH and base saturation.

As for the land of U 406 covered with *S. senanensis* at relatively lower altitude, the soils are always clayey, classified as light clay or heavy clay, whereas the real

fine soils obtained from *Sasa*-growing lands

| Ex-change acidity | Loss on igni-tion (%) | C (%) | N (%) | C/N ratio | Total organic matter (%) | CEC (me/100 g) | Exchangeable cations (me/100 g) | | | | Degree of base satura-tion (%) | Absorption coefficient of $P_2O_5$ (mg/100 g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Ca | Mg | K | Na | | |
| 1.4 | 41.9 | 21.1 | 1.28 | 16 | 36.3 | 49.4 | 3.2 | 1.7 | 2.9 | 0.8 | 17 | 1,240 |
| 4.4 | 26.9 | 11.8 | 0.94 | 13 | 20.4 | 31.7 | 1.4 | 1.0 | 1.2 | 0.4 | 13 | 1,820 |
| 5.6 | 17.3 | 5.1 | 0.41 | 12 | 8.8 | 23.5 | 0.6 | 0.3 | 0.4 | 0.4 | 7 | 2,190 |
| 5.1 | 10.6 | 0.4 | 0.03 | 13 | 0.8 | 34.9 | 0.7 | 0.4 | 0.1 | 0.8 | 6 | 1,530 |
| 10.6 | 10.4 | 0.5 | 0.03 | 17 | 0.8 | 27.2 | 0.8 | 0.5 | 0.2 | 0.8 | 8 | 1,840 |
| 1.2 | 49.3 | 27.5 | 1.74 | 16 | 47.4 | 85.3 | 4.9 | 2.5 | 1.8 | 0.7 | 12 | 2,570 |
| 5.9 | 23.7 | 9.6 | 0.71 | 14 | 16.6 | 26.5 | 1.1 | 0.9 | 0.7 | 0.5 | 12 | 2,330 |
| 5.6 | 18.0 | 5.7 | 0.42 | 14 | 9.9 | 24.0 | 0.8 | 0.4 | 0.4 | 0.4 | 8 | 2,170 |
| 8.3 | 10.9 | 1.0 | 0.08 | 13 | 1.7 | 24.8 | 0.5 | 0.1 | 1.0 | 0.7 | 9 | 2,200 |
| 1.5 | 63.5 | 34.7 | 1.89 | 18 | 59.9 | 118.5 | 13.6 | 3.7 | 4.8 | 1.0 | 19 | 1,310 |
| 3.7 | 9.9 | 4.2 | 0.33 | 13 | 7.2 | 24.9 | 1.4 | 0.5 | 0.5 | 0.2 | 10 | 1,110 |
| 7.6 | 7.9 | 1.5 | 0.11 | 14 | 2.7 | 20.3 | 0.3 | 0.1 | 0.2 | 0.2 | 4 | 1,500 |
| 2.2 | 61.8 | 34.8 | 1.56 | 22 | 60.0 | 61.8 | 12.6 | 3.8 | 2.6 | 0.6 | 32 | 1,000 |
| 4.0 | 20.2 | 10.1 | 0.53 | 19 | 17.4 | 24.8 | 3.1 | 1.2 | 1.2 | 0.5 | 24 | 1,310 |
| 5.7 | 12.1 | 2.4 | 0.17 | 14 | 4.2 | 18.0 | 0.6 | 0.5 | 0.5 | 0.3 | 11 | 1,320 |
| 5.7 | 11.0 | 1.3 | 0.10 | 13 | 2.2 | 32.5 | 0.4 | 0.2 | 0.2 | 0.4 | 4 | 1,430 |

specific gravity is in the range of 2.6 to 2.7, the values for the ordinary soils. The soils in B horizon contain some organic matters determined at 2.2 to 4.2%, differing from those of U 418. But the soils also indicate an inferior chemical property, showing the similar low pH and base saturation to those at U 418.

The moisture contents of the fine soils at various pF values are shown in Table 3, expressed by water ratio together with the contents on maximum water holding capacity (pF 0) and air dry (pF 5.7). The soils containing organic matters at about 50% in $A_0$ layer give naturally a considerable moisture such as 36 to 66 points calculated by the difference of the water ratios between pF 1.6 and 4.2. The soils from A and B horizons, on the other hand, reveal generally low available moistures. Compared with the moisture contents in the wet soils shown in Table 2, the contents at the surveyed time are high. They can be pointed out to contain an excessive water, corresponding to below 1.6 of pF, field capacity, except the soils of B horizon at U 406-I plot, the content of which corresponds to pF 2.7, namely moisture equivalent.

**Table 3.** Moisture content at various pF values of fine soils obtained from *Sasa*-growing lands (water ratio %)

| Plot | Horizon | pF | | | | | | | Available moisture (points) |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1.6 | 2.7 | 3.1 | 3.9 | 4.2 | 5.7 | |
| U-418-I | $A_0$ | 335 | 92 | 70 | 63 | 49 | 46 | 11 | 46 |
| | $A_1$ | 146 | 56 | 48 | 45 | 41 | 39 | 10 | 17 |
| | $A_2$ | 99 | 41 | 35 | 33 | 29 | 28 | 9 | 13 |
| | $B_1$ | 72 | 53 | 41 | 36 | 29 | 27 | 13 | 26 |
| | $B_2$ | 79 | 55 | 41 | 37 | 30 | 29 | 14 | 26 |
| U-418-II | $A_0$ | 323 | 93 | 76 | 71 | 60 | 57 | 11 | 36 |
| | $A_1$ | 119 | 51 | 44 | 41 | 37 | 36 | 10 | 15 |
| | $A_2$ | 92 | 44 | 35 | 33 | 30 | 28 | 10 | 16 |
| | B | 69 | 51 | 40 | 37 | 31 | 29 | 11 | 22 |
| U-406-I | $A_0$ | 471 | 133 | 99 | 90 | 73 | 67 | 10 | 66 |
| | A | 81 | 51 | 38 | 34 | 24 | 21 | 4 | 30 |
| | B | 66 | 37 | 32 | 30 | 25 | 23 | 5 | 14 |
| U-406-II | $A_0$ | 439 | 112 | 91 | 84 | 70 | 66 | 12 | 46 |
| | A | 102 | 49 | 40 | 37 | 31 | 29 | 6 | 20 |
| | $B_1$ | 75 | 42 | 33 | 31 | 27 | 26 | 6 | 16 |
| | $B_2$ | 81 | 44 | 37 | 35 | 31 | 30 | 8 | 14 |

**Table 4.** Inorganic composition of *Sasa*, *Picea glehnii* and *Abies sachalinensis* (%)

| Species | Location (Compartment No. in Uryu Exp. For.) | Organ | N | Ash | Components as oxide | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | MgO | CaO | $K_2O$ | $Na_2O$ | $P_2O_5$ | Total |
| *Sasa kurilensis* | 418 | Culm | 0.17 | 2.84 | 1.31 | 0.05 | 0.17 | 0.05 | 0.13 | 0.80 | 0.10 | 0.24 | 2.85 |
| | | Leaf | 1.75 | 11.49 | 7.79 | 0.13 | 0.79 | 0.15 | 0.57 | 0.99 | 0.18 | 0.35 | 10.95 |
| *Sasa senanensis* | 406 | Culm | 0.27 | 2.76 | 1.24 | 0.02 | 0.19 | 0.07 | 0.10 | 0.75 | 0.05 | 0.18 | 2.60 |
| | | Leaf | 1.31 | 16.59 | 11.68 | 0.18 | 1.14 | 0.17 | 1.03 | 0.91 | 0.12 | 0.23 | 15.46 |
| *Picea glehnii* | 113 | Bark | 0.10 | 3.69 | 1.25 | 0.36 | 0.34 | 0.20 | 0.47 | 0.62 | 0.08 | 0.17 | 3.49 |
| | | Wood | 0.05 | 1.12 | 0.27 | 0.03 | 0.05 | 0.11 | 0.27 | 0.22 | 0.02 | 0.12 | 1.09 |
| | | Less than 1-year-old leaf | 1.14 | 2.63 | 0.72 | 0.02 | 0.16 | 0.23 | 0.38 | 0.66 | 0.04 | 0.30 | 2.51 |
| | | One-year-old leaf | 0.82 | 2.87 | 1.14 | 0.04 | 0.19 | 0.22 | 0.39 | 0.61 | 0.05 | 0.25 | 2.89 |
| | | Over 2-year-old leaf | 0.84 | 3.46 | 1.42 | 0.03 | 0.14 | 0.22 | 0.62 | 0.73 | 0.05 | 0.22 | 3.43 |
| *Abies sachalinensis* | 113 | Bark | 0.09 | 2.81 | 0.56 | 0.15 | 0.09 | 0.20 | 0.57 | 0.57 | 0.08 | 0.29 | 2.51 |
| | | Wood | 0.04 | 1.11 | 0.19 | 0.05 | 0.05 | 0.09 | 0.26 | 0.30 | 0.03 | 0.16 | 1.13 |
| | | Less than 1-year-old leaf | 1.22 | 3.16 | 0.35 | 0.17 | 0.14 | 0.33 | 0.86 | 0.76 | 0.06 | 0.41 | 3.08 |
| | | One-year-old leaf | 1.16 | 3.39 | 0.59 | 0.26 | 0.12 | 0.32 | 0.89 | 0.80 | 0.07 | 0.34 | 3.39 |
| | | Over 2-year-old leaf | 1.00 | 3.61 | 0.65 | 0.25 | 0.12 | 0.26 | 1.12 | 0.82 | 0.08 | 0.32 | 3.62 |

**Table 5.** Soil properties at each experimental

| Plot | Treatment | Horizon | Depth (cm) | Thickness (cm) | Color in wet | | Hardness | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Description with naked eye | By Munsell | Tester (mm) | Consistency |
| 1 | $A_0$-removal | $A_0$ | | 2 | — | — | — | — |
| | | A | 0–22 | 22 | very dark brown | 7.5YR2/3 | 16 | slightly hard |
| | | B | 22– | 38< | brown | 10YR4/4 | 22 | very hard |
| 2 | Raking of A horizon after $A_0$-removal | $A_0$ | | 2 | — | — | — | — |
| | | A | 0–13 | 13 | dark brown | 7.5YR3/3 | 15 | slightly hard |
| | | B | 13– | 47< | brown | 7.5YR4/6 | 22 | very hard |
| 3 | $A_0$ and A horizon-removal | $A_0$* | | 1 | — | — | — | — |
| | | A | 0–2 | 2 | dark brown | 10YR3/3 | 5 | loose |
| | | $B_1$ | 2–23 | 21 | brown | 10YR4/4 | 21 | hard |
| | | $B_2$ | 23– | 37< | 〃 | 〃 | 24 | very hard |
| 4 | Non-treatment | $A_0$ | | 6 {L1, F3, H2} | — | — | — | — |
| | | $A_1$ | 0–9 | 9 | brownish black | 10YR2/3 | 13 | soft |
| | | $A_2$ | 9–23 | 14 | dark brown | 7.5YR3/3 | 21 | hard |
| | | $B_1$ | 23–46 | 23 | brown | 10YR4/6 | 20 | 〃 |
| | | $B_2$ | 46– | 24< | 〃 | 7.5YR4/4 | 19 | 〃 |

* Impossible to take a core sample on account of an extremely thin layer.

**Table 6.** Properties of fine soils

| Plot | Horizon | Mechanical analysis (%) | | | | Soil class | Air-dried moisture (%) | Maximum water holding capacity (%) | Bulk density |
|---|---|---|---|---|---|---|---|---|---|
| | | Coarse sand | Fine sand | Silt | Clay | | | | |
| 1 | A | 4 | 1 | 50 | 45 | HC | 8.37 | 110 | 0.73 |
| | B | 8 | 13 | 49 | 30 | SiCL | 9.58 | 73 | 0.86 |
| 2 | A | 2 | 12 | 64 | 22 | 〃 | 9.94 | 110 | 0.78 |
| | B | 2 | 30 | 22 | 46 | HC | 10.14 | 76 | 0.90 |
| 3 | A | 1 | 21 | 44 | 34 | LC | 9.20 | 167 | 0.55 |
| | $B_1$ | 3 | 23 | 64 | 10 | 〃 | 9.92 | 85 | 0.88 |
| | $B_2$ | 7 | 25 | 19 | 49 | HC | 10.20 | 76 | 0.89 |
| 4 | $A_1$ | 1 | 59 | 13 | 28 | SC | 8.50 | 112 | 2.31 |
| | $A_2$ | 2 | 11 | 45 | 42 | LiC | 8.46 | 92 | 2.78 |
| | $B_1$ | 3 | 5 | 55 | 37 | SiC | 10.85 | 97 | 2.90 |
| | $B_2$ | 2 | 38 | 16 | 44 | SC | 10.38 | 83 | 2.66 |

plot under natural condition

| Soil structure | Apparent specific gravity | | Moisture content based on | | Gravel (%) | Distribution of three phases (vol. %) | | | Porosity (vol. %) |
|---|---|---|---|---|---|---|---|---|---|
| | Fresh soil | Air-dried soil | Fresh soil | Air-dried soil | | Solid | Liquid | Gas | |
| — | 0.49 | 0.28 | 43.5 | 77.1 | 0 | 13 | 13 | 74 | 87 |
| crumby | 1.02 | 0.64 | 38.1 | 61.6 | 0 | 27 | 35 | 38 | 73 |
| blocky | 1.44 | 1.07 | 25.7 | 34.5 | 23 | 38 | 37 | 25 | 62 |
| — | 0.29 | 0.16 | 45.8 | 84.7 | 0 | 22 | 22 | 56 | 78 |
| crumby | 1.00 | 0.60 | 39.5 | 65.2 | 1 | 24 | 39 | 37 | 76 |
| blocky | 1.27 | 0.84 | 33.7 | 50.9 | 28 | 30 | 43 | 27 | 70 |
| — | — | — | — | — | 0 | — | — | — | — |
| granular | 0.86 | 0.54 | 37.1 | 58.9 | 1 | 24 | 32 | 44 | 76 |
| blocky | 1.07 | 0.68 | 36.7 | 57.9 | 10 | 23 | 39 | 38 | 77 |
| " | 1.34 | 0.94 | 30.1 | 43.1 | 4 | 32 | 40 | 28 | 68 |
| — | 0.22 | 0.09 | 57.8 | 136.7 | 0 | 7 | 13 | 80 | 93 |
| loose granular | 0.81 | 0.50 | 39.1 | 64.3 | 0 | 22 | 32 | 46 | 77 |
| crumby | 1.09 | 0.67 | 38.3 | 62.0 | 0 | 24 | 42 | 34 | 76 |
| " | 0.99 | 0.61 | 38.6 | 62.8 | 38 | 21 | 38 | 41 | 79 |
| blocky | 1.36 | 0.93 | 32.0 | 47.0 | 16 | 36 | 44 | 20 | 64 |

obtained from each experimental plot

| Real specific gravity | pH | | pF value (water ratio %) | | | | | Available moisture (points) |
|---|---|---|---|---|---|---|---|---|
| | $H_2O$ | N-KCl | 1.6 | 2.7 | 3.1 | 3.9 | 4.2 | |
| 2.30 | 4.1 | 3.8 | 40 | 31 | 29 | 23 | 21 | 19 |
| 2.84 | 4.5 | 4.2 | 44 | 35 | 32 | 26 | 23 | 21 |
| 2.48 | 4.2 | 3.8 | 47 | 37 | 34 | 28 | 24 | 23 |
| 2.80 | 4.6 | 4.3 | 46 | 36 | 33 | 27 | 24 | 22 |
| 2.24 | 4.3 | 3.8 | 52 | 38 | 34 | 27 | 24 | 28 |
| 2.89 | 4.4 | 4.0 | 42 | 31 | 29 | 24 | 22 | 20 |
| 2.91 | 4.5 | 4.1 | 44 | 35 | 32 | 25 | 24 | 20 |
| 2.31 | 3.9 | 3.5 | 50 | 38 | 32 | 23 | 20 | 30 |
| 2.78 | 4.2 | 3.8 | 40 | 32 | 29 | 23 | 20 | 20 |
| 2.90 | 4.0 | 3.9 | 51 | 41 | 37 | 29 | 26 | 25 |
| 2.66 | 4.1 | 4.0 | 44 | 33 | 30 | 26 | 23 | 21 |

3. Inorganic Components in *Sasa* Bamboo

The results of inorganic analysis of the *Sasa* species are shown in Table 4, together with those of an Akaezomatsu spruce (*Picea glehnii*) and a Todomatsu fir (*Abies sachalinensis*). As all the samples were collected in September in Uryu Experiment Forest, the comparison might be possible with one another. The culms of the *Sasa* species have nitrogen of 0.17 to 0.27%, which is relatively higher than the barks and woods of the conifers. Meanwhile, the *Sasa* leaves show also the higher content than those of the conifers. However, compared with broad-leaved trees, having the nitrogen of 2.71 and 3.25% in those of an oak and a basswood, respectively,[11] that of the *Sasa* leaves is considerably less. The ash content, on the other hand, shows about the same in the *Sasa* culms as the barks of the conifers, but that in the *Sasa* leaves is extremely high, as shown at 11.49 and 16.59% in *S. kurilensis* and *S. senanensis*, respectively. The greater part of it is silicon that coinsides with the fact the *Sasa* species are a typical silicicolous plant. Aside from the silicon, both the culms and leaves have in general high potassium content. It is also recognized that the potassium content is considerably high in the inorganic composition of the culms and that iron is somewhat more contained in the leaves.

On phosphorus, one of the essential elements of the plant, the content in the *Sasa* is higher in the leaves than in the culms and lower than that of the fir tree and broad-leaved trees.

The comparison of the two coniferous trees, the woody part of which has higher ash content in some degree than that from previous data owing probably to the use of the branches, shows the similar ash content to each other. The ash, however, is composed much of silicon in the spruce, whereas that in the fir is composed much of calcium. In comparison of ages of the leaves, a tendency is shown that the younger leaves have higher nitrogen and phosphorus but lower ash content than the older ones.

4. Changes of Soils and Floor Plants by Surface Treatments

Soil properties of the land elapsing for 14 years after the surface treatments are shown in Table 6 and Fig. 3, together with those of the untreated. The profiles indicate to be all composed of $A_0$ layer, A and B horizons. And the thickness of $A_0$ layer is naturally thin at the treated plots, especially as thin as 1 cm at the Plot 3 removing $A_0$ and A horizon soils, while the untreated land has $A_0$ layer of a 6-cm thickness divided into L, F and H layers. As for A horizon, Plot 3 gives a 2-cm A horizon newly formed in dark bown color, whereas Plot 2 raked with a bulldozer possesses A horizon of a 13-cm thickness gradually transformed to B horizon. Plot 4 of the non-treatment has A horizon of a 23-cm thickness divided into $A_1$ and $A_2$ with naked eye. The structure of A horizon is either crumby or loose granular one, showing a hardness of below 16 mm by the hardness gauge. On the other hand, B horizon in brown color, relatively abundant in gravels, forms blocky structure, indicating the consistency of either hard or very hard. The moisture content of B horizon soils is in general less than that of A horizon,

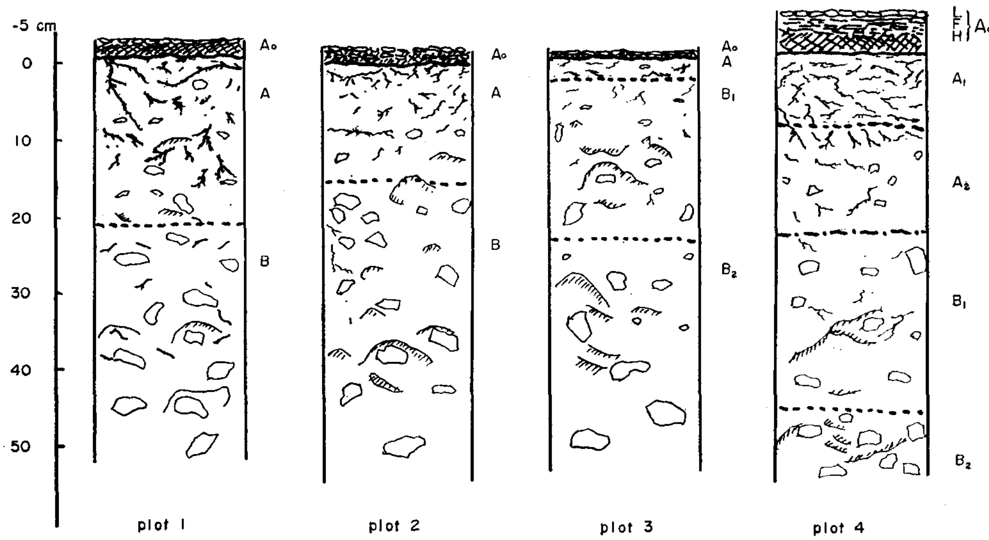


**Fig. 3.** Soil profiles at each experimental plot.

though giving a high rate of liquid phase in the distribution calculated by volume percent, while the rate of solid phase is as high as 30 to 38%, compared with that occupied in A horizon.

The results of fine soil analyses are shown in Table 6. All the soils are rich in clay and belong largely to clayey texture of soil class classified by the mechanical analysis (heavy, silty, loamy or sandy clay). In the analysis of maximum water holding capacity, the maximum of 167% is given by the A horizon soils obtained from Plot 2, which bring also to the minimum bulk density of 0.55. The value of pH is in general low, especially as strongly acidic as 3.5 in 1-N KCl solution in case of the soils from $A_1$ horizon of the untreated. The available moisture calculated is also low ranging from 19 to 30 points.

Floor plants growing at each experimental plot are summarized in Table 7. The largest number of the vegetation is given at Plot 1, removal of $A_0$ layer, while at Plots 3 and 4 the number is smallest. The untreated Plot 4 is naturally covered with *S. kurilensis*, but the shrubs of *Vibrunum furcatum* are in some extent growing in the *Sasa* community. At Plots 1 and 3, regenerated *Sasa* is numbered 10 and 1, respectively, whereas no *Sasa* is found at Plot 2 raked after removal of $A_0$ layer.

5. Regeneration of Trees

Table 8 shows the results of inventory of the trees and *Sasa* examined at each experimental plot. The numbers of the trees are 28, 30 and 80 excluding the withered, at Plots 1, 2 and 3, respectively. The largest obtained at Plot 3 corresponding to 200,00 per hectare, is inferred to be based on the decrease of both insects and micro-organisms living in $A_0$ and A horizon by the treatment. The main tree species listed are: *Betula ermanii, Abies sachalinensis* and *Acer mono.*

**Table 7.** Floor plants at each experimental plot

| Plot | Species | Cover degree | Sociability |
|---|---|---|---|
| 1 | *Hydrangea petiolaris* | 2 | 2 |
| | *Symplocarpus renifolius* | 1 | 2 |
| | *Disporum sessile* | 2 | 1 |
| | *Sasa kurilensis* | 1 | 1 |
| | *Codonopsis lanceolata* | 1 | 1 |
| | *Cirsium kamtschaticum* | + | 1 |
| | *Vitis coignetiae* | + | 1 |
| | *Galium trachyspermum* | + | 1 |
| | *Maianthemum dilatatum* | + | 1 |
| | *Rubus* spp. | + | 1 |
| | *Sambucus sieboldiana* var. *miquelii* | + | 1 |
| | *Peracarpa carnosa* | + | 1 |
| | *Euonymus* spp. | + | 1 |
| 2 | *Rubus* spp. | 2 | 1 |
| | *Disporum sessile* | 1 | 2 |
| | *Eupatorium chinense* var. *sachalinense* | + | 1 |
| | *Symplocarpus renifolius* | + | 1 |
| | *Vitis coignetiae* | + | 1 |
| | *Dryopteris austriaca* | + | 1 |
| 3 | *Hydrangea petiolaris* | 2 | 3 |
| | *Maianthemum dilatatum* | + | 1 |
| | *Rubus phoenicolasius* | + | 1 |
| | *Sasa kurilensis* | + | 0 |
| 4 | *Sasa kurilensis* | 5 | 5 |
| | *Viburnum furcatum* | 2 | 2 |
| | *Hydrangea petiolaris* | + | 1 |
| | *Peracarpa carnosa* | + | 1 |

**Table 8.** Trees and *Sasa* growing at each experimental plot (2 m×2 m)

| Plot | Species | Number | Diameter at butt: Mean (cm) Min.-Max. | Diameter at butt: Standard deviation (cm) | Diameter at butt: Coefficient of variation (%) | Height: Mean (m) Min.-Max. | Height: Standard deviation (m) | Height: Coefficient of variation (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | *Acer mono* | 15 | 0.63 / 0.3-1.1 | 0.226 | 35.9 | 0.61 / 0.21-0.03 | 0.233 | 38.2 |
| | *Betula ermanii* | 7 | 6.24 / 1.4-12.3 | 3.314 | 53.1 | 5.85 / 1.99-7.50 | 1.704 | 29.1 |
| | *Phellodendron amurense* | 5 | 0.96 / 0.4-1.7 | 0.422 | 44.0 | 0.74 / 0.46-1.67 | 0.466 | 63.0 |
| | *Ulmus davidiana* var. *japonica* | 1 | 0.50 | — | — | 0.33 | — | — |
| | (*Sasa kurilensis*) | (10) | 1.50 | — | — | 2.85 | — | — |
| | Total of trees | 28 | | | | | | |
| 2 | *Betula ermanii* | 18 | 3.31 / 0.7-8.3 | 2.484 | 75.0 | 3.37 / 0.76-6.67 | 2.077 | 61.6 |
| | *Acer mono* | 10 | 1.05 / 0.4-1.7 | 0.406 | 38.7 | 1.17 / 0.45-2.12 | 0.507 | 43.3 |
| | *Salix bakko* | 2 | 2.7 | 0 | 0 | 3.53 / 3.52-3.53 | 0.010 | 0.3 |
| | Total | 30 | | | | | | |
| 3 | *Betula ermanii* | 42 | 1.52 / 0.8-2.6 | 0.625 | 41.1 | 2.08 / 0.81-3.33 | 0.707 | 34.1 |
| | *Abies sachalinensis* | 24 | 0.49 / 0.3-0.9 | 0.153 | 31.2 | 0.33 / 0.20-0.56 | 0.096 | 29.1 |
| | *Acer mono* | 11 | 0.70 / 0.4-1.0 | 0.359 | 51.3 | 0.87 / 0.16-1.43 | 0.559 | 64.3 |
| | *Quercus mongolica* var. *grosseserrata* | 1 | 0.40 | — | — | 0.39 | — | — |
| | *Salix bakko* | 1 | 4.40 | — | — | 3.17 | — | — |
| | *Sorbus commixta* | 1 | 0.30 | — | — | 0.32 | — | — |
| | (*Sasa kurilensis*) | (1) | 1.20 | — | — | 2.10 | — | — |
| | Total of trees | 80 | | | | | | |
| 4 | *Sasa kurilensis* | 43 | 1.67 / 1.3-2.1 | 0.158 | 9.5 | 3.34 / 2.66-4.02 | 0.316 | 9.2 |
| | Total | 43 | | | | | | |

The results show to coinside nearly with the report on the relation between soil type and natural regeneration of *Sasa* land.[15] On the height of the trees, the tallest is obtained from a tree of *Betula ermanii* which attained to 7.5 m in the 14-year passage, while 24 trees of *Abies sachalinensis* measured at Plot 3 were all small in their height, having an average of 33 cm. The number of *Sasa kurilensis* surveyed at Plot 4 of the non-treatment is 43, excluding 19 of withered one corresponding to 30% of the total. The size is on an average a basal diameter of 1.67 cm and a length of 3.43 m.

Biomass of trees and *Sasa* in the area of 2 m×2 m is shown in Fig. 4. The maximum is obtained at 26.4 kg of dry matters at Plot 2, occupying the stem weight of about 60%. Plot 1 also shows the biomass of a big weight including *S. kurilensis*, while Plot 3 shows only 6.9 kg. The biomass at Plots 1 and 2 is shown to reach and exceed the *Sasa* biomass through the 14-year growth, respectively. Though the total weight obtained at Plot 4 amounts to 21.1 kg including the rhizomes and leaves, the weight of the culms and branches available for the utilization is 9.74 kg, corresponding to 24 tons per hectare, which coinside nearly with the previous data.[5]

It is shown from the results that the treeless land densely covered with *S. kurilensis* can changed to forests of *Betula ermanii etc.*, having the comparable biomass after only 14 years by the surface treatment.

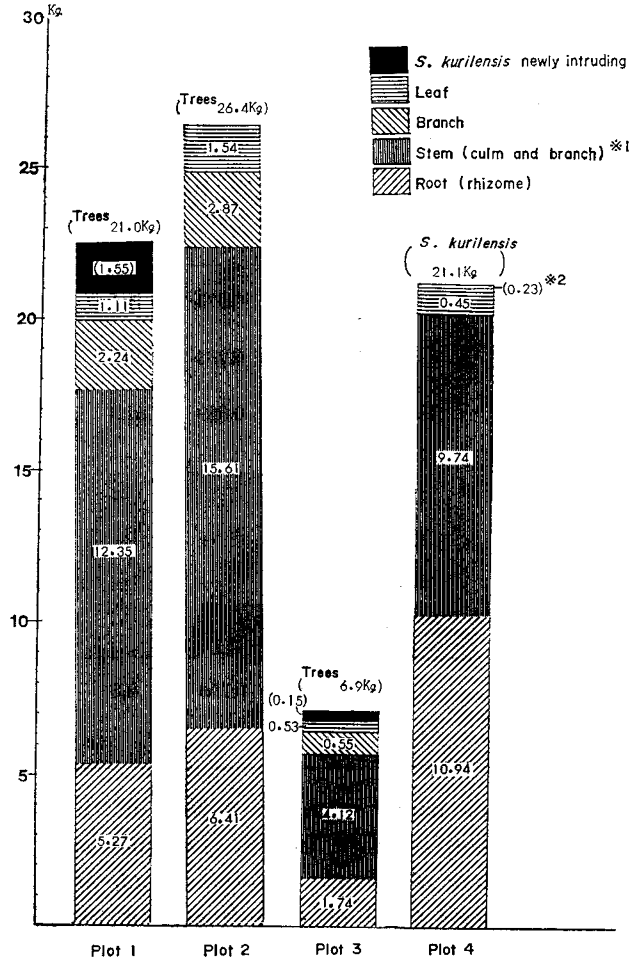


**Fig. 4.** Biomass at each experimental plot.

*1. Designations in parenthesis are for *S. kurilensis* of Plot 4.

*2. Figures in parenthesis are weights of other plants.

## Conclusions

The soils of the lands covered densely with *S. kurilensis* are shown to be physically superior, forming a thick A horizon, although chemically a little inferior with strong acidity.

*Sasa* bamboo is growing on such lands at 20 to 30 tons of the culm and branch weights as dry matter per hectare with procreative power and this biomass is estimated to be responsible for the forest resources in Hokkaido. Furthermore, the leaf has a characteristic rich in ash and a potential for some medicines, on which the researchers have recently studied.[5] However, the land is often intruded by other new plants including tree species, if *Sasa* has been removed. Accordingly, the surface treatment is a very useful method to promote it. The treated land can be easily changed to the forests composed of trees such as *Betula ermanii*, *Abies sachalinensis etc.*, corresponding to the *Sasa* biomass after only 14 years by the treatment like raking of A horizon. This also indicates the young forest has a possibility to form a valuable forest.

## Literature


1. AOYAGI, M.: Northern Forestry (北方林業) **35**, 49 (1983).
2. Hokkaido Regional Forestry Office: Natural Forest Managements in Hokkaido (北海道における天然林施業) pp. 1–214 (1984).
3. Hoppo Ringyo Kai: An Essential Handbook for Hokkaido Foresters–I (北海道林業技術者必携—上) 36 (1982).
4. KAWAHARA, T. and SUZUKI, T.: J. Jap. For. Soc., **63**, 173 (1981).
5. KAWASE, K., IMAGAWA, K. and UJIIE, M.: Res. Bull. Col. Exp. For. Hokkaido Univ., **41**, 493 (1984).
6. KUDO, H.: J. Jap. For. Soc., **62**, 1 (1980).
7. TOYODA, M., HARADA, S. and SAITO, S.: Trans. Mtg. Hokkaido Br. Jap. For. Soc. (日林北支講) **22**, 96 (1973).
8. TOYOOKA, H., SATO, A. and ISHIZUKA, M.: Northern Forestry, **33**, 143 (1981).
9. TOYOOKA, H., SATO, A. and ISHIZUKA, S.: Distribution Map of the *Sasa* Group in Hokkaido—Explanatory Note (北海道ササ分布図—概説). Hokkaido Br. For. & For. Prod. Res. Inst. (林試道支場) pp. 1–36 (1983).
10. UCHIDA, T. and MATSUDA, K.: Trans. Mtg. Hokkaido Br. Jap. For. Soc., **29**, 74 (1980).
11. UJIIE, M. and NISHI, Y. and KUDO, H.: *ibid.*, **26**, 120 (1977).
12. UJIIE, M. and MAEDA, Y.: Res. Bull. Col. Exp. For. Hokkaido Univ., **40**, 464 (1983).
13. UJIIE, M.: *ibid.*, **41**, 149 (1984).
14. UJIIE, M.: Proceedings IUFRO Symposium on Forest Management Planning and Managerial Economics, 782, (1984).
15. Uryu Exp. For. Office: Outlines of Uryu Exp. For. Hokkaido Univ. (北海道大学雨竜地方演習林) (1982).
16. YOKOTA, K., MATSUZAKA, S. and KAWAHARA, T.: Northern Forestry, **33**, 211, 247, (1981).

## 摘　　要

北海道の山野を覆っているササ類は，その旺盛な繁殖力と適応性により，北海道全面積の89%，500万haにわたって生育している。その中，稈長2m以上の大型のササ（チシマザサ別名 ねまがりだけ *Sasa kurilensis* MAKINO et SHIBATA）は，日本海側および山間高所の多雪地帯に広く分布し，しばしば広大な無立木地を呈している。一方，稈長1m前後の中型のササ（クマイザサ *Sasa senanensis* RHED.）はササ類の主体を形成し，この両者を合せた蓄積量は，本道における立木の重量蓄積量の実に28%にも達すると言われている。北海道の北部に位置する北海道大学雨竜地方演習林においては，標高およそ400m以上の森林には，主としてチシマザサが繁茂し，またそれ以下の低所の林床には，クマイザサが密生している。このようなところは，樹木の種子が落下しても，厚い落葉層のため発芽が困難で，たとえ発芽しても，多くはササの被圧や土壌昆虫あるいは微生物により枯死し，林木の更新は見られない。雨竜地方演習林では，その経営方針に則り，ササ地への林木更新技術確立の一環として，昭和43年（1968）以来，大型機械を導入してかき起しを実行し，樹木の発芽更新を図っている。昭和43年には，同林418林班のチシマザサを筋刈して，パーチクルボード原料として売却した跡地に，ブルドーザを使用して$A_0$層除去あるいはA層かき起しを含む種々の地表処理を行い，ササ試験地としてその推移を観察している。

本研究では，道北で多く見られるチシマザサ生育無立木地（雨竜地方演習林418林班）とクマイザサ生育の疎林地（406林班）を選んで，土壌の理化学的性状を調査し，あわせて，ササの主要無機成分をしらべた。さらに，上記ササ試験地を設定14年後に調査し，地表処理の違いが樹木の侵入，生育状況，植物現存量に及ぼす影響，あるいは$A_0$, A層の回復の状態や処理後の土壌の理化学的性質の変化を追究した。

これらの結果は次の通りである。

1）チシマザサ生育無立木地のA層は極めて厚く，$A_1$, $A_2$層合せて25～33cmにも達し，土壌はいずれも直径0.1～0.3cmの団粒構造を形成している。しかもA層の孔隙量は70%を超え，容積重も小さい。

2）しかし，細土の分析結果，A層の土性は重埴土で，遠心分離法によるpF1.6と4.2における含水比より求めた有効水分は，15～17ポイントであり，腐植に富むため，pHが低く，塩基飽和度も低い。CN率は12～14で微生物による土壌有機物の分解は進んでいるものと思われる。

3）B層は典型的な褐色森林土の色調で，下部は礫が多く，孔隙量は小さいが，土性は壌土質であり，理学的には良好であるが，A層と同様に酸性が強く，塩基飽和度が小さいため，化学的に良好とはいえない。

4）一方，クマイザサ地では，A層の厚さは7～10cmと薄く，B層は礫に富む比較的赤味

の強い褐色で，チシマザサ生育地とは異なり，埴土質である。また細土の性質は，強酸性で，化学的に良いとはいえない。

5) チシマザサとクマイザサの無機物分析の結果，葉部の窒素分は，針葉樹のそれとくらべ多いが，以前に報告した広葉樹(ミズナラ，シナノキ)葉より著しく少ない。リン酸の割合は，いずれの樹葉とくらべても大差はなく，カリについては針葉よりわずかに高く，広葉樹の葉よりかなり低い値がえられている。

一方，灰分は11～16%にも達し，その大部分は珪酸であり，樹葉とは大きく異なっている。

6) ササ試験地の14年後の調査結果，$A_0$層除去，$A_0$層除去後A層かき起し，および$A_0$層A層除去で，新たに形成された$A_0$層の厚さは，それぞれ2，2および1 cmで，対照区では，6 cmの厚さをもっている。またA層まで除いた試験地では，A層が漸く2 cmの厚さで形成されている。

7) これらのA層の土壌は，大部分団粒か細粒構造をもち，水分保持力は高いが，粘土質である。B層は硬度が高く，礫が多いが，一般的に理学性は良好な土壌といえよう。

8) 地表処理試験地の植生の発生状態は，$A_0$層除去では，種類が最も多く，ササも10本回復している。一方，$A_0$層除去後A層をかき起したところでは，エゾイチゴなどイチゴ類が多く，ササは少ない。また$A_0$層，A層除去試験地は，ツルアジサイが多い。

9) つぎに，樹木の生育状況を2 m×2 mの一定面積の毎木調査によって調べたところ，$A_0$層除去と，$A_0$層除去A層かき起し地は，それぞれ生立本数が28と30本で，互いによく似ているが，$A_0$, A層を除いた試験地は，樹木の本数が80本と多い。上層を形成している樹種はほとんどダケカンバであり，その大きさは処理の違いで異なり，$A_0$層除去では，14年間ですでに7.5 mの樹高のダケカンバが見られたのに対し，A層まではぎとった試験地では，平均樹高2 mの細いダケカンバと平均33 cmの小さいトドマツで林分を構成している。

10) その植物現存量を根・幹・枝・葉に分けて，乾物に換算して算出した結果，$A_0$層を除いたところと，$A_0$層除去後A層をかき起した試験地の樹木のバイオマスは21.0 kgおよび26.4 kgで，すでに対照区のササ現存量に匹敵するか，あるいはそれを超えている。しかし，A層まではぎとったところでは，そのバイオマスはわずか6.9 kgである。

11) 以上のことから，チシマザサの密生している無立木地への樹木の導入には，地表処理はよい手段であり，とくに栄養に富み，膨軟な土壌であるA層をかき起す方法は，極めて良い結果をもたらした。

12) しかしながら，それを価値ある森林へもっていくためには，今後一層研究を深める必要がある。またこのように繁茂しているササは樹木の発芽，生育の邪魔物として徒らに除去することのみ考えず，新たなバイオマス資源としてもう一度見直し，それを有効に利用することも考慮することが重要であろう。