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An Investigation on Forests in Nepal

By

Tsuneo NAKASUGA*

ネパールの森林について

中須賀常雄

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Introduction

Up to the present day, many scientists of Hokkaido University have visited Himalayan Ranges to make their natural history clear. Chamlang (1962), Nal-Kankar (1963) and Central Nepal Himalaya Geological and Glaciological (1965) Expeditions brought various informations on geology, glaciology and botany. In 1968, the Himalayan Committee of Hokkaido University sent a biologist party to the Central Nepal. This party obtained many data in relation to invertebrates, mammalia, birds, insects and fresh water algae. In the next year, the Himalayan Committee of Hokkaido University dispatched an investigation party to the Nepal Himalaya again. This expedition was constituted by three groups; geological, anthropological and botanical group.

The author was a member of the botanical party of Scientific Expedition of Hokkaido University in 1969. The botanical group stayed in Nepal from August to November in 1969.

Our research program was prevented by the lack of manpower and heavy rainfall. In this paper, the author describes a preliminary investigation on the forest type of Nepal.

Botanical investigation of the Nepal Himalaya was started by B. HAMILTON (1802, 1803). NATHANIEL WALLICH (1820, 1821) compiled a flora of Nepal on the base of species collected at Kathmandu and Gosainkunda. In 1847, J. D. HOOKER traveled through East Nepal and recorded the Flora of British India. Thereafter, during about a half century, nobody entered into Nepal for collecting plant.

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Recently, U. SCHWEINFURTH and others reported about the vegetation of Nepal.

After 1960, many Japanese expeditions entered into Nepal and collected phanerogams, ferns, mosses, fresh water algae and lichens. KAWAKITA (1955), NAKAO (1955) and NUMATA (1967) reported the ecological study of vegetation. KITAMURA (1955) and HARA (1966) investigated the flora of Central and East Nepal respectively. From the phytogeographical viewpoint, the Nepal Himalaya range belongs to Chino-Japanese Region. There are many species in common with Nepal and Japan. On this problem, KITAMURA (1955) and KANAI (1966) emphasized the close relation between both floras.

Basing on the alternation of dominant species with increasing altitude, natural vegetation of the Nepalese Himalayas has been classified into six vegetation zones by KAWAKITA (1956). These are *Shorea* zone in 500–1200 m alt., *Shima-Castanopsis* zone in 1200–1900 m, *Picea* or *Quercus semicarpifolia* zone in 1900–2500 m, *Abies* zone in 2500–3900 m and alpine zone in 3900–5000 m. YODA (1967) referred to this problem and reported more detailed investigation of forest types.

Outline of Topography and Climate

Generally speaking, the Himalayan Ranges divided into six topographic areas along S–N direction. These are the Terai area, the Siwalik Range, the Mahabarat Range, the Midland, the Lesser Himalaya and the Great Himalaya. The northern part of the Great Himalaya called the Inner Himalaya has dry and cold atmosphere

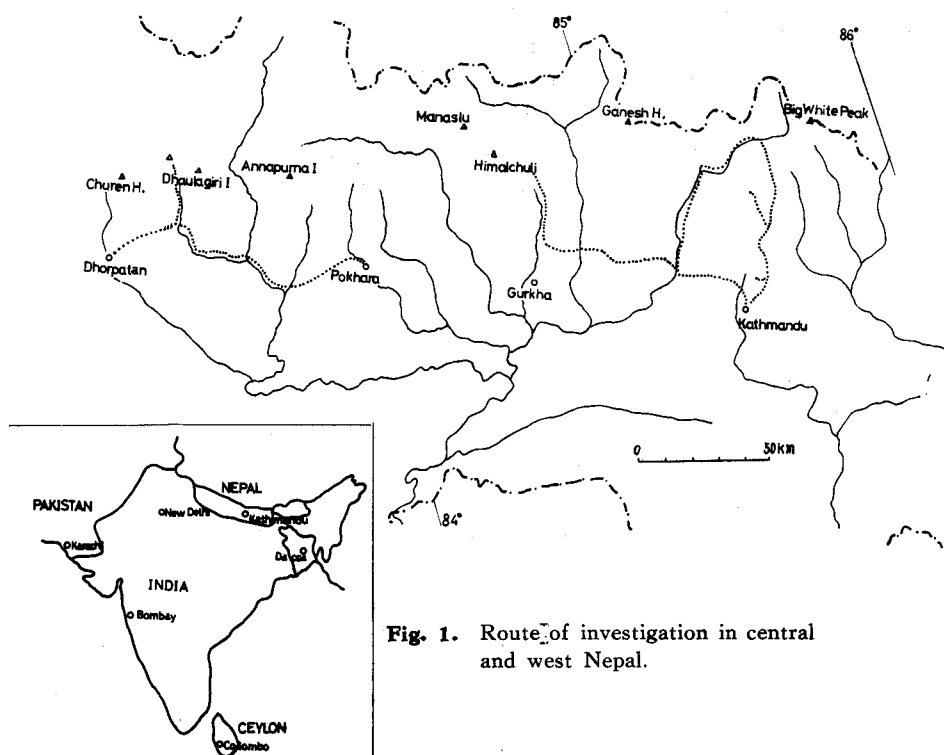


Fig. 1. Route of investigation in central and west Nepal.

(T. HAGEN, 1961). At first monsoon is cut off by the Siwalik Range and the Mahabarat Range and finally reaches the fence of the Great Himalaya. Therefore, the southern districts of the Siwalik Range and the Mahabarat Range have humid or subhumid atmosphere, and the Midland shows comparatively less humid one. The Lesser Himalaya and the southern slopes of the Great Himalaya possess heavy precipitation.

Another important factors in addition to the mountain ranges are antecedent rivers which run from north to south across the Great Himalayan Ranges. These wide and deep rivers permit monsoon to go upstream. Therefore, the fence of the mountain ranges do not completely cut off monsoon.

From climatic viewpoint, the Nepal Himalayan Range belongs to the tropical seasonal wind zone. In winter, N-E seasonal wind blows and S-W seasonal wind blows in summer. This S-W seasonal wind is called monsoon. Monsoon which originates from low atmosphere pressure of the South Indian Ocean includes very humid air and reaches to the Great Himalaya beyond Indian Plateau. The monsoon gives heavy precipitation on the Siwalik Range and Mahabarat Range. Then the monsoon passes up northward and carries rainfall on southern slopes of the Himalayas. Summer seasonal wind reaches to the Himalayas middle in May and recedes in October. Therefore, monsoon season in the Nepal ranges from May to September or early October and dry season from October to April of next year.

Annual precipitation at Kathmandu is shown in Table 1. About 90% of total precipitation is concentrated during monsoon season. The types of seasonal precipitation on the other districts in the Nepal Himalayan Range are similar respectively, however, different on its total amount of precipitation.

The Himalayan Range cuts off S-W seasonal wind and has much rainfall in

Table 1. Annual precipitation at Kathmandu (mm)

| | 1957 | 1958 | 1959 | 1069 | 1961 |
|-------|--------|--------|--------|--------|--------|
| Jan. | 70.2 | 15.5 | 35.0 | — | 10.3 |
| Feb. | — | — | 2.0 | 9.0 | 73.5 |
| Mar. | 33.0 | 19.5 | 24.0 | 44.5 | 24.0 |
| Apr. | 13.5 | 25.2 | 55.5 | 16.3 | 21.0 |
| May | 24.0 | 91.3 | 138.3 | 19.5 | 33.8 |
| June | 153.3 | 140.5 | 233.8 | 191.8 | 238.3 |
| July | 339.5 | 263.8 | 214.8 | 316.3 | 344.5 |
| Aug. | 323.3 | 317.0 | 285.0 | 233.0 | 494.8 |
| Sept. | 43.0 | 154.5 | 159.5 | 149.5 | 110.3 |
| Oct. | 13.3 | 65.3 | 90.5 | 30.8 | 172.5 |
| Nov. | — | — | — | — | 4.3 |
| Dec. | 11.8 | — | — | 0.3 | 14.5 |
| Total | 1024.9 | 1092.6 | 1238.4 | 1011.0 | 1541.8 |

(from NUMATA 1966)

summer. In winter, this range cuts off N-E seasonal wind, therefore, the southern part of the Himalayan Range shows comparatively warm atmosphere. On the contrary, the opposite slope of the Himalayan Range shows arid and cold atmosphere. This is one of the important factors as to distribution of forest type.

Nepal Himalaya is divided into three climatic zones as follows ;

1. Subtropical: the Terai, the Siwalik and the Mahabarat Range. Climate is hot and humid during monsoon. Temperature goes up sometimes more than 35°C in summer, however it never goes down below 10°C in winter.
2. Temperate: the Midland and the Lesser Himalaya. Temperature ranges from 0°C to 35°C.
3. Alpine: the Great Himalaya and the Inner Himalaya. Rainfall is scanty and temperature is low. Winter is long and cold. Summer is short and cool. Temperature ranges from below 0°C to 10°C.

Investigation of Forest Types

Investigated area is situated in the Lesser Himalaya in temperate zone. The lower part of Nepalese forest has been heavily destroyed by mankind and by grazing of buffalo, sheep and goat. The author could not observe a clear virgin forest in this area. Fully stocked forest remained was found above 2000 m in altitude. Various types of forest and scrub observed as follows ;

1. i) *Alnus nepalensis* forest
2. i) *Quercus semicarpifolia*·*Abies spectabilis* forest
3. i) *Populus*·*Salix* forest
4. i) *Tsuga dumosa*·*Quercus semicarpifolia* forest
- ii) *Tsuga dumosa*·*Abies spectabilis* forest
- iii) *Tsuga dumosa* forest (forest floor: *Arundinaria*)
5. i) *Abies spectabilis* forest (under canopy: *Rhododendron*)
- ii) *Abies spectabilis* forest (under canopy; *Juniperus*, *Acer*, *Betula*)
- iii) *Abies spectabilis* forest (under canopy: *Rhododendron*, *Viburnum*)
6. i) *Pinus Roxburgii* forest
- ii) *Pinus Griffithii*·*Abies spectabilis* forest
7. i) *Juniperus* forest
- ii) *Juniperus* scurb
8. i) *Betula utilis* forest
- ii) *Betula utilis*·*Sorbus foliolosa* forest
- iii) *Betula utilis*·*Acer* forest
9. i) *Rhododendron* forest
- ii) *Rhododendron* scrub

The author described several forest types of sample plots which were selected between 2800 m and 3200 m in altitude. From geological viewpoint, sample plots No. 1-3 located in biotite gneiss zone, No. 4, in gneiss zone and No. 5, 6, in phylites and crystalline limestone zone.

All investigation were done by belt-transect method. Sample plots were selected on the most suitable place in forest. The size of sample plot ranged from 300 m² to 500 m². All tree stems over 5 cm DBH (130 cm above the ground) were measured with diameter tape. Tree height was measured with Weise's hypsometer or scaled wood pole. Horizontal projection of crown of all trees over 5 cm DBH was drawn together with the position of their stems bases. Vertical section of the plot was also drawn.

1) *Abies spectabilis* forest

Place: Melmjan Altitude: 3050 m
 Direction: S20 W Inclination: 30°
 Size: (10 × 50) m²

Investigated area is located near the famous holy place Gosainkunde, which is in the northwest of Kathmandu, the capital city of the Nepal. Sample plot situated on the range running southwestwards from the Gosainkunde Range. This

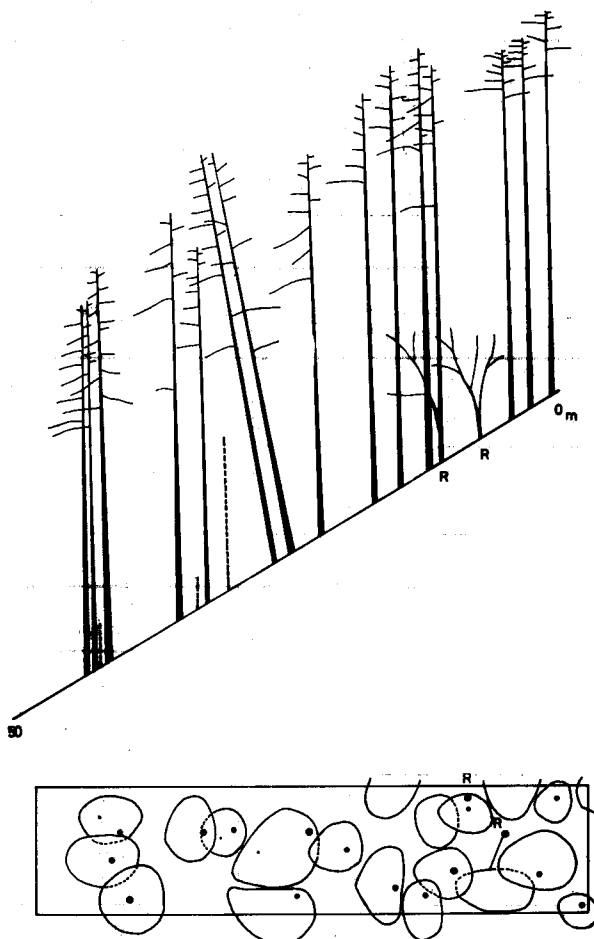


Fig. 2. No.1 *Abies spectabilis* forest.

area is the head water of Mulmchi Khola-a tributary of the Indrawati Khola. In this place, *Abies*, *Tsuga* and *Rhododendron* forest still remained. Along the gully, *Juniperus*, *Betula* and *Sorbus* forest went upwards and the limit of forest line was 3800 m or 4000 m in altitude.

In higher place of this zone, there was occupied by *Rhododendron* of alpine type and the higher place belonged to alpine zone. Beyond this range, there was arid and cool zone of the Lantang valley.

The structure of this plot was divided into three layers. The first layer was *Abies spectabilis*, the second layer was *Rhododendron* and the third layer was mosses and ferns. Lower trees and herbs were scanty. *Abies* trees of the first layer seems to be very old and tree stems and their branches were covered by mosses and ferns. Tree density was 360 per hectare, and the total of DBH basal area of all measured tree stems in the plot was 0.498% of the ground. Average height was 27.5 m and average diameter was 40.7 cm.

Table 2. Number of trees in each diameter class of belt-transect in *Abies spectabilis* forest

| Species | Breast height diameter (cm) | | 16 } | 21 } | 26 } | 31 } | 36 } | 41 } | 46 } | 51 } | 56 } | 61 } | 66 } | Total |
|------------------------------|-----------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
| | 6 } | 11 } | | | | | | | | | | | | |
| <i>Abies spectabilis</i> | . | . | . | . | . | 1 | . | 8 | 3 | 2 | . | . | 1 | 15 |
| <i>Rhododendron arboreum</i> | . | 1 | 2 | . | . | . | . | . | . | . | . | . | . | 3 |
| Total | . | 1 | 2 | . | . | 1 | . | 8 | 3 | 2 | . | . | 1 | 18 |

Table 3. Number of trees in each height class of belt-transect in *Abies spectabilis* forest

| Species | Height (m) | | 16 } | 21 } | 26 } | 31 } | Total |
|------------------------------|------------|---------|---------|---------|---------|---------|-------|
| | 6 } | 11 } | | | | | |
| <i>Abies spectabilis</i> | . | . | . | . | 8 | 7 | 15 |
| <i>Rhododendron arboreum</i> | 3 | . | . | . | . | . | 3 |
| Total | 3 | . | . | . | 8 | 7 | 18 |

Table 4. Tree composition of belt-transect in *Abies spectabilis* forest

| Species | 1st layer H>25 m | | 2nd layer H<10 m | | Total | |
|------------------------------|-------------------------|---------------------------|------------------|---------------------------|-------------------------|---------------------------|
| | Density no./plot no./ha | Basal area % of land area | Density | Basal area % of land area | Density no./plot no./ha | Basal area % of land area |
| <i>Abies spectabilis</i> | 15 300 | 0.497 . | . | . | 15 300 | 0.497 . |
| <i>Rhododendron arboreum</i> | . | . | 3 60 | 0.001 . | 3 60 | 0.001 . |
| Total | 15 300 | 0.497 . | 3 60 | 0.001 . | 18 360 | 0.498 . |

Investigation results on this belt-transect were shown in Figure 2 and Table 2, 3, 4.

2) *Tsuga dumosa*·*Abies spectabilis* forest

Place : Melmjan Altitude : 2900 m
 Direction : N40E Inclination : 30°
 Size : (10 × 50) m²

This plot is located on the slopes along the river about 300 m lower than No. 1 plot. In this altitude, forest type is usually *Abies* and *Tsuga* mixed forest. Sample plot is situated on the small range where *Tsuga* trees prevail. In this area, *Tsuga* forest appeared about 2500 m in altitude. Between 2800 m and 3000 m in alt., it replaced by *Tsuga*·*Abies* mixed forest and *Abies* forest prevailed between 3000 m and 3800 m in alt. Forest stand composition was similar to No. 1 plot. The first layer was *Tsuga dumosa* and *Abies spectabilis*, the second layer was *Rhododendron arboreum* and third layer was mosses.

Tree density was 600 per hectare there. The sum of DBH basal area of all measured tree stems in the plot was 1.065% of the ground area. Average height

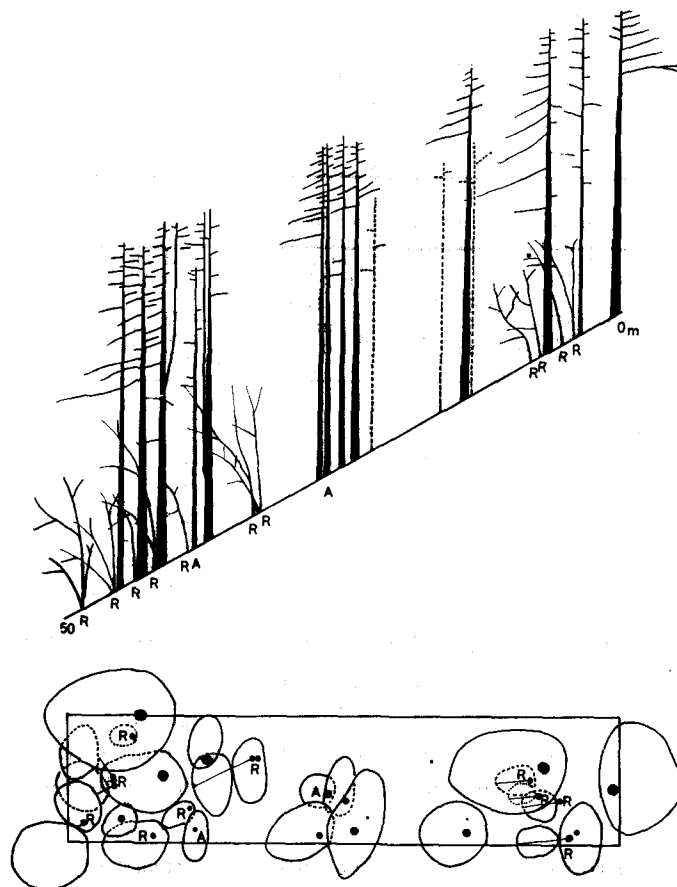


Fig. 3. No. 2 *Tsuga dumosa*·*Abies spectabilis* forest.

Table 5. Number of trees in each diameter class of belt-transect in *Tsuga dumosa*-*Abies spectabilis* forest

| Breast height diameter (cm) | 6 | 11 | 16 | 21 | 26 | 31 | 36 | 41 | 46 | 51 | 56 | 61 | 66 | 71 | 76 | 81 | 86 | 91 | 96 | 101 | Total | |
|-----------------------------|----|----|----|------|----|------|----|----|----|------|----|----|----|----|----|----|----|----|-----|-----|-------|-------|
| Species | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 | 105 | | |
| <i>Tsuga dumosa</i> | . | . | . | (1) | . | (1) | . | 2 | . | 2(1) | 1 | 1 | 1 | . | 1 | 2 | 1 | . | . | 1 | 12(3) | |
| <i>Abies spectabilis</i> | . | . | . | . | . | 1 | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | 2 |
| <i>Rhododendron</i> sp. | 1 | 7 | 5 | 3(1) | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 16(1) |
| Total | 1 | 7 | 5 | 3(2) | . | 1(1) | . | 2 | . | 3(1) | 1 | 1 | 1 | . | 1 | 2 | 1 | . | . | 1 | 30(4) | |

Table 6. Number of trees in each height class of belt-transect in *Tsuga dumosa*-*Abies spectabilis* forest

| Height (m) | 0 | 6 | 11 | 16 | 21 | 26 | 31 | Total |
|--------------------------|------|-------|----|-----|----|----|----|-------|
| Species | 5 | 10 | 15 | 20 | 25 | 30 | 35 | |
| <i>Tsuga dumosa</i> | . | . | . | (3) | 3 | 9 | . | 12(3) |
| <i>Abies spectabilis</i> | . | . | . | . | 1 | 1 | . | 2 |
| <i>Rhododendron</i> sp. | 3(1) | 11(1) | 2 | . | . | . | . | 16(2) |
| Total | 3(1) | 11(1) | 2 | (3) | 4 | 10 | . | 30(5) |

Table 7. Tree composition of belt-transect in *Tsuga dumosa*-*Abies spectabilis* forest

| Species | 1st layer H > 21 m | | 2nd layer 20 m > H > 10 m | | 3rd layer H < 10 m | | Total | |
|--------------------------|-------------------------|---------------------------|------------------------------|---------------------------|-------------------------|---------------------------|-------------------------|---------------------------|
| | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area |
| <i>Tsuga dumosa</i> | 12 240 | 0.959 . | (3) (60) | . | . | . | 12(3) 240(60) | 0.959 . |
| <i>Abies spectabilis</i> | 2 40 | 0.058 . | . | . | . | . | 2 40 | 0.058 . |
| <i>Rhododendron</i> sp. | . | . | 2(1) 40(20) | 0.001 . | 14 280 | 0.047 . | 16(1) 320(20) | 0.048 . |
| Total | 14 280 | 1.017 . | 2(4) 40(80) | 0.001 . | 14 280 | 0.047 . | 30(4) 600(680) | 1.065 . |

was 16.6 m and average diameter was 38.0 cm. Forest floor seems to be not so dark, however there was found no seedling of *Tsuga* and *Abies*. It seems that thick carpet of mosses causes to prevent the reproduction of these trees.

Investigation results on this belt-transect were shown in Figure 3 and Table 5, 6, 7.

3) *Abies spectabilis* forest (arbor under canopy: *Juniperus*, *Acer*, *Betula*)

Place: Melmjan Altitude: 3200 m

Direction: N60E

Inclination: 25°

Size: (10 × 30) m²

This plot was located 200 m above No. 1 plot and sample plot was selected in rocky place. Trees seemed to be young and forest form was uniform. The first layer which was 20 m high above the ground was *Abies spectabilis* the second layer was *Rhododendron*, *Betula*, *Acer* and *Juniperus*, the third layer was *Pieris*, *Rosa* and *Cartex*. This plot composed of six tree species (two species below 5 cm DBH) and five herbs. The ground surface was covered with mosses. Tree density was 726 per hectare. The sum of DBH basal area of all measured tree stems in the plot was 0.431% of the ground area. Average height was 18.5 m and average diameter was 26.4 cm.

Investigation results on this belt-transect were shown in Figure 4 and Table 8, 9, 10.

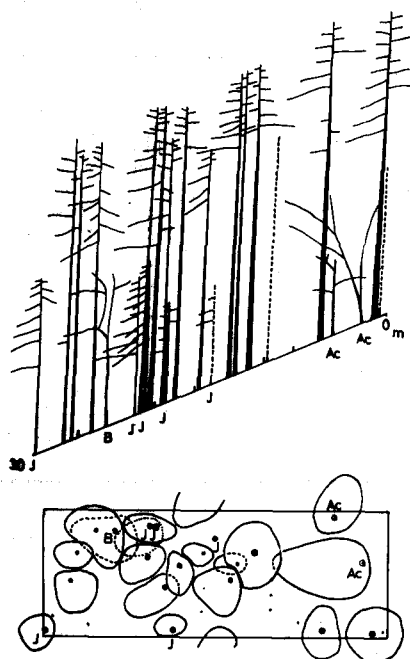


Fig. 4. No. 3 *Abies spectabilis* forest

Table 8. Number of trees in each diameter class of belt-transect in *Abies spectabilis* forest

| Breast height diameter (cm) | 6 | 11 | 16 | 21 | 26 | 31 | 36 | 41 | 46 | Total |
|-----------------------------|----|----|----|----|----|----|----|----|----|-------|
| Species | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | |
| <i>Abies spectabilis</i> | . | . | 2 | 5 | . | 2 | 2 | 1 | 2 | 14 |
| <i>Juniperus</i> sp. | . | 2 | . | . | 1 | . | . | . | . | 3 |
| <i>Acer</i> sp. | 1 | . | 2 | . | 1 | . | . | . | . | 4 |
| <i>Betula</i> sp. | . | 1 | . | . | . | . | . | . | . | 1 |
| Total | 1 | 3 | 4 | 5 | 2 | 2 | 2 | 1 | 2 | 22 |

Table 9. Number of trees in each height class of belt-transect in *Abies spectabilis* forest

| Height (m) | 6 | 11 | 16 | 21 | 26 | Total |
|--------------------------|----|----|----|----|----|-------|
| Species | 10 | 15 | 20 | 25 | 30 | |
| <i>Abies spectabilis</i> | . | . | 2 | 12 | . | 14 |
| <i>Juniperus</i> sp. | . | 3 | . | . | . | 3 |
| <i>Acer</i> sp. | 3 | 1 | . | . | . | 4 |
| <i>Betula</i> sp. | . | 1 | . | . | . | 1 |
| Total | 3 | 5 | 2 | 12 | . | 22 |

Table 10. Tree composition of belt-transect in *Abies spectabilis* forest

| Species | 1st layer H>20 m | | 2nd layer 19 m>H>10 m | | 3rd layer H<10 m | | Total | |
|--------------------------|-------------------------------|------------------------------------|-------------------------------|------------------------------------|-------------------------------|------------------------------------|-------------------------------|------------------------------------|
| | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area |
| <i>Abies spectabilis</i> | 14 462 | 0.365 . | . . | . . | . . | . . | 14 462 | 0.365 . |
| <i>Juniperus</i> sp. | . . | . . | 3 99 | 0.027 . | . . | . . | 3 99 | 0.027 . |
| <i>Acer</i> sp. | . . | . . | 1 33 | 0.019 . | 3 99 | 0.016 . | 4 132 | 0.035 . |
| <i>Betula</i> sp. | . . | . . | 1 33 | 0.004 . | . . | . . | 1 33 | 0.004 . |
| Total | 14 462 | 0.365 . | 5 165 | 0.050 . | 3 99 | 0.016 . | 22 726 | 0.431 . |

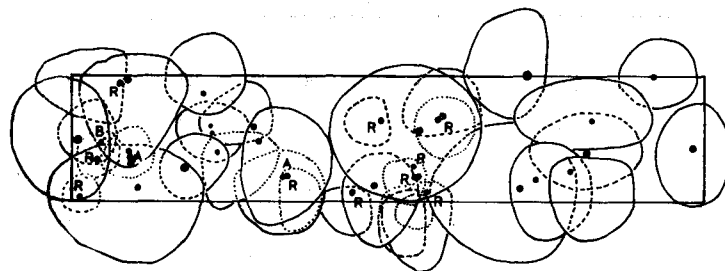
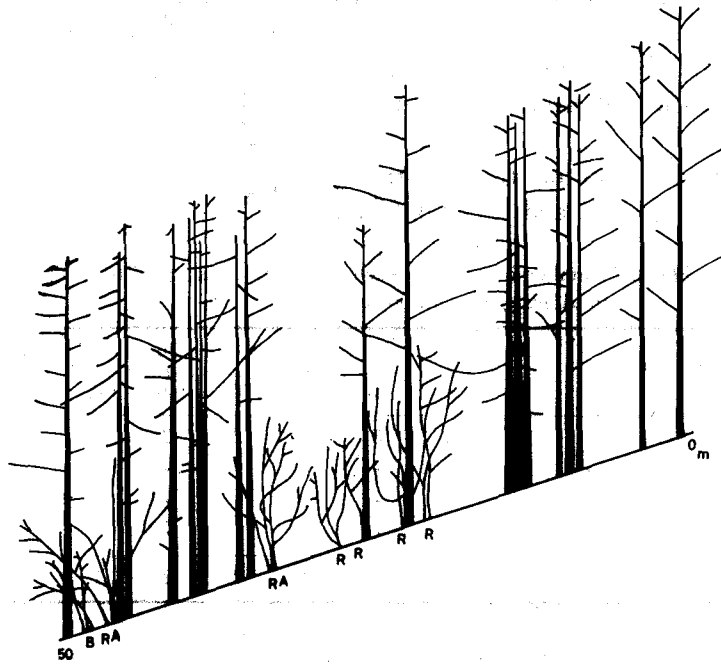


Fig. 5. No. 4 *Abies spectabilis* forest.

4) *Abies spectabilis* forest (arbor under canopy: *Rhododendron*)

Place: Barback Altitude: 3100 m
 Direction: S60E Inclination: 18°
 Size: (10 × 50) m²

Investigated area was situated in the south-eastwards range from Himlchuli. This area was the head water of Darondi Khola a tributary of the Bri Gandaki. There were many fine virgin forests everywhere between 2800 m and 3500 m in altitude. Below 2000 m in altitude of his investigated route, small forest was only found near the village and along the river. Observed forest types were *Rhododendron-Quercus* forest, *Sorbus-Betula-Rhododendron* forest and *Abies spectabilis* forest *Tsuga-Abies* forest and *Abies spectabilis* (arbor under canopy: *Acer, Rhododendron, Viburnum*) forest. Between 3500 m and 4500 m in altitude alpine type of *Rhododendron* prevailed, however, in the humid area it was replaced by alpine meadow such as *Primula, Potentilla, Gentiana* and *Leontopodium*. In this area, *Abies* forest type was the finest one and distributed everywhere. As the climate in this area is very humid, tree stems and their branches are covered with mosses, and the ground with thick mosses too.

Sample plot was selected on the small range joined with humid alpine meadow. Soil was deep and humid. Forest floor was grazed by buffalo. Canopy layer was 30 m high *Abies spectabilis* and covered more than 90% of the ground area. The second layer was *Rhododendron* and *Acer* and the third layer was seedling

Table 11. Number of trees in each diameter class of belt-transect in *Abies spectabilis* forest

| Breast height diameter (cm) | 11 | 16 | 21 | 26 | 31 | 36 | 41 | 46 | 51 | 56 | 61 | 66 | 71 | 76 | 81 | 86 | 91 | Total |
|-----------------------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-------|
| Species | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | |
| <i>Abies spectabilis</i> | . | . | . | 1 | 1 | 4 | 1 | . | 3 | 2 | 2 | 1 | . | . | 2 | 1 | 2 | 20 |
| <i>Rhododendron</i> sp. | 3 | 8 | 3 | 2 | . | . | 1 | . | . | . | . | . | . | . | . | . | . | 17 |
| <i>Acer</i> sp. | . | 2 | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | 4 |
| <i>Betula</i> sp. | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 |
| Total | 3 | 11 | 3 | 3 | 1 | 6 | 2 | . | 3 | 2 | 2 | 1 | . | . | 2 | 1 | 2 | 42 |

Table 12. Number of trees in each height class of belt-transect in *Abies spectabilis* forest

| Height (m) | 5 | 11 | 16 | 21 | 26 | 31 | Total |
|--------------------------|----|----|----|----|----|----|-------|
| Species | 10 | 15 | 20 | 25 | 30 | 35 | |
| <i>Abies spectabilis</i> | . | . | . | 1 | 11 | 8 | 20 |
| <i>Rhododendron</i> sp. | 11 | 6 | . | . | . | . | 17 |
| <i>Acer</i> sp. | 3 | 1 | . | . | . | . | 4 |
| <i>Betula</i> sp. | 1 | . | . | . | . | . | 1 |
| Total | 15 | 7 | . | 1 | 11 | 8 | 42 |

of *Abies*, *Acer* and some herbs.

Tree density was 840 per hectare, and the sum of DBH basal area of all measured tree stems in the plot was 1.182% of the ground area. Average height was 18.7 m and average diameter was 38.7 cm.

Investigation results on this belt-transect were shown in Figure 5 and Table 11, 12, 13.

Table 13. Tree composition of belt-transect in *Abies spectabilis* forest

| Species | 1st layer H>20 m | | 2nd layer 20m>H>10 m | | 3rd layer H<10 m | | Total | |
|--------------------------|-------------------------------|------------------------------------|-------------------------------|------------------------------------|-------------------------------|------------------------------------|-------------------------------|------------------------------------|
| | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area |
| <i>Abies spectabilis</i> | 20 400 | 1.007 . | . . | . . | . . | . . | 20 400 | 1.007 . |
| <i>Rhododendron</i> sp. | . . | . . | 6 120 | 0.073 . | 11 220 | 0.045 . | 17 340 | 0.118 . |
| <i>Acer</i> sp. | . . | . . | 1 20 | 0.021 . | 3 60 | 0.031 . | 4 80 | 0.052 . |
| <i>Betula</i> sp. | . . | . . | . . | . . | 1 20 | 0.005 . | 1 20 | 0.005 . |
| Total | 20 400 | 1.007 . | 7 140 | 0.094 . | 15 300 | 0.081 . | 42 840 | 1.182 . |

5) *Pinus Griffithii*-*Abies spectabilis* forest

Place : Dhorpatan

Altitude : 2800 m

Direction : S20 W

Inclination : 5°

Size : (10 × 30) m²

The aim of this investigation was to find out the forest of *Picea* and *Larix*. And the another object was to investigate the difference between arid area forest and humid area forest. The author and his supporters started at Pokara and went up along the Kali Gandaki and arrived at the head water of Mayangdi Khola, a tributary of the Kali Gandaki. In this area, the author observed the following forest types ; *Quercus* and deciduous broad leaf forest, *Tsuga* forest, *Betula* forest, narrow *Alnus* forest on river bed and scrubby *Juniperus* and *Rhododendron* forest. The character of this area was lack of *Abies* and existence of strip of deciduous broad leaf trees such as *Juglans* and *Acer*. Another one was

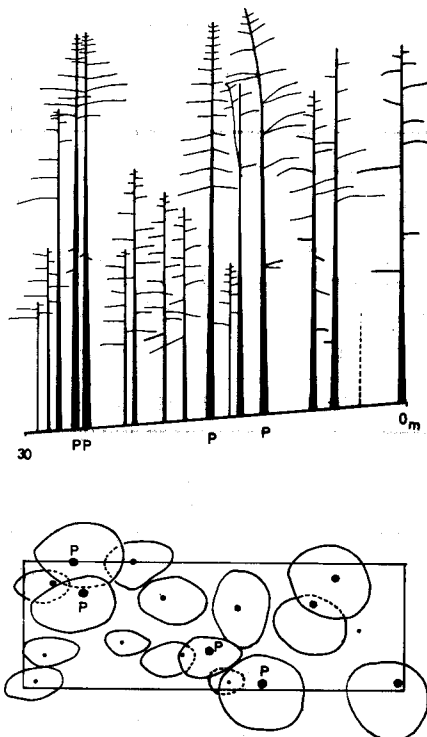


Fig. 6. No. 5 *Pinus Griffithii*-*Abies spectabilis* forest.

the existence of *Arundinaria* which distributed everywhere.

Investigated route was along the Dhola Khola, a tributary of the Mayangdi Khola and passed the Jongla Bhanjyang. The Dhola Khola side of this pass was very steep. *Quercus·Abies* mixed forest and *Betula·Acer* forest were observed there. The opposite side of the pass was very gentle and humid. In this slope, forest observed were as follows ;

Juniperus forest, *Pinus·Abies* forest, *Populus* and *Salix* forest on river side and *Betula* secondary forest due to fire on the nothern slopes :

Sample plot was selected on the flat place of river side, upstream of the Uttarganga Khola. Soil was very moist and was not so deep. From geological viewpoint, this area belongs to phyllite and crystalline limestone zone.

Tree height was 35 m above the ground and the canopy was composed of *Pinus* and *Abies* trees covered more than 60% of the ground area. The second

Table 14. Number of trees in each diameter class of belt-transect in *Pinus Griffithii·Abies spectabilis* forest

| Breast height diameter (cm) | 11 | 16 | 21 | 26 | 31 | 36 | 41 | 46 | 51 | 56 | 61 | 66 | 71 | 76 | 81 | Total |
|-----------------------------|----|----|----|----|----|------|----|----|----|----|----|----|----|----|----|-------|
| Species | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | |
| <i>Pinus Griffithii</i> | . | . | . | . | . | . | . | . | . | 1 | 2 | . | 1 | . | . | 4 |
| <i>Abies spectabilis</i> | 2 | 4 | . | . | 1 | 1(1) | . | . | 2 | . | 1 | 1 | . | . | . | 12(1) |
| Total | 2 | 4 | . | . | 1 | 1(1) | . | . | 2 | 1 | 3 | 1 | 1 | . | . | 16(1) |

Table 15. Number of trees in each height class of belt-transect in *Pinus Griffithii·Abies spectabilis* forest

| Height (m) | 6 | 11 | 16 | 21 | 26 | 31 | 36 | Total |
|--------------------------|------|----|----|----|----|----|----|-------|
| Species | 10 | 15 | 20 | 25 | 30 | 35 | 40 | |
| <i>Pinus Griffithii</i> | . | . | . | . | . | 4 | . | 4 |
| <i>Abies spectabilis</i> | 1(1) | 3 | 3 | 3 | 2 | . | . | 12(1) |
| Total | 1(1) | 3 | 3 | 3 | 2 | 4 | . | 16(1) |

Table 16. Tree composition of belt-transect in *Pinus Griffithii·Abies spectabilis* forest

| Species | 1st layer H>25m | | 2nd layer H<25m | | Total | |
|--------------------------|-------------------------|---------------------------|-------------------------|---------------------------|-------------------------|---------------------------|
| | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area |
| <i>Pinus Griffithii</i> | 4 132 | 0.422 . | . | . | 4 132 | 0.422 . |
| <i>Abies spectabilis</i> | 2 66 | 0.218 . | 10 330 | 0.242 . | 12 396 | 0.460 . |
| Total | 6 198 | 0.640 . | 10 330 | 0.242 . | 16 528 | 0.882 . |

layer was *Abies spectabilis*. Tree density was 528 per hectare. The sum of DBH basal area of all measured tree stems in the plot was 0.882% of the ground area. Average height was 22.1 m and average diameter was 40.9 cm. *Pinus* tree belonged to high diameter class and *Abies* tree distributed over the all diameter classes. Therefore, this forest stand was two-storied. Lack of *Pinus* in lower diameter classes shows that this forest stand would be replaced by *Abies* in future.

Investigation results on this belt-transect were shown in Figure 6 and Table 14, 15, 16.

6) *Juniperus* forest

Place : Dhorpatan Altitude : 3000 m
 Direction : S10W Inclination : 5°
 Size : (10 × 30) m²

This plot was located above No. 5 plot. Sample plot was selected on southern gentle slope. Soil in this area was moist. Upwards of this slope, *Juniperus* forest was replaced by *Pinus* forest because of low soil moisture. The highest tree was only 15 m above the ground. Tree density was 429 per hectare and the sum of DBH basal area of all measured tree stems in the plot was 0.636% of the ground area. Average height was 9.4 m and average diameter was 33.5 cm. Dominant tree species was *Juniperus* which distributed over the all diameter classes. This plot was composed of *Juniperus*, *Pinus*, *Berberis* and herbs.

Investigation results on this belt-transect were shown in Figure 7 and Table 17, 18, 19.

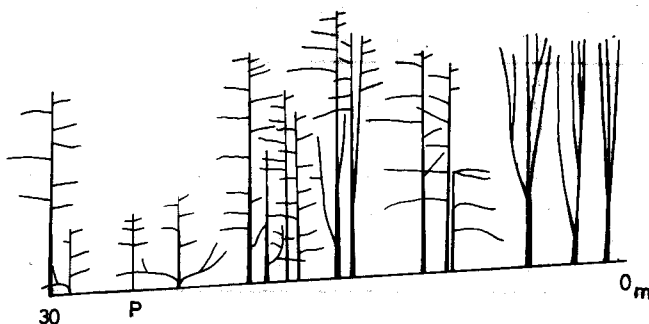


Fig. 7. No. 6 *Juniperus* forest.

Table 17. Number of trees in each diameter class of belt-transect in *Juniperus* forest

| Breast height diameter (cm) | 6 | 11 | 16 | 21 | 26 | 31 | 36 | 41 | 46 | 51 | 56 | 61 | Total |
|-----------------------------|----|----|----|----|----|----|----|----|----|----|----|----|-------|
| Species | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | |
| <i>Juniperus</i> sp. | • | 1 | 2 | 4 | 2 | 3 | 2 | 1 | 3 | • | 1 | 1 | 20 |
| <i>Pinus Griffithii</i> | 1 | • | • | • | • | • | • | • | • | • | • | • | 1 |
| Total | 1 | 1 | 2 | 4 | 2 | 3 | 2 | 1 | 3 | • | 1 | 1 | 21 |

Table 18. Number of trees in each height class of belt-transect in *Juniperus* forest

| Height (m) | 0 | 6 | 11 | Total |
|-------------------------|---|----|----|-------|
| Species | 5 | 10 | 15 | |
| <i>Juniperus</i> sp. | 4 | 3 | 13 | 20 |
| <i>Pinus Griffithii</i> | 1 | . | . | 1 |
| Total | 5 | 3 | 13 | 21 |

Table 19. Tree composition of belt-transect in *Juniperus* forest

| Species | 1st layer H>10m | | 2nd layer 10m>H>5m | | 3rd layer H<5m | | Total | |
|----------------------|-------------------------------|------------------------------------|-------------------------------|------------------------------------|-------------------------------|------------------------------------|-------------------------------|------------------------------------|
| | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area | Density no./plot no./ha | Basal area % of land area |
| <i>Juniperus</i> sp. | 13 429 | 0.595 . | 3 99 | 0.038 . | 4 132 | 0.003 . | 17 660 | 0.636 . |
| Total | 13 429 | 0.595 . | 3 99 | 0.038 . | 4 132 | 0.003 . | 17 660 | 0.636 . |

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Summary

1. Forest types observed during the time of expedition in the Nepal Himalaya in 1969 were described in this paper.

2. In the area above 2000 m in altitude, the author classified various forest types as mentioned already.

3. Sample plots were selected between 2800 m and 3200 m in altitude. Number of tree species in each plot ranged from two to six. Average tree height was 27.5 m in *Abies spectabilis* (arbor under canopy *Rhododendron*) forest and was 9.5 m in *Juniperus* forest. Tree density ranged from 360 to 840 per hectare.

4. The maximum of DBH basal area of all measured tree stems among sample plots was 1.182% of the ground area in *Abies spectabilis* (arbor under canopy; *Rhododendron*) forest and the minimum was 0.431% in *Abies spectabilis* (arbor under canopy; *Juniperus*, *Acer*, *Betula*) forest. Even in *Juniperus* forest, the basal area reached to 0.636% of the ground area.

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要 旨

1. 本稿は北海道大学ネパール・ヒマラヤ調査隊 1969 によって調査されたネパールの森林について記述したものである。

2. 調査は 1969 年 8 月より 11 月間になされた。調査プロットは中央ネパールの海拔 2800 m~3200 m 間にとった。調査された森林型はモミ林, ツガ・モミ林, マツ・モミ林, ビャクシン林である。

3. 調査プロットの樹種数は 2~6 種, 平均樹高はモミ林の 27.5 m よりジャクシン林の 9.5 m 間にあった。ha 当りの立木本数は 360~840 本であった。

4. ha 当りの胸高断面積はモミ林で 1.182% と最高値を示し, 別のモミ林で 0.431% と最小であった。また最高海拔高のビャクシン林でも 0.636% であった。



Photo 1. *Abies spectabilis* forest (Plot 1)



Photo 2. *Tsuga dumosa* · *Abies spectabilis* forest (Plot 2)



Photo 3. *Abies spectabilis* forest (Plot 4)



Photo 4. *Pinus Griffithii*-*Abies spectabilis* forest (Plot 5)



Photo 5. *Juniperus* forest (Plot 6)



Photo 6. *Betula utilis*·*Sorbus* forest (Langtang Valley)



Photo 7. *Pinus Griffithii*-*Abies spectabilis* forest (Dhorpatan)

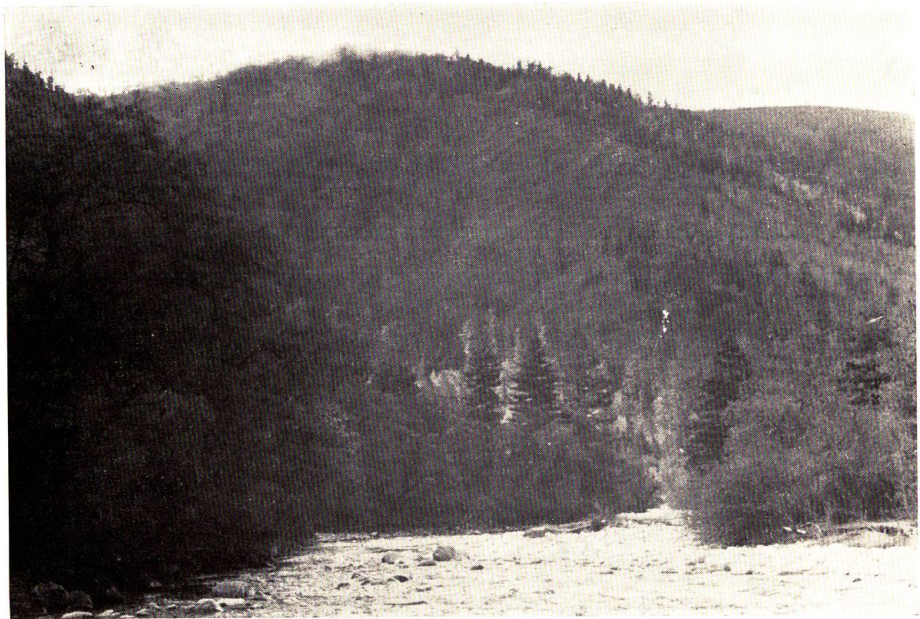


Photo 8. *Populus*-*Salix* forest (Dhorpatan)