AVALANCHE DEVELOPING PROCESS AFTER FOREST CUTTING ON HEAVY SNOW SLOPES

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Introduction

About ten to fifteen years ago, clear cutting of natural beech forests (*Fagus Crenata* Bl.) and planting of *Cryptomeria japonica* thereafter were extensively carried on in heavy-snow mountainous districts of Japan. Large beech stumps were left, because these stem bases were extensively bent by snow pressure and had lesser market values. It was well known that not only forest trees but also taller stumps were effective in supporting sloped snow-packs in avalanche hazardous areas. However, the inevitable decaying of fine roots and rootlets brought about much loss of holding capacity between soil and stumps in years after cutting, thus inducing up-rooting of the stumps when they were strongly pulled by snow-pack. Today some parts of the clear cut slopes are developing into avalanche tracks, denuded of vegetation inclusive of stumps and newly planted seedlings.

This report focuses itself on uprooting process of stumps and decrease of stumps after cutting in south Niigata Prefecture, where snow lies 3 to 5 meters deep on the avalanche hazardous slopes in mid- and late-winter.

Site and Snow Condition

Komatsubara- and Naeba-forests in the Naeba Mountains were selected with the object of comparing the uprooting

Table 1. Observed sites and stump densities.

	Observed plot						Type of forestry			Stump		
	Site. No.	Elevation. m	Aspect.	Width. m	Length. m	Sloping. degree	Cutting. year	Treatment.	Stand loss % in vol.	Density. No./ha	H* cm	D** cm
Naeba	1	1300	NNE	150	150	33	1967	thinning	90	208	160	41.5
	2	1300	ENE	150	150	33	1967	thinning	50	120	200	33.8
	3	1300	ESE	70	90	35	1967	clearcutting, leaving dense bush	100	143	150	48.0
Komatsubara	4	1100	E	100	300	35	1969	clearcutting and planting *Cryptomeria*	100	153	130	54.0
	5	1100	NW	80	200	35	1966		100	189	100	42.0
	6	1100	WNW	80	100	25	1971		100	264	70	39.6

* H Mean height, ** D Mean diameter

process after clear cutting (Komatsubara) to the one after thinning (Naeba). A 90-year-old beech forest in an area of 300 ha at Komatsubara was clear cut during the years 1966 to 1971 and then planted to Cryptomeria seedlings in that year or the year after cutting, followed by annual weeding during the first five years after the planting. While a 150-year-old beech forest at Naeba was thinned into various density by cutting of large trees alone, leaving dense bamboo grasses and bushes.

The so-called maximum snow rod, fixed with horizontal cross pieces at every 10 cm, can indicate th maximum snow depth, by measuring in the spring the maximum range of cross pieces broken due to settling snow. Also the so-called snow-glide stake, made of wood with two stair-like cross-cut incisions and a cross head as shown in Fig. 1, can give us a near total displacement of the surrounded snow-pack, since the upper half of the stake detaches easily from the fixed lower half when snow-pack pulles it downslope, and the distance between the lower and the upper half after snow melting reflects the snow movement of the winter.

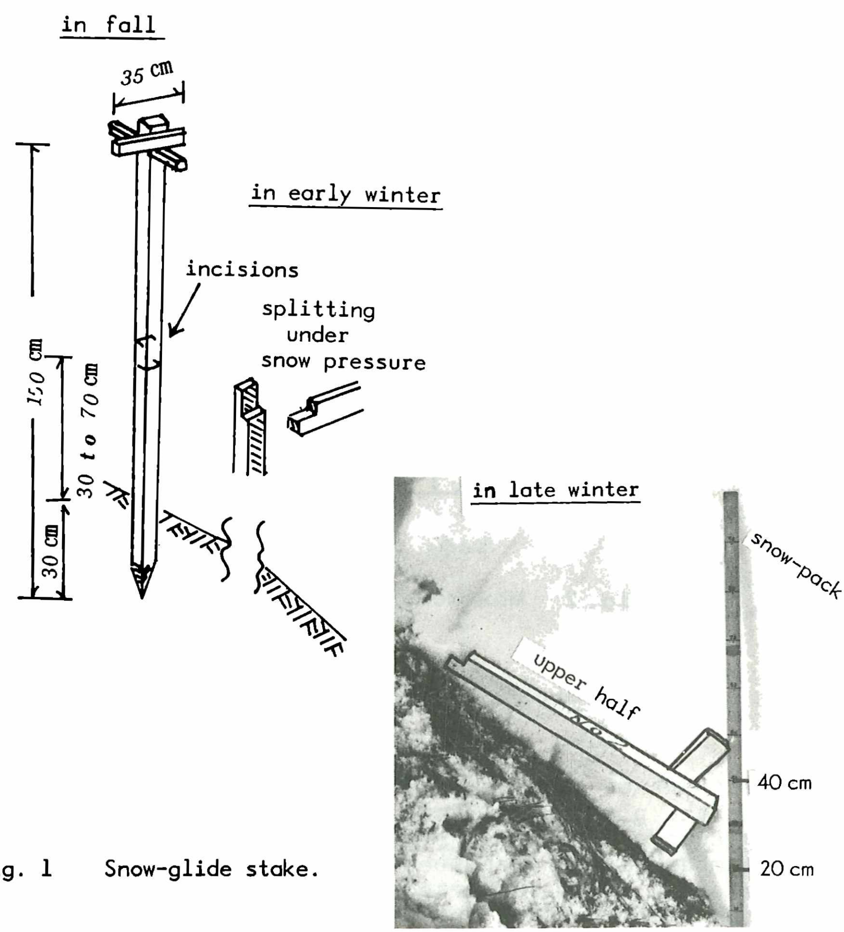


Fig. 1 Snow-glide stake.

Each fall, about ten snow-glide stakes were distributed in every plot. The average displacement of the stakes indicated the extent of the snow stability.

Among all the sites observed, No. 3 recorded a maximum of 6 m in snow depth as shown in Fig. 2. The snow survey at site No. 2 gave us a snow depth of 498 cm, a water equivalent of 1,942 mm and a snow density of 0.39 gr·cm^{-3} on March 26, 1974. At that time, almost all the small trees of less than 15 cm in d.b.h. were buried beneath the hard granular snow. Another survey on March 29, 1977 at site No. 6 showed a depth of 262 cm, a water equivalent of 1,386 mm and a snow density of 0.53 gr·cm^{-3}. The snow-pack consisted mainly of fine-grained compact snow there.

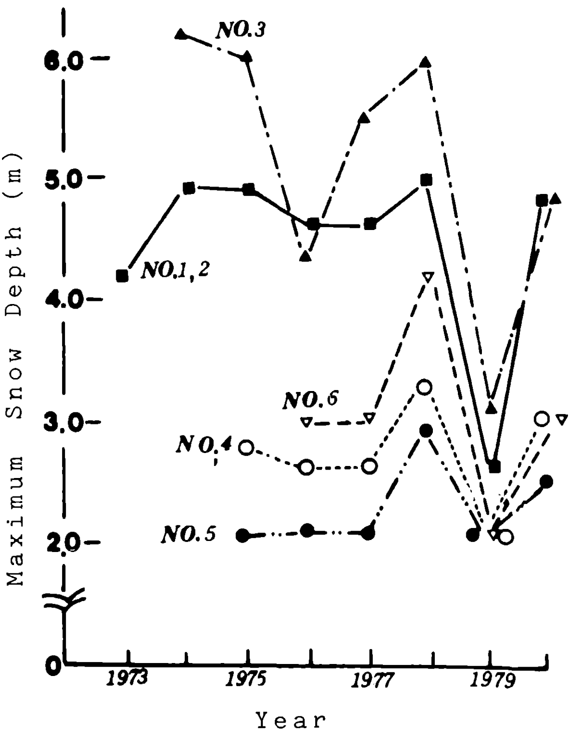


Fig. 2 Maximum Snow Depth.

Stump Uprooting Process

At the start of observation, every stump and intact tall trees in the plots were numbered, measured and mapped to check any change at a later date. The features of stump decline in number may be described as follows:

1. The number of stumps strarted to decrease at 8 years after the clear cutting and at 10 years after the thin-

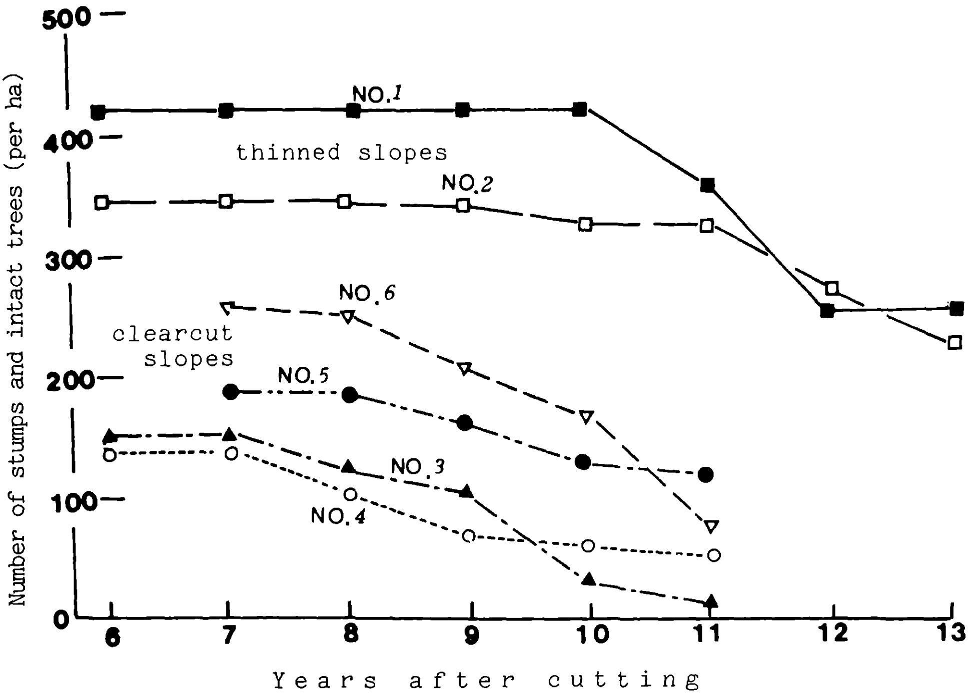
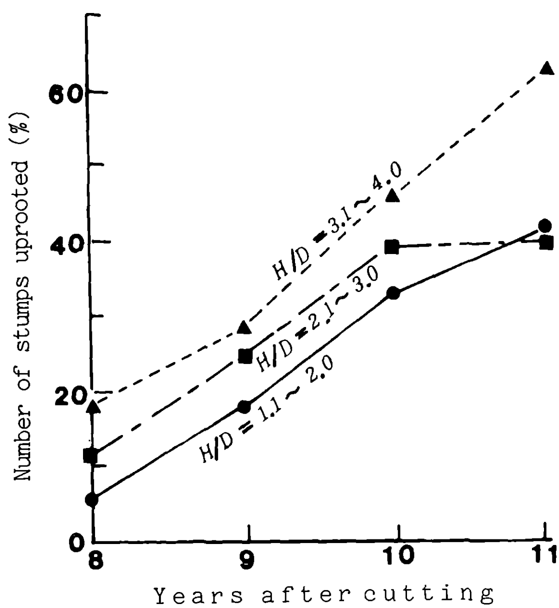


Fig. 3 Declining stump number with the elapse of years.

Fig. 4

Relationship between stump proportion H/D (height-to-diameter ratio) and number of stumps uprooted.



ning (Fig. 3), taking the form uprooting and of breakage.

2. Responding to the extent of snow pressure, stumps in snow-drifting depression sites (No. 6) fell at a higher rate than those of less snowy sites (No.4 and No.5). In a clump of closer spaced stumps, stumps located on the hill-side boundaries, fell in greater number than those on the valley-side.
3. Regarding stump proportion, stump with higher center of gravity uprooted only a year or two earlier than those with the lower gravity, as shown in Fig. 4. Therefore, it is doubtful if the two-year-delay of stump uprooting will deserve the additional expense of sawing off valueless stem-bases.
4. Generally the displacement of inclined snow-pack increased with decreasing stump density. Avalanches occured often on clear cut slopes when the stump density decreased to under 100 per ha. If compensated by growth

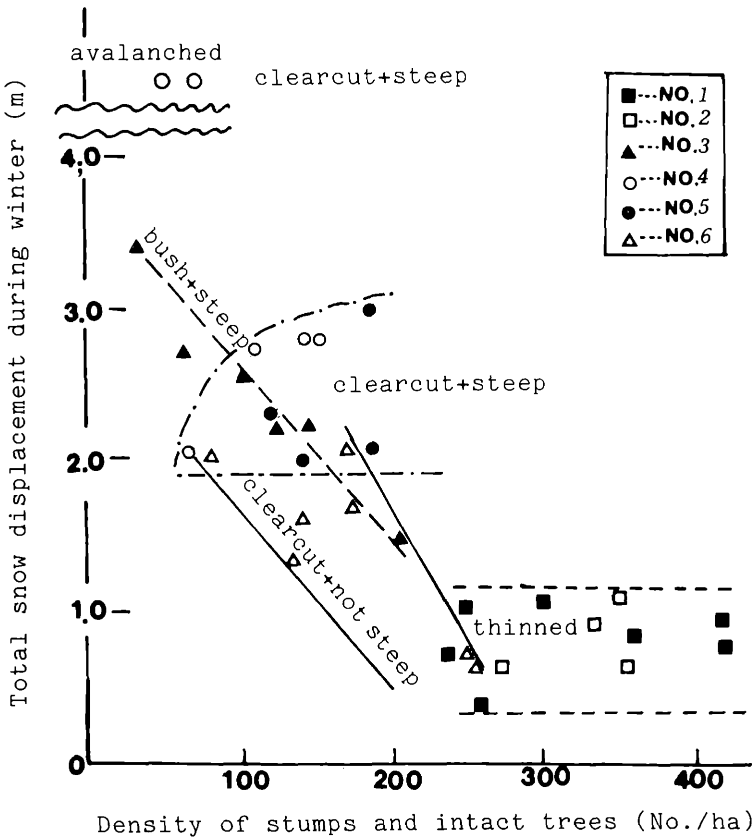


Fig. 5 Relationship between stump density and average snow displacement of site, from the measurement of "snow-glide stakes"

of bushy trees in a d.b.h. over 4 cm with a density of more than 8,000 per ha, the stump decline in number does not directly cause avalanches on regenerative slopes, as shown in Fig. 5.

Snow Erosion Developing

On heavy snow slopes, reforestation after clear cutting is not easy, because uprooted massive stumps not only leave hollow patches, but also scratch soil and vegetation (including newly planted seedlings) off the slopes on their way downslope. An uprooted 50 cm-thick beech stump alone can leave a crater-like hollow of an average size of 1.8 m (width) x 3.0 m (length) x 0.7 m (depth) at the beginning. Moreover, these hollows develope into larger denuded patches and later join together in activity of snow- and avalanche erosion as shown in Figures 7 to 10.

The elapse time after forest cutting in Fig. 6 shows that not curve A but curve B is more probable on snowy areas after forest cutting. In order to regenerate mountain forests in such heavy snow areas, it is preferable to retain effective snow-supporting stands by treatment like thinning.

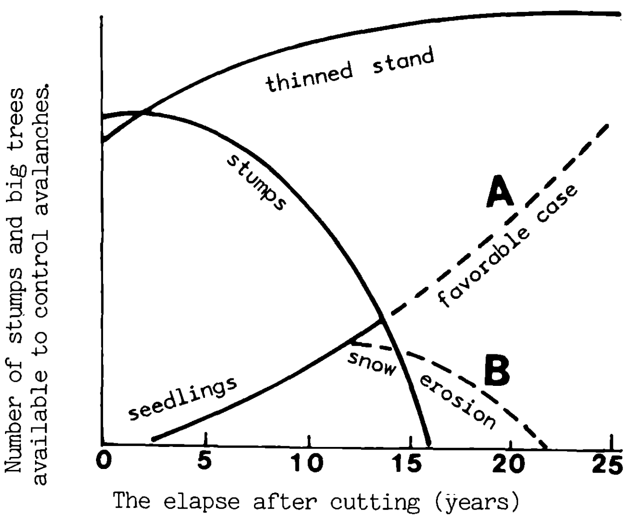


Fig. 6 Schematic process of stand developing after cutting on steep slopes from a view of avalanche-controlling.

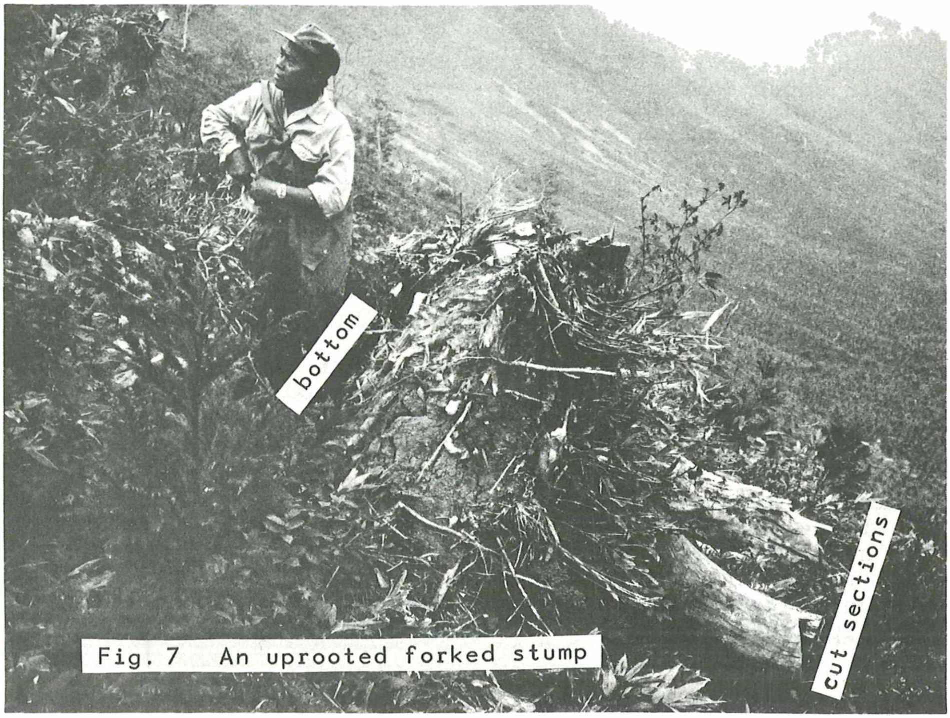


Fig. 7 An uprooted forked stump

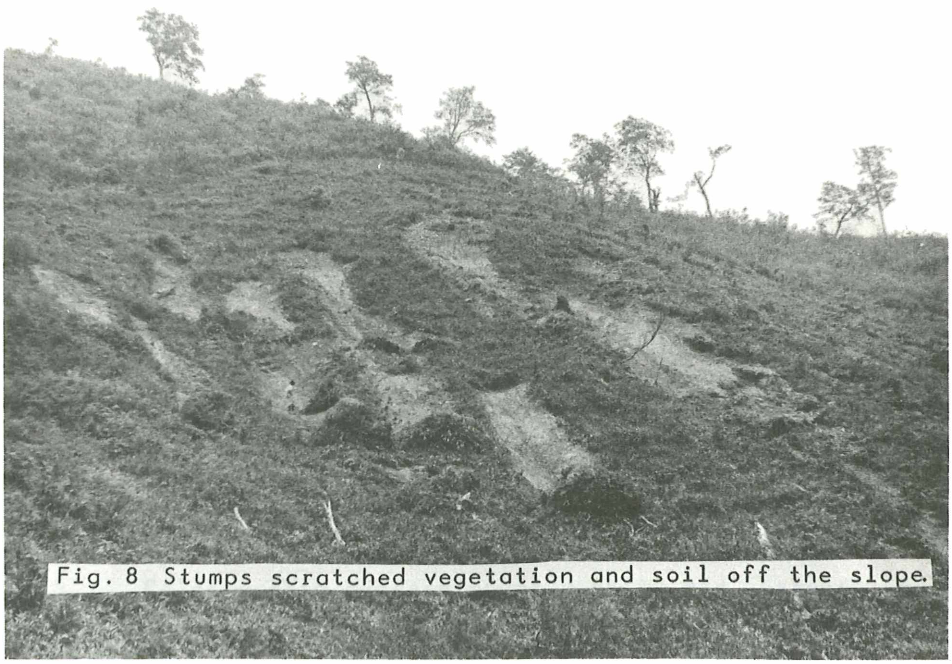


Fig. 8 Stumps scratched vegetation and soil off the slope.

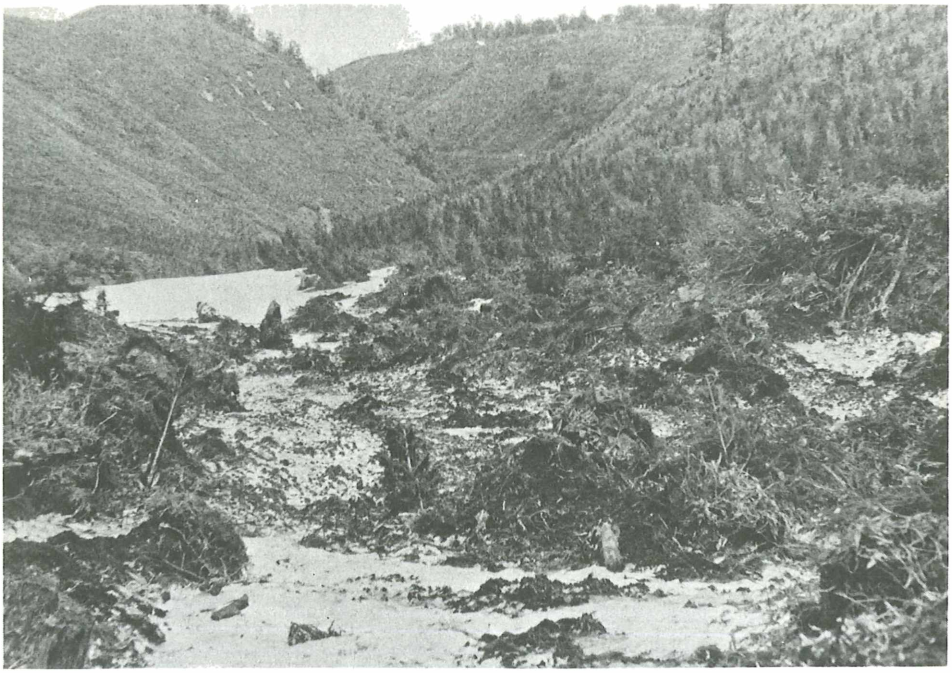


Fig. 9 Avalanches conveyed soil, stumps, seedlings, and other vegetation from the slope to the valley.

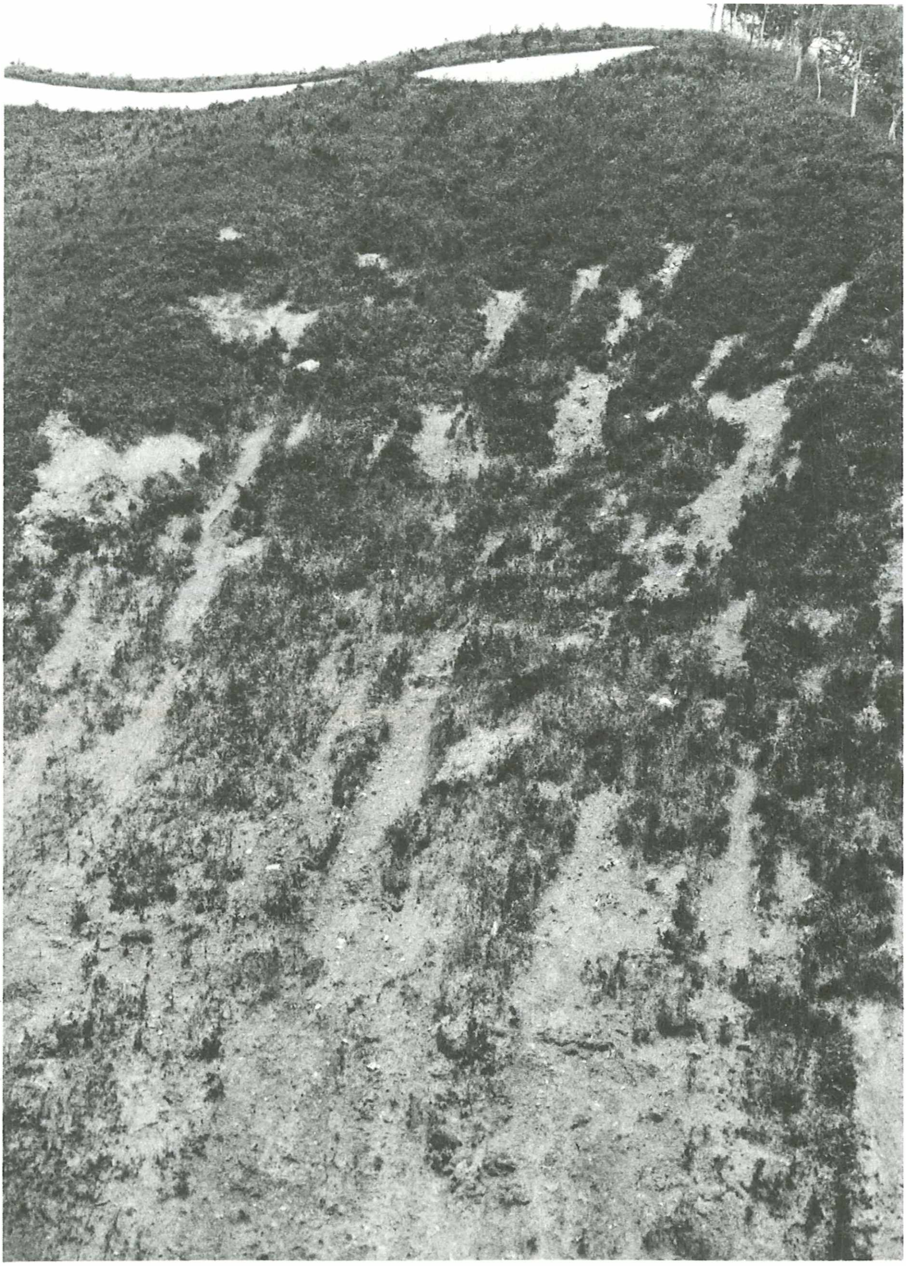


Fig. 10 A very severe chain of snow- and avalanche-erosion developes after clear cutting of beech forests.

Summary

The uprooting process and decrease in stumps after cutting on the mountain slopes in the Naeba Mountains, South Niigata Prefecture, where seasonal snow lies between 3 m and 5 m deep on the average, were followed 9 years regarding their work in controlling avalanches.

1. Stumps with a higher center of gravity, or a greater height-to-diameter ratio, decreased in number from earlier years after cutting than those in lower ratio. Stumps started to decline in number at 8 years after clear cutting and they decreased to half in 10 years, as a result of decay and uprooting due to large snow pressure.
2. In general the total displacement of inclined snow-packs in each winter increased with decreasing stump density. Ground avalanches occurred on the lush grass slopes where seedlings had been planted just after clear cutting, only when the stump densities decreased to about 100 per ha. On the bushy uncontrolled slopes where no trees had been planted after clear cutting, no avalanches occurred despite decrease of stumps and an increase of snow displacement, because some of the bushes grew to a greater size, which was enough to check release of avalanches.
3. No avalanches occurred on the slopes where different intensities of thinning had been tried, while the larger parts of clear cut slopes were developing into avalanche tracks denuded of vegetation inclusive of stumps and newly planted seedlings. In order to regenerate mountain forests in such heavy snow areas, it is preferable to retain effective snow-supporting stands by treatment like thinning rather than clear cutting.

Key words: Stump uprooting, clear cutting, erosion, snow avalanche.