Severe Snow Loads on Mountain Afforestation in Japan[1]

Ryuzo Nitta, Yoshio Ozeki, and Shoichi Niwano[2]

Abstract: A simple device for estimating snow settling force on tree branches was used to determine the distribution of snow settling force at various heights in a snowy mountainous region in Japan. A trapezoidal distribution of snow settling force was found to exist at all sites tested. It is thought that a zoning scheme based on the damaging potential of snow on young man-made forests would become possible, with the acquisition of sufficient data.

One of the largest problems in Japanese forestry lies in the low survival rate of young man-made forests in the heavy snow areas. It is rare to see a beautiful conifer plantation where snow reaches over 4 m in depth because of mechanical damage caused by large snow pressure. Both on flat locations and gentle slopes, snow settlement causes branch and stem deformation which often brings fatal breakage. To decrease such unsuccessful plantings much basic data for forest zoning are indispensable. Out of such necessity the authors have devised and set new snow poles in mountains to obtain tree-deforming factors such as maximal snow depth and snow settling force without batteries or power supply. The data from the new snow poles explain to us how severely snow loads work on young trees.

DAMAGES TO CRYPTOMERIA IN SNOW REGIONS

The Forestry and Forest Products Research Institute has a long established snow experiment station at Tokamachi City in Niigata Prefecture, Central Honshu. The Tokamachi Station is encircled by the snowy Naeba Mountains in which the authors have surveyed many conifer plantations of Cryptomeria Japonica D. Don. (Japanese cedar) (Fig. 1). The types of snow damage to Cryptomeria [Iwatsubo and Nitta 1987] are shown in Fig. 2. Straight stems have much higher market value than crooked stems. Therefore in field survey, the authors classify every Cryptomeria tree to

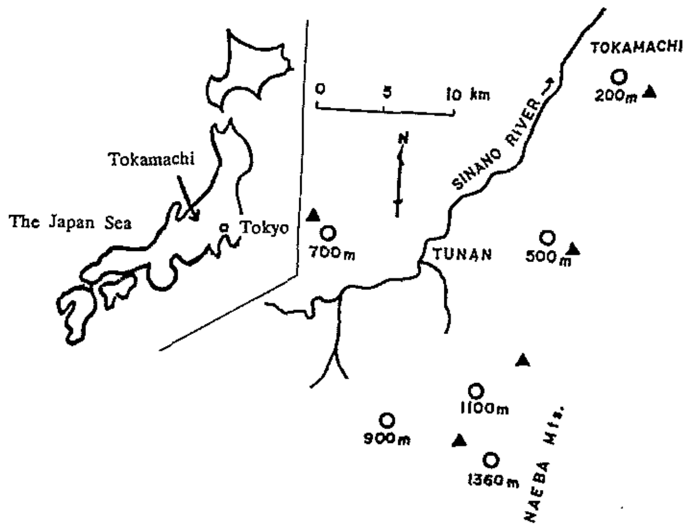

Fig. 1--The sites surveyed.
Circle: Snow settlement recorder
Triangle: Plot of Cryptomeria

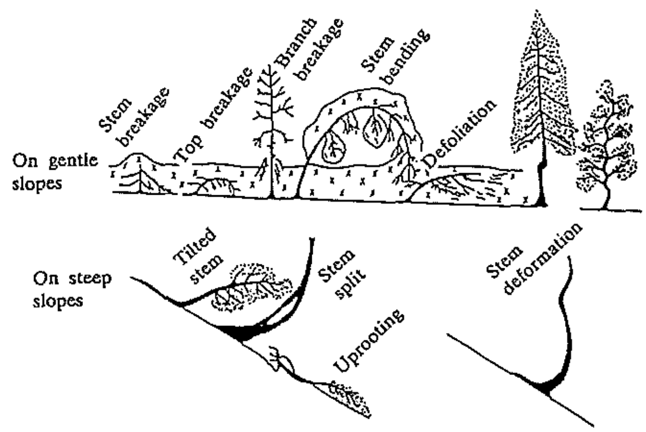

Fig. 2--Damage to Cryptomeria caused by snow loads.

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[2]Forestry and Forest Products Research Institute, Tsukuba Nohrin, Ibaraki, Japan.

Table 1 Class distribution of Cryptomeria at plots of various altitudes.

Altitude m a.s.l.	Age yr	Share A+B(pct)	Height of B m	Max. snow depth m	Altitude m a.s.l.
300	13	28	7.7 (6)*	3.1	200
620	13	41	4.4 (8)	4.0	500
750	11	39	4.1 (10)	5.2	700
1100	18	5	5.0 (10)	4.7	1100
1250	15	63	4.4 (9)	4.6	1360

*Mean of unsusceptible tree height (meter)

the following four types:

A: Middle and upper stems is straight.
Normal value.

B: Middle and upper stems are crooked, or they have traces of recovery from stem top breakage.
Lower value.

C: Tilted and crooked stem with lower tree height.
No Value.

D: Stem with breakage or large bending, totally suppressed or dead in near future.
No value.

Unless the proportion of trees in classes A and B reaches 50 percent in a surveyed plot (20 m by 20 m) when the tree height reaches twice the mean of maximal snow depth, the planting would end in failure [Shidei 1954].

Table 1 shows the result of plot surveys of Cryptomeria stands on flat sites at several altitudes. The trees at the 1250 m level would receive much more snow damage in the future because their crowns could not project over the snow surface for the next five-year period, though they show a larger share of A + B at the age of 15. In short, all of the man-made forests surveyed would bring no wood market value in the future.

INDICATIONS OF SNOW SETTLEMENT

Lower branches are often bent down due to partial destruction of their bases by heavy snow packing and settling (Fig. 3). The height above ground of the highest bent branches indicates the maximal snow depth. This deformation is being reproduced by an inexpensive recorder for maximal snow depth in Japan. The recorder consists of a pole with horizontal "branches" made of soft metal fixed at every 10 cm height increment [Takahashi K. 1968].

Long term snow settling causes the bending not only of the highest branches,

Fig. 3--Snow damage to a Cryptomeria stand.

but also of the lower branches. If the bent angles of the branches from the horizontal direction show great variety according to above-ground height, the angles would indicate the difference of snow settling power of the layers which catch and deform the branches.

To obtain more information on snow layer settling, 20-cm long galvanized iron wires of regulation quality were fixed horizontally to a 5-m tall pole at every 20-cm height increment. Late each fall, these poles with horizontal wires were set and, after the snow melted, the angles that the wires had been bent down by snow settling were measured (Fig. 4).

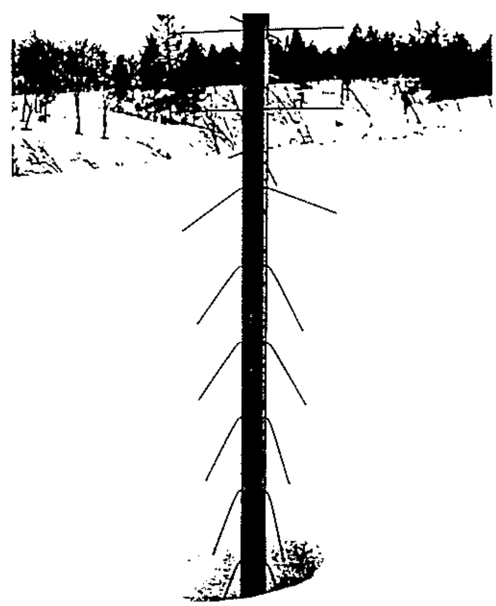

Fig. 4--Snow settling recorder.

Table 2 Average temperature during snow season at Tokamachi Expt. Stn.

Season	Dec	Jan	Feb	Mar	Apr	Mean
1980/81	1.7	-2.2	-1.4	1.8	7.2	1.4
81/82	1.6	-0.3	-1.0	3.0	10.7	2.8
82/83	3.0	-0.2	-0.9	2.3	11.9	3.2
83/84	0.1	-2.4	-2.7	0.3	6.0	0.3
84/85	1.8	-2.1	+0.4	2.7	9.8	2.5
85/86	0.8	-2.1	-2.1	2.7	7.9	1.4

(°C)

The wire was calibrated by loading in the basement of Tokamachi Station where room temperature stays at around 0°C during the whole winter (Tab. 2). Point loads were applied at the free ends of 20-cm long cantilevers for 150 days continuously during winter, and after that the bent down angles were measured (Fig. 5). The calibration curve in relation to wire diameter, angle and point load, shown in Fig.6, provides us a good indication of distribution of snow settling force along the vertical profile of the snowpack.

The data of those angles in winter 1982/83 indicate a feature common to the five profiles, that is, a trapezoidal distribution of the angles (Fig. 7). The wires planted at between +60 cm above ground and -40 cm from the highest snow surface of the season were bent at a large but almost constant angle in each case.

Figure 8 indicates that maximum snow depth at the 1360 m altitude site is about 1 m deeper than that at 500 m altitude and

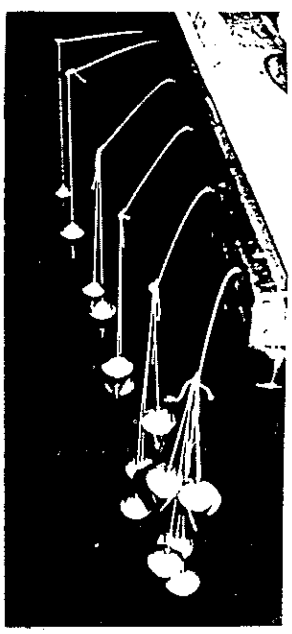

Fig. 5--Calibration of the wires by loading.

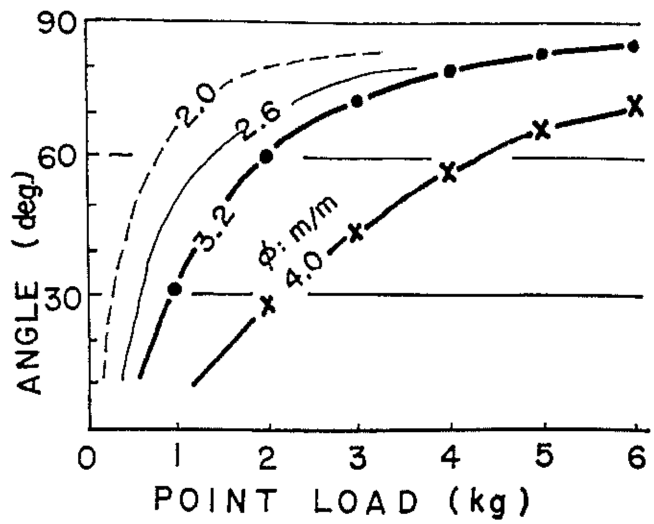

Fig. 6--The calibration curve in relation to wire diameter, bent-down angle and point load (applied at the free end of 20-cm long cantilevers).

that the angle in the middle layers of the former is about 5 degrees greater than that of the latter.

By picking sites where the average bent angle in the middle layers exceeded 60 degrees, and sites where the maximum snow height exceeds 4 m, Table 3 is obtained. It is clear from this table that extremely severe conditions prevail at altitudes over 700 m.

Considering Tables 1 and 3, it is possible to apply a zoning in this region, according to which altitudes of 700 m and over are unsuited to economical forest planning.

Although little data is available at the present, a zoning scheme based on damaging potential should become possible in the future by collecting large amounts of data on damaging potential index with

Table 3 Severity of forestry environment based on max. snow depth and bent angle.

Winter	200	500	700	900	1100	1360
1982/83			A+B	A	ava	A+B
83/84	A	A+B	A+B	A+B	A+B	A+B
84/85			A+B		A	A

A : Angle more than 60 degrees
Diameter of wire: 3.2 mm
B : Max. snow depth more than 4 m
ava: Snow pole lost by avalanches.

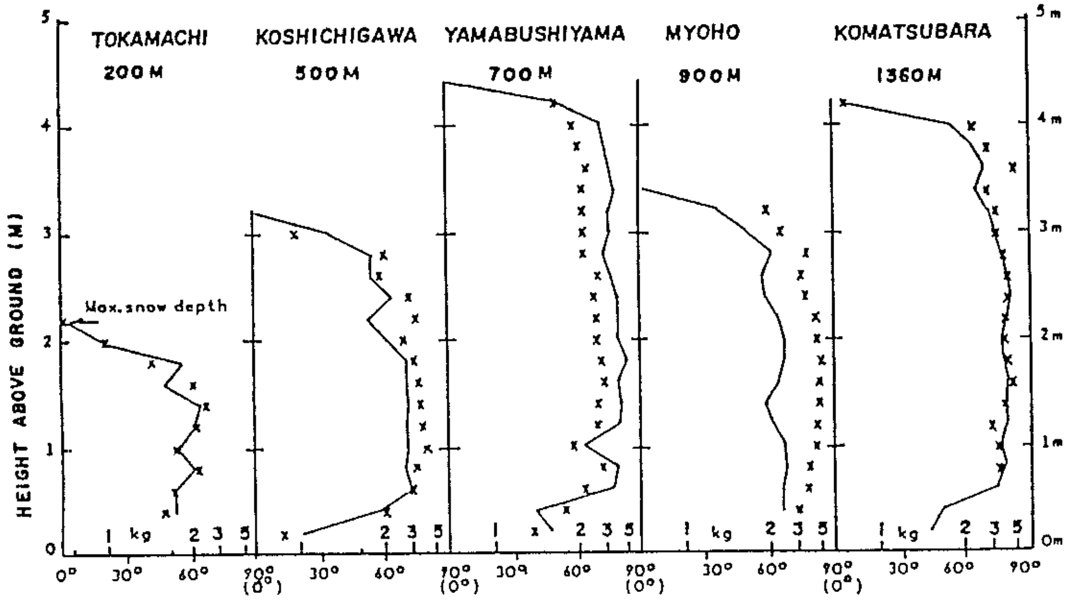

Fig. 7--Distribution of the wire angle along the vertical profile. Data for winter 1982/83 at five altitudes.

Wire diameter: 3.2 mm
x : S-side of snow pole
-- : N-side of snow pole

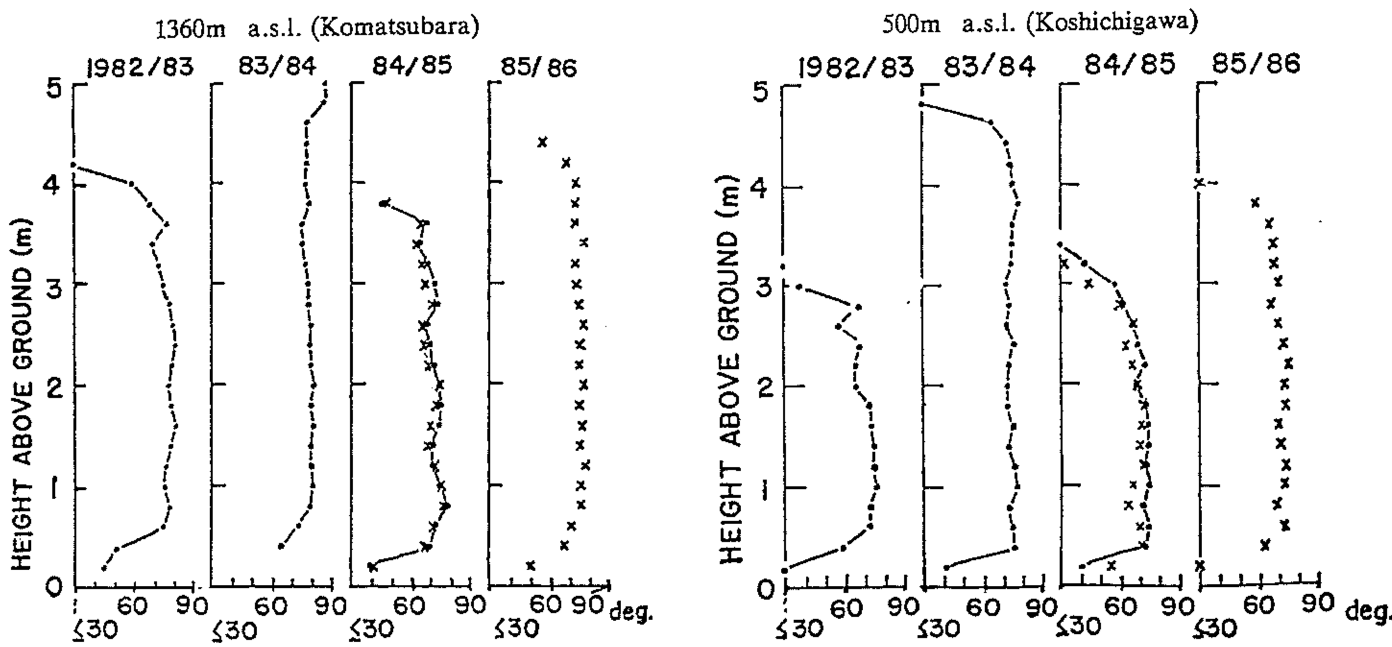

Fig. 8--Distribution of the wire angle along the vertical snow profile. Four season data at the sites on 1360 m and 500 m a.s.l.

Wire diameters:
x x: 4.0 mm
o-o: 3.2 mm

the simplified method stated above. In such belief, data is presently being acquired in several regions in Japan [Takashino and Wakabayashi 1975; Nitta et al. 1982 and 1984].

REFERENCES

Iwatsubo, G. and Nitta, R. 1987. Snow. In [Shidei, T. edited: Forest Protection. 48,Asakura Shoten, Tokyo.]

Nitta, R., Ozeki, Y. and Niwano, S. 1982. Development of simple snow settling recorder. Trans, Jpn. Soc. Snow and Ice. 147.

Nitta, R., Ozeki, Y. and Niwano, S. 1984. Height indicator of branches susceptible to settling snow. Proc. 95th Jpn. For. Soc. 313-314.

Shidei, T. 1954. On the snow damages of forest trees by snow pressure. Res. Bulletin Government Forest Exp. Stn. 73. 1-89.

Takahashi, K. 1968. On the snow scale for measuring maximum snow depth. Seppyo 30. 111-114.

Takashino, K. and Wakabayashi, R. 1975. Wire (branch model) deformation by snow settling. Trans, Jpn. Soc. Snow and Ice. 105.

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