Studies on a Planting Indicator of Forest Land Covered with Heavy Snow*

By

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多雪地帯における育林指標に関する研究*

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Contents

Introduction

Since 1960, "Timber Production Increase Plan" has been carried out in Hokkaido. This plan included the regeneration under large clear cutting area and directed to the planting of quick growth tree species. At preliminary stages or at the beginning process of this plan, forest researchers and foresters discussed on several problems about planting practices. One of them, late professor Dr. K. MUTO had pointed out a few weak points of planting after large clear cutting area considering the future situation.[8] These view points referred by the researchers had confirmed in the progresses of this plan. In facts, many troubles preventing vigorous growth of the plantation have appeared. The Scleroderris Canker (*Scleroderris lagerbergii* GREMMEN) of Todomatsu-fir and defective cultural treatments of Japanese larch (*Larix leptolepis*) which have been planted in great quantities are examples of those troubles. The damage by snow cover, which is analyzed in this paper, are also an example of the troubles.

In Japan, there are many reports on the snow damages of forest trees, but in Hokkaido only a few good studies have been done. Most part of Hokkaido, especially the coast of the Japan Sea and the central mountain ranges are covered with

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deep snow of more than 2 m every winter. In these deep snowy regions, forest trees are influenced directly or indirectly and damaged by snow. The mechanical damages of young forest trees by the snow cover pressure are the most serious problem in all snow influences. In the mountain regions covered with snow more than 2 m depth, treatments for forest regeneration are very difficult.

It will be useful to present criteria for forest regeneration. This paper discusses the possibility of using planted trees as criteria for forest regeneration in deep snowy region.

Planted trees as a snow damage indicator

It is well known that the concept of indicator plant and phytometer which express characteristics of a specific site was introduced by F. E. CLEMMENTS. There is complex interactions between organisms and their environment that designate the total surroundings which may or do directly affect the organisms. This problem to clear surrounding effects on organisms has been studied by many researchers over the past years and the concept of plant indicator has taken a great progress. The studies by Dr. NUMATA[9] and Dr. HIGASHI[4] influenced largely these problems. Considering such progress of study mentioned above, the aim of this study was taken at planting indicator which would be used to judge for forest regeneration in snowy forest area.

In Japan, there are several studies on the life forms of *Cryptomeria japonica* in snow cover district, but the detail reports on other forest tree species have not been published up to date.[5,11,16] In Hokkaido, the relation between snow cover and planted trees has attracted the attention of many foresters and researchers after Scleroderris Canker had spread on Todomatsu-fir plantation in heavy snow cover region. So the correlation between planted young tree characters and snow cover was discussed in this paper by actual field observations. Many tree species were selected as the observed object.

Some results of this observations are described as follows. The adaptation of trees to snow pressures showed large differences among tree species and among individuals of the same species. And also some differences on the adaptation to snow pressures depending on the growth stage of trees and regeneration practices were recognized.

Pinus strobus (White pine), *P. sylvestris* (Scots pine), *P. koraiensis* and *P. resinosa* (Red pine) showed severe bending and breaking, and those deformations remained for a long time in growth stage of 1–2 m height. While seyeral years after planting, the stem forms of those pines have shown S-shape, tendril-shape and other multiple shape.

Picea abies (Norway spruce) was easy to be broken in the height under the maximum snow depth as compared with other spruce; *Picea glehnii*, *P. glauca* (White spruce) and *P. pungens* (Colorado spruce). The deformations by elliptic growth caused by the breaking of the stem were remained until the final stage.

Japanese larch is more flexible and tough as compared with above the pines and Norway spruce, but its texture is easy to be bent by snow pressures and other factors.

Picea glehnii is one of tough species against the snow pressure in observed species. At growth stage about 5 m in height, the deformations of tree form caused by snow pressures were observed only as slight bending of root side.

Abies sachalinensis (Todomatsu-fir) has a wide range of deformations as described later and its grade of flexibility and toughness to snow pressure is considered to be between Japanese larch and *Picea glehnii*. The natural distribution of Todomatsu-fir covers whole forest area in Hokkaido and it is a main species of forest tree has been planted continuously for fifty years.

Consequently Todomatsu-fir was chosen as a tree species of planting indicator.

Outlines of the observed area

The research was carried out mainly at Kamiotoineppu district of Nakagawa Experiment Forest of Hokkaido University. This district lies in the northern part of Hokkaido and is situated on latitude 44°45′N and longitude 141°15′E (Fig. 1).

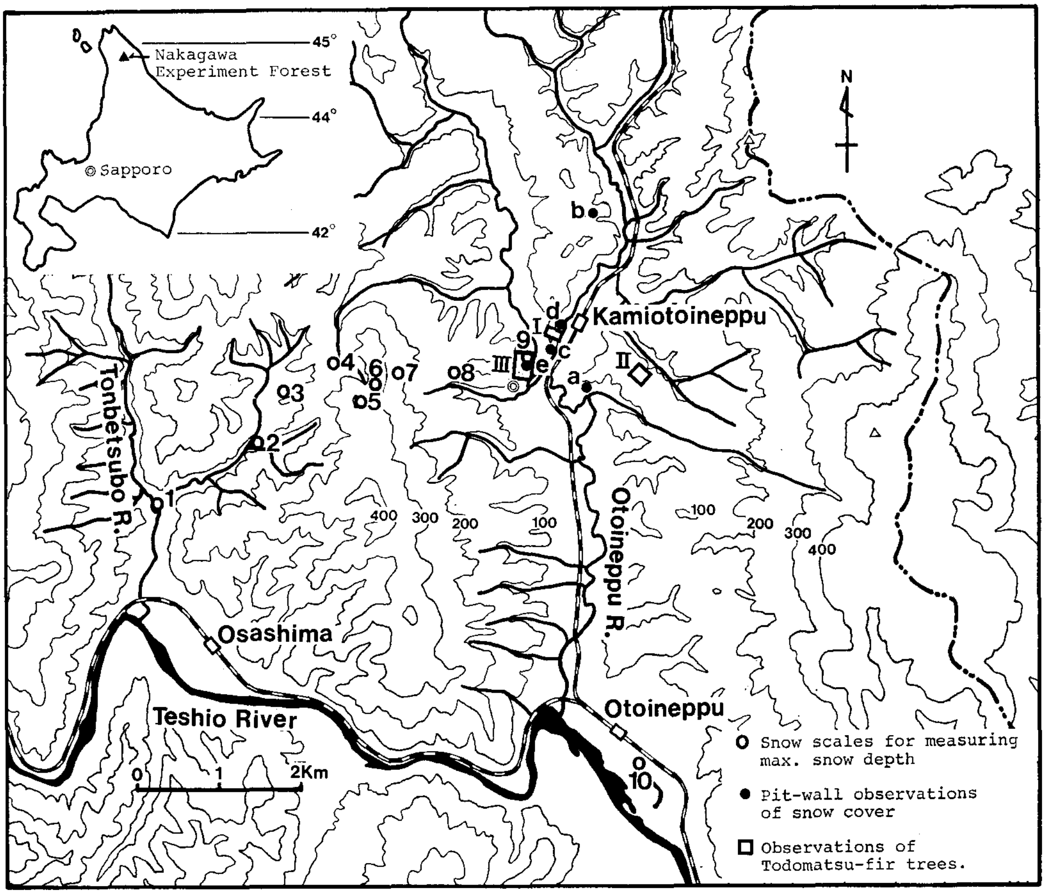

Fig. 1. Topographic map showing location of observations.

The Experiment Forest belongs to the Pan-Mixed Forest Zone, the intermediate zone between the northern Asiatic Temperate and Subarctic Zone. The forests are largely composed of conifers and broadleaved trees such as Todomatsu-fir, *Picea jezoensis, P. glehnii, Acer mono, Tillia japonica, Quercus mongolica* var. *grosseserrata, Betulla ermanii* and others. In the undergrowth, Sasa is dominant but occasionally absent in a small area. Accordingly the natural regeneration of trees involves difficulties. Since 1915, for this reason many species were planted or sown on unstocked land which had been destructed by forest fire and over cutting. However, good growth of these trees could not be expected with a few exceptions such as *Fraxinus mandshurica* var. *japonica* and native conifer trees.

The main climatological data recorded at the Kamiotoineppu meteorological observatory from 1966 to June 1974, are as follows. The annual mean temperature was 4.9°C, maximum temperature 32.8°C, minimum temperature −35.5°C, and annual precipitation 1650 mm. The continuous snow cover was usually from the beginning of November until the beginning of May. The total amount of daily snow fall depth in a winter season was 10–15 m, and maximum depth of snow cover attained a depth of 1.5–2.0 m in March.

Snow cover affecting the planted trees

Mechanical damages of planted trees by snow cover have origin in the static snow pressure that are classified into four sorts; the weight of crown snow on the tree, the settling force (settlement), the creeping pressure and the pressure caused gliding (Fig. 2). It is rarely that the forest tree damages by the weight of crown snow occur repeatedly at the same area in Hokkaido, so the crown snow on the tree is excluded from this paper.

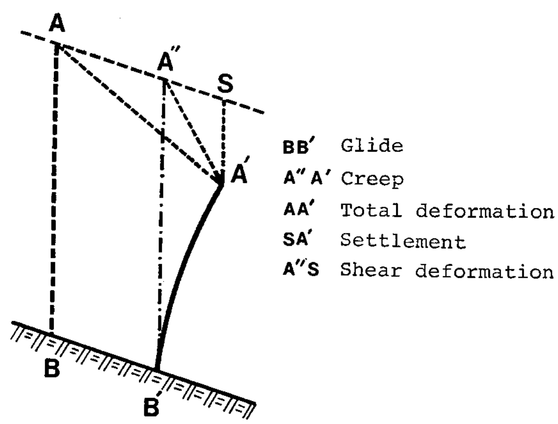

Fig. 2. Schematic profile of creep and glide deformations.

The settling force of snow originates in the settlement of snow deposit. It was found that this force is nearly equivalent to the weight of deformed snow layers or this force can be considered as the sum of internal stresses of deformed snow layers over the object.[12] The creeping pressure of snow which is more powerful than that of the settling is originated in the creeping of snow along the slope, and acts on the lower parts of stem or root side. It is satisfactory to consider that those snow pressures are related to the composition and the construction of snow cover. There are many factores in deciding the snow pressures, and especially the shape and size of snowparticle, depth, the density (water equivalent) and deformation of snow cover are the important factors among them.

Table 1. Descriptions of pit-wall observations of snow cover and Todomatsu-fir trees observations

Plots of Pit-wall	Compart-ment	Direction of slope	Length of slope (m)	Slope angle (°)	Planting tree species	Year of plantation	Undergrowths (main species)
a	238	S W	40	30	*Abies sachalinensis*	1955	*Sasa senanensis*
b	213	N E	115	15	〃	1946	*Sasa senanensis* *Cirsium kamtschaticum*
c	212	S E	40	30	〃 (*Larix leptolepis*)	1954 (1952)	*Sasa senanensis* *Polygonum sachalinense*
d	212	S E	20	20	*Abies sachalinensis*	1954	*Sasa senanensis*
e	186	—	—	flat	*Abies sachalinensis* *Picea glehnii etc.*	1970	*Phreum pratense*
Plot of trees observation							
I	212	S E	130	27	*Abies sachalinensis*	1961	*Sasa senanensis*
II	237	N E	80	25	〃	1971	*Sasa senanensis* *Polygonum sachalinense*
III	186	—	—	flat	*Picea glehnii* *Abies sachalinensis* *Pinus sylvestris* *Pinus resinosa etc.*	1970	*Phreum pratense*

The observations of pit-wall and deformations of snow cover on the slope were carried out during 4 winter seasons from the winter of 1969-1970.[8] The slope conditions of observed site were shown in Table 1 and some results of this observations were shown in Fig. 3, 4 and Table 2.

The observations using the snow scale for measuring maximum snow cover which was designed by K. TAKAHASHI,[15] and the measurements of water equivalent of snow cover using a snow sampler were carried out at locations shown in Fig. 1 from 1977 to 1982. These results were shown in Table 3.

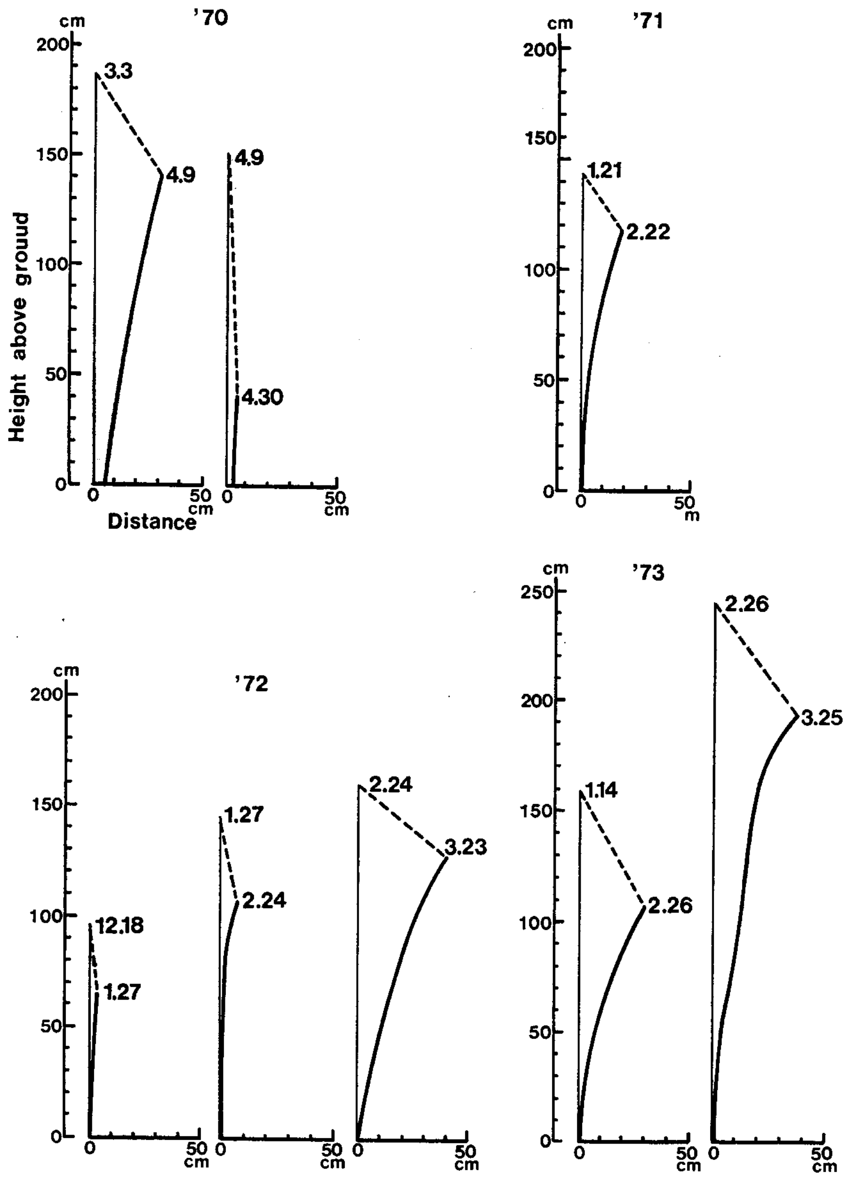

Fig. 3. Creep and glide deformations at upper point of c pit-wall observation.

After the snow is deposited the particle shapes are modified by a process known as metamorphism. New snow crystals decompose into fragments and the larger fragments grow at the expense of the small ones. This process continues until the snow melt.

In mid-winter (January-March), the three major snow types; new snow, fine grained compact snow, coarse grained granular snow were found and depth hoars were only slightly observed at all pit-wall observations. Values of density of fine

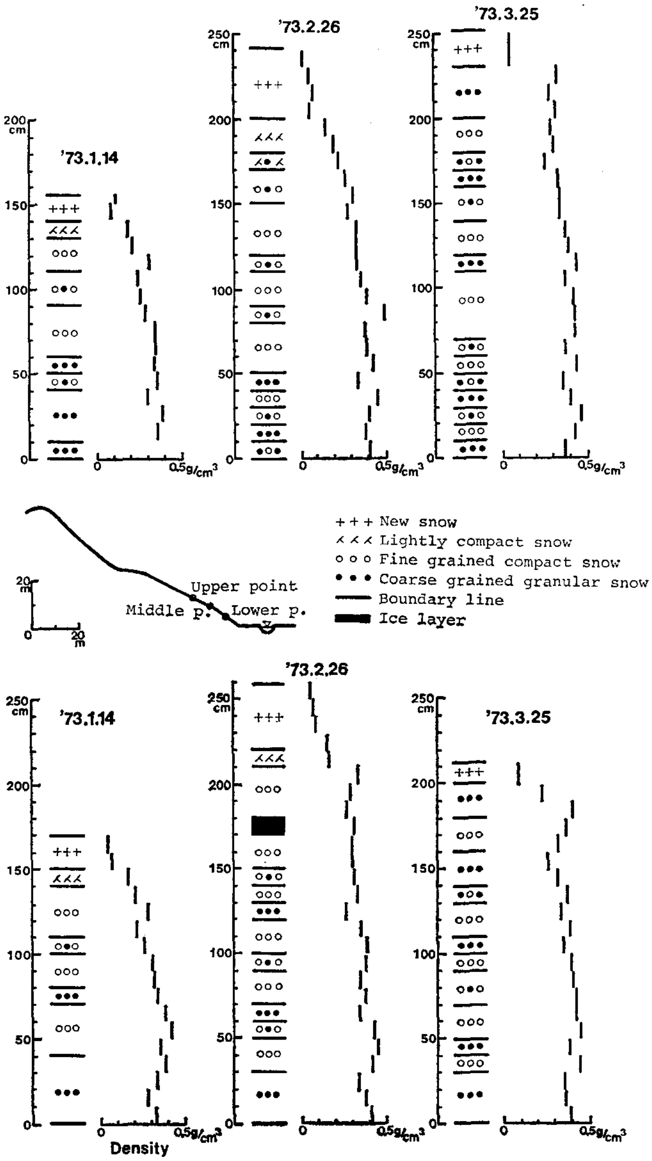

Fig. 4. Profile of snow layer and density.
upside: at upper point of c observation
bottom: at middle point of c observation

Table 2. Depth (cm) and total snow water equivalent (mm) at pit-wall observations in March

Plots of pit-wall \ Observation year		1970			1971			1972			1973		
		Date	Depth	Water equi-valent	Date	Depth	Water equi-valent	Date	Depth	Water equi-valent	Date	Depth	Water equi-valent
a	Upper	15	213	611	19	190	625	22	120	430	24	204	467
	Middle	"	228	549	"	176	475	"	122	429	"	216	646
	Lower	"	245	588	"	156	485	"	151	305	"	202	549
b	Upper	17	173	612	21	130	452	23	128	422	26	212	687
	Middle	"	210	769	"	152	585	"	177	618	"	170	537
	Lower	"	245	943	"	168	608	"	155	515	"	222	670
c	Upper	3	193	631	20	186	642	23	124	422	25	248	694
	Middle	"	190	604	"	139	521	"	116	416	"	222	548
	Lower	"	183	747	"	205	740	"	148	515	"	214	554
d	Upper							22	115	405	24	163	427
	Middle				20	142	520	"	102	380	"	183	554
	Lower				"	127	451	"	143	581	"	209	721
e	Upper							23	128		25	213	
	Lower							"	130		"	202	
Kamiotoineppu Meteorological observatory		3	220		19	150		22	142		24	189	
		15	220		20	142		23	137		25	202	
		17	214		21	142					26	199	

Table 3. Maximum snow depth (upper, cm) and total snow water equivalent (lower, mm) at maximum snow scale site

Year and date of observation \ Snow scale site	1	2	3	4	5	6	7	8	9	mean
1977—1978	180	200	170	230	180	180	180	150	140	180
1978 3. 8	562	552	482	713	623	648	590	477	510	575
1978—1979	150	160	150	200	160	190	170	110	140	160
1979 3. 12	581	539	522	788	606	730	647	413	506	593
1979—1980	160	170	140	190	180	170	180	100	150	160
1980 3. 31	465	535	460	648	658	651	637	380	545	553
1980—1981	160	160	170	180	180	160	150	100	140	160
1981 3. 25	506	478	471	657	656	639	531	370	463	530
1981—1982	190	240	200	270	220	250	260	150	230	230
1982 3. 26	723	763	665	936	—	—	—	548	765	733
1982—1983	190	210	150	240	120	210	220	100	180	190
1983 3. 31	602	613	530	807	542	732	673	463	583	693

grained compact snow were distributed from 0.3 to 0.45 g/cm^3 in mid-winter.

The normal and shear stresses in a sloping snow cover produce permanent deformation because of its viscous nature. A schematic profile of creep and glide deformation was shown in Fig. 2. In these observations, the glide moving along the ground were found in only a few cases and the maximum moving distance was 10 cm per one month. The greater part of deformations of snow cover were induced by creep. The relations between the rates of creep or glide and slope conditions or observed elements of snow cover could not be clarified.

On a large scale, the depth and total snow water equivalent in mountain regions are influenced by the topographical conditions. The differences in the distribution of the depth and the water equivalent were clarified in Table 2, 3. Those major differences were due to slope directions and elevations in connection with wind directions of winter monsoon from Siberia to Hokkaido via the Japan Sea. However, at the slope of about 100 m in length the differences of the depth and the snow water equivalent were observed in less than 30% in round numbers, as shown in Fig. 4 and Table 2.

The mass, characteristics and strength of deposited snow are influenced by many factors; climatic factors (amount of snowfall, wind velocity and direction, temperature etc.), topographical features (slope direction and angle, forest cover, various obstacles etc.) and others. Especially, climatic factors were variated every passing year as the data of maximum snow depth as shown in Fig. 5. So the deposited snow pressure is changeable by location and season with the consequence to damage on planted trees, and therefore it is very difficult to observe snow cover and pressure with necessary accuracy.

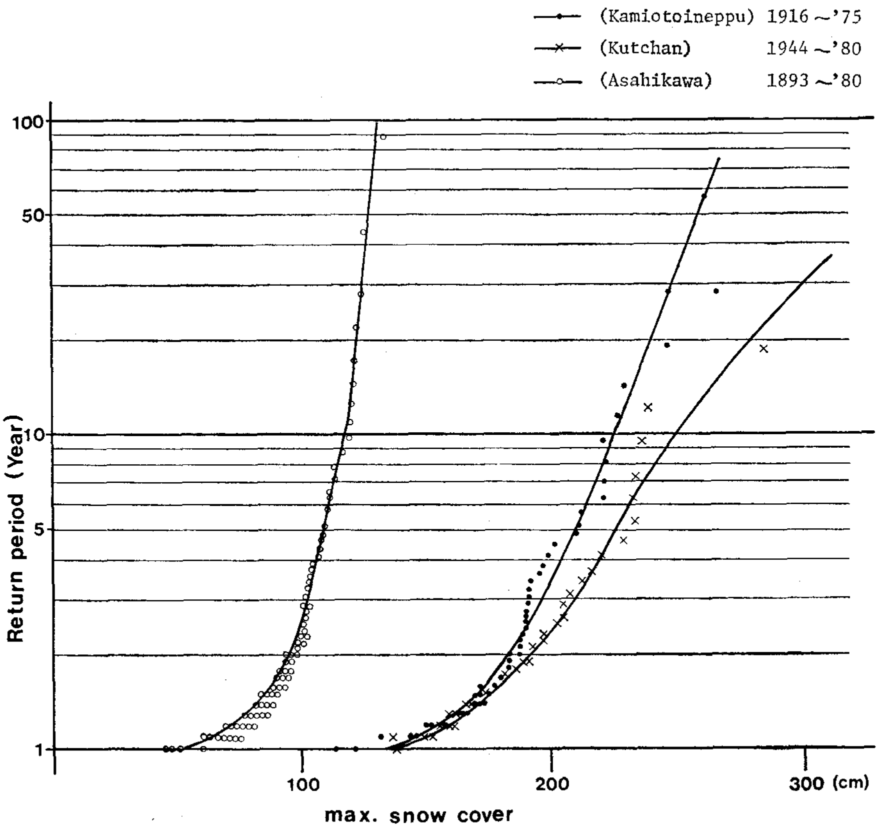

Fig. 5. Return period of maximum snow depth at Kamiotoineppu, Kutchan and Asahikawa.

Life form of young Todomatsu-fir in heavy snow cover area

During several year period after planting, the growth of Todomatsu-firs is 1 m high at the most and its stems have large flexiblity. At the moment when it thawed in spring, the stems of young trees, which were inevitably buried under the snow cover, showed various bending forms such as S-shape, inverted U-shape and other multiple shape. The greater part of bent stems returned to its original forms after a few hour, but a part of root side bending and destructive bending of top remained for a long time in some degree. In this growth age, some forms of mechanical damages as falling down, pulling out and breaking of stem were combined with the death of the tree. The flexibility of stems decreased with growing of planted tree. At the growth stage when the trees have grown to about 2 m more over in height, deformations of the stems remained continuously after one vegetation period.

Following observations of life forms of young Todomatsu-fir trees were made at the plot I from 1977 to 1983, and at the plot II from 1978 to 1984. Location and conditions of the plots were shown in Fig. 1 and Table 1.

1. Measurements of height and diameter at breast height and basal diameter were made on alternate years.
2. The tree stem forms were observed every year and classified into 18 sorts of deformation types with combinations of grade on bending, breaking and falling-down, and the damaged parts such as tops, stems and root side.
3. Observations of pulling out and damages by brush cutting tools and Sclero-

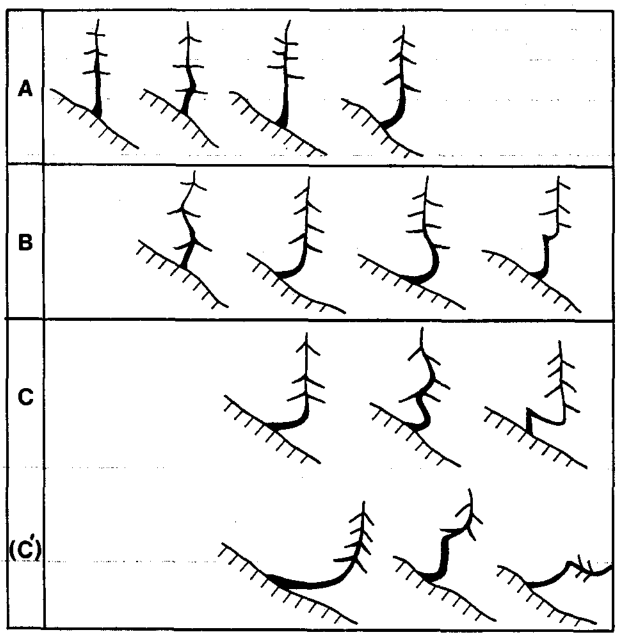

Fig. 6. Stem form diagram of young Todomatsu-fir trees.

derris Canker and other external forms were done every year.

The stem forms of 18 sorts were rearranged into four forms as shown in Fig. 6.

Form A : The normal trees and trees with slightly bending of root side and stem belonged to this form. Presently they can be anticipated as practical wood utilizations of at the final stage.

Form B : The greater part of bending trees and small amount of breaking trees belonged to this form. It was assumed that in these trees the defects of wood by bending and breaking remained until the final stage.

Form C : Heavily bending trees and a large percentage of breaking trees belonged to this form. The deformations of this form affect the growth of the tree, especially it may be quite all right to consider that the trees belonging to stem form C' can not expected to have a large viability for a long time.

In these observation plots, damages by Scleroderris Canker were slight and the loss caused by this canker was not observed.

Young Todomatsu-fir as a planting indicator

The results of stem form deformations were given in Table 4. In 1977 at plot I, the average of all tree height was 2.9 m, and it grew to 4.6 m in 1983. During the six year period the proportion of the stem form deformations which transited to other stem form was a half in stem form A, and was 25% in total. The greater part of the trees belonging to stem forms B and C did not changed. At the plot II, average height of all tree was 1.8 m in 1978 and grew to 2.9 m in 1982, and 4.4 m in 1984. During the first four year period, the proportion of stem

Table 4. Stem form deformation of young Todomatsu-fir trees

Plot	Stem form	number of trees	%	Stem form in 1983 A	B	C	(%) dying
		1977					
I	A	106	24	49	40	8	3
	B	220	50	3	82	11	4
Av. of Height	C	117	26	0	16	75	9
1977 : 2.9 m							
1983 : 4.6 m	total	443	100	13	55	27	5
		1978			(1982)		
II	A	619	67	67	23	8	2
	B	185	20	34	44	15	7
Av. of Height	C	120	13	34	28	28	10
1978 : 1.8 m							
1982 : 2.9 m	total	924	100	56	28	12	4
		1982			(1984)		
II	A	522	59	88	5	5	2
	B	259	29	20	54	24	2
Av. of Height	C	108	12	7	6	73	14
1984 : 4.4 m							
	total	889	100	59	19	19	3

form deformations was 42% in total, especially a large number of the trees belonging to stem forms B and C were deformed. During the last two year period, the proportion of them decreased to about 25%. From the above it was assumed that the stem form of young Todomatsu-fir at the growth stage in 3～5 m height became stable for snow pressure.

From the results of height measurment, trees were subdivided into three height grade of lower, middle and higher. The lower height grade trees under 4 m in height, were severely influenced by snow pressures. The higher grade trees above 5 m were not susceptible to damages caused by the snow pressures. The results of height measurement were given in Table 5. The rate of height growth subdivided into three height grade was shown in Fig. 7. The percentage of the

Table 5. Height distribution of young Todomatsu-fir trees (subdivided stem form)

Plot	Stem form in 1983: stem form	number of trees	%	Height distribution (%): 5m<	4-5 m	4m>
					(1983)	
I	A	56	13	56	14	30
	B	242	58	55	16	29
	C	123	29	24	13	63
	total	421	100	46	16	38
					(1982)	
II	A	513	58	16	34	47
	B	257	29	9	20	71
	C	119	13	3	8	89
	total	889	100	14	26	60

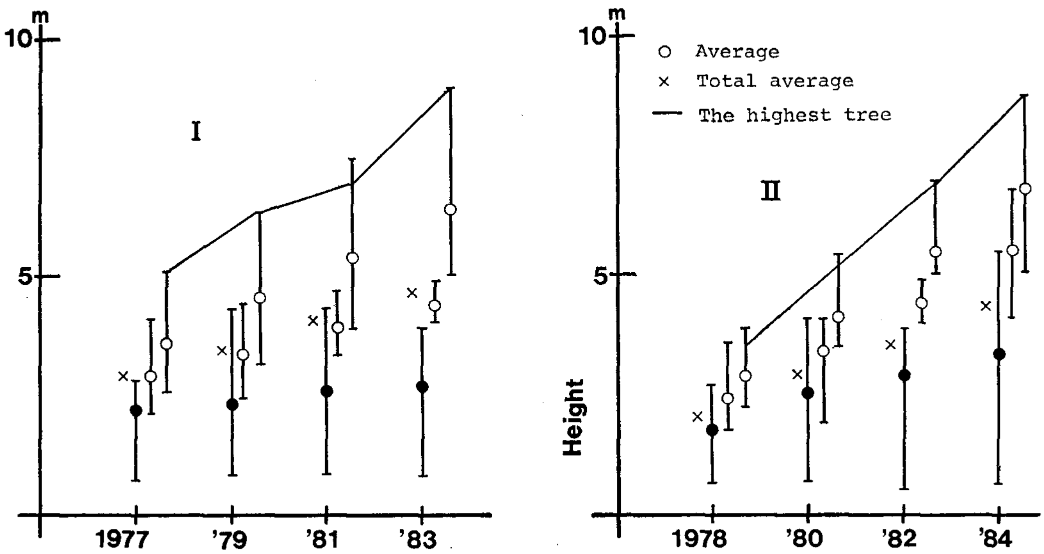

Fig. 7. Height growth of young Todomatsu-fir trees which were subdivided by height grade at observation plot I and II.

higher grade of the trees belonging to the form A was larger than that of the forms B and C, and the rate of height growth of trees under 4 m in height was smallest.

In a general way the rate of height growth of Todomatsu-fir becomes in large rapidly as the time proceeds in stage of 3～5 m height. Fig. 8 gives an interested relation betweeen the rate of height growth and maximum depth of snow cover. According to the study by Masuda, the maximum snow cover depth in Uryu Exp. Forest is 2 m more over and that of Teshio Exp. Forest is from 1.4 to 1.8 m.[6] The data of height growth rate illustrated in Fig. 8 were obtained from measur-ments of Todomatsu-fir man-made forest planted from 1964 to 1975 at the Uryu, Nakagawa and Teshio Exp. Forests.

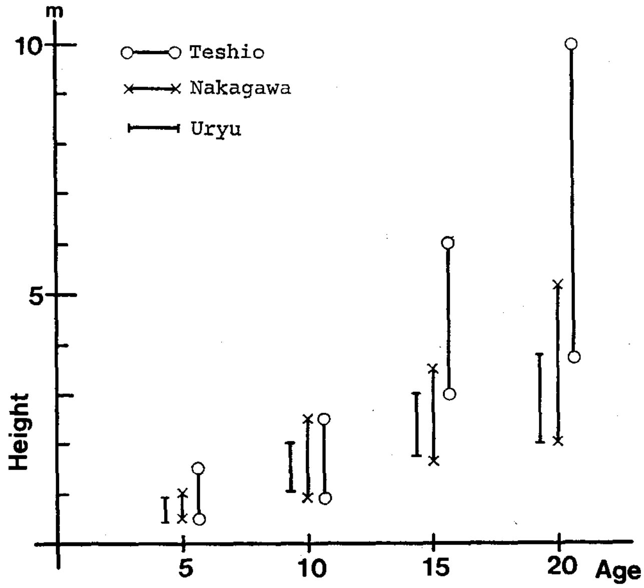

Fig. 8. Height growth of planted Todomatsu-fir trees at Teshio, Nakagawa and Uryu Ex. Forest.

It was assumed that the snow cover influenced the height growth of Todomatsu-fir at stage of 3～5 m in height. In other words, the height growth rate of young Todomatsu-fir might become the indicator of site environment at this stage.

As a result of observed many data, it can be concluded that the combination with height growth rate and stem forms of Todomatsu-fir at height of 3～5 m results in the significance of a planting indicator which introduce silvicultural practices on young plantations and non-reforested site in heavy snow cover forest area.

Applications of the planting indicator

The influences of snow pressures on a tree are not permanent. It can be considered that there is no effect of snow pressure in stage of above 5 m height. After this stage, snow damages of forest trees must be considered on crowned snow. The most important point is that a good choice must be made in tendings of young plantations and plannings of regenerations. Here, instead of conclusion, applications of the planting indicator will be described. However, it is very difficult to explain conditions of the plantation, so followings were itemized.

1) A single tree of Todomatsu-fir in stage of about 5 m height

In the trees of stem form C, normal growth could not be expected to the final stage. Especially, the trees of stem form C' shall die in several year. Among the trees belonging to stem forms A and B, the trees of height growth in 0.1～0.2 m per year during the latest several year period has possible damages caused by snow pressures in root or root side.

2) Young plantations of Todomatsu-fir and other species

If high frequency of stem bendings or breakings is found in the Todomatsu-fir plantation at height of 3～5 m, it is neccessary to investigate the frequency of stem form and other factors. From the results of this investigation, stand cultivation with planted trees except *Picea glehnii* can not be expected in the stand where planted trees of stem form C contain about 20%. In these forest stand, the tending specifications must be changed with expection of growth of nutural seeding trees. By this aspects, the non-reforested stands which situated at relatively short distances from the above plantation must be treated mainly by natural regenerations or seedings.

In the case of plantation where the stand contains about 10% stem form C, and has height growth under 0.3 m per year during the latest 2～3 year period, carefully tending must be taken, and the tending method must be decided by the results of observations. As the planting species near the above plantation, the tough species to snow pressures such as Todomatsu-fir, *Picea jezoensis* and *Picea glehnii* must be chosen. In addition, it is advisable that the planting shall be done under fair amount of reserved trees.

It is necessary to apply the planting indicator only in a small region. Because, the characteristics of the snow are very changeable by location and the height growth rate of young Todomatsu-fir seems to be influenced by many factors including snow pressures. However, this planting indicater will be a great help in the practices of regeneration in heavy snow cover forest land.

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References

(in japanese)

1) AKITAYA E. and ENDO Y.: Characteristics of Snow Cover in Mid-Winter in Hokkaido. Low Temperature Science, Ser. A **39**, 55–61 (1980).
2) FUZIOKA T., SHIMIZU H., AKITAYA E. and NARITA H.: Properties of Snow Cover at the Avalanche Research Station, Toikanbetsu, Northern Hokkaido. Low Temperature Science Ser. A **26**, 169–185 (1968).
3) FUJIWARA K. and ONODERA H.: Snow Cover Obeservations at the Nakagawa Experiment Forest of Hokkaido Univ. Bull. Coll. Exp. Forests No. **16**, 1–48 (1976).
4) HIGASHI S.: Geophysical Processes of Land Surface. Hokkaido University 280 pp. (1979).
5) ISHIKAWA M., KAWAGUCHI T. and SATO S.: Estimation of Snow Depths by Tree Forms of Japanese Cedar and Japanese Larch. Seppyo **32–1**, 2, 10–17 (1970).
6) MASUDA H.: A Map of Max Snow Cover Depth in Hokkaido. New Technical Announcement No. 6 Hokkaido Branch, Forestry and Forestry Products Research Insutitute. (1983).
7) MATSUI Z.: Historical and Sylvicultured Research for Each Species of Plantation in Hokkaido. Bull. of the Goverment Forest Exp. Station **189**, 1–160 (1966).
8) MUTO K.: Reconsideration of the "Production Capacity Increase Plan" and Treatments of Natural Forests in Hokkaido. Argument of Symposium held on the 12th congress of Hokkaido Branch of the Japanese Forestry Society. (1963).
9) NUMATA M.: Methods of Ecology. Kokin Shyoin (Tokyo) (1979).
10) ONODERA H. and WAKABAYASHI R.: Life Forms of Trees Adapted to Snow Pressure. Seppyo **33–2**, 24–27 (1971).
11) SHIDEI T.: Studies on the Damages on Forest Tree by Snow Pressures. Bull. of the Goverment Forest Exp. Station **73**, 1–89 (1964).
12) SHIDEI T.: Snow Cover and Growth Form of Trees. Seppyo **33–1**, 42–43 (1971).
13) TAKAHASHI Keiji and TAKAHASHI K.: Damage of Cryptomeria Japonica-forests Caused by Snow Pressure at the Heavy-Snow Area, Especially in Relation to Topography. Seppyo **32–1**, 2, 30–36 (1970).
14) TAKAHASHI Kihei: Study of the Crown Snow on the Forest Trees (I) Bull. of the Goverment Forest Exp. Station **44**, 140–148 (1952).
15) TAKAHASHI K.: On the Snow Scale for the Measuring Maximum Snow Depth. Seppyo **30–4**, 111–114 (1968).
16) TAKAHASHI K.: Characteristics of Cryptomeria japonica in Heavy Snow Region. Sorin **236**, 1–12 (1969).

摘　　要

北海道で，1950年代末より実施された林力増強計画にともなう拡大造林は，十分な育林技術の裏付なしにはじめられた。武藤など多くの研究者が，拡大造林の計画が明らかにされた時点で，あるいは実行の初期の段階で問題点を指摘した。20年余経た今日，その経過をみるとトドマツ枝枯病など，指摘された問題以上の課題を抱えている。このような問題の一つに雪害がある。

本州では主要造林樹種のスギについて多くの成果があげられていたが，北海道ではほとんどとりあげられなかった。筆者は，多雪地帯の育林条件を判定することに，植栽木を指標として使用することを考えて研究を続けてきたが，その可能性がみえたので報告する。

1. チョウセンゴヨウ，ヨーロッパアカマツ，ストローブマツ，レジノーザマツ，ヨーロッパトウヒ，カラマツ，トドマツ，アカエゾマツ等の植栽された幼齢木の積雪への対応形態を調査し，育林指標としてトドマツを選んだ。

2. この研究の資料は大部分，北海道大学中川地方演習林の上音威子府地区で得た。

3. 積雪については，1969年の冬期より4冬期にほぼ1ヵ月に1回5箇所の斜面で積雪断面観測を行ない，雪質，移動量観測を行なった。また，筬島・幌加間の9箇所で高橋式最深積雪指示計により最深積雪深と3月にスノーサンプラーによる積雪水量の調査を1977年より1983年まで行なった。(表1〜3，図1〜4)。積雪の移動では，グライドは極めて少なく，大部分はクリープによるものであり，この移動と斜面傾斜・方向との関係はみられなかった。雪質は，しもざらめ雪はほとんどみられず，硬いしまり雪の層が多かった。積雪量は，同一斜面でも10m離れると30%以上の差があった。

また，年による積雪量の変動係数は約0.2であり（図5)，造林地等の積雪圧を推定することは極めて困難であることが判明した。

4. 多雪地帯に植栽されたトドマツは，1m前後のときは積雪の中に埋れ，幹の形は複雑に曲っているが，この大きさの段階は，根元・幹折れを除き，幹曲りの大部分は融雪後間もなく回復し直立する。幹曲りがほぼ固定するのは樹高3m位に達してからであり（表4，図5)，樹高3〜5mの大きさのとき，積雪圧の影響を最も強くうける。また，樹高生長にも積雪が大きく影響する（表5，図7・8)。植栽されたトドマツの樹高3〜5mのものの樹幹形態とこの時期の樹高生長を組合せて，育林指標とした。

5. この育林指標は，積雪の性質は場所によって著しく変化すること，またトドマツの樹高生長が積雪以外の要素の影響もうけることから使い方は慎重でなければならないが，既存の造林地の判断や，多雪地帯の更新計画をするときは有効な情報を提供する。