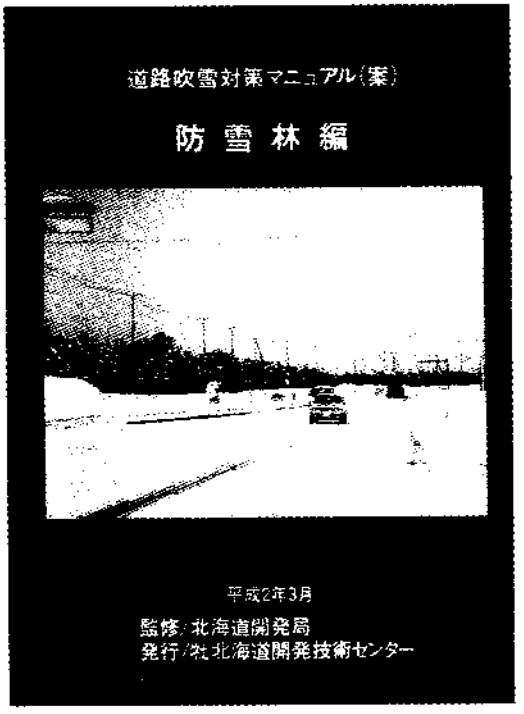
HIGHWAY SNOWSTORM COUNTERMEASURE MANUAL

TRANSLATED FROM THE JAPANESE ORIGINAL

SNOWBREAK FOREST BOOK



U.S. Department of Transportation

Federal Highway Administration

INTERNATIONAL TECHNOLOGY

Highway Snowstorm Countermeasures Manual
Snowbreak Forest Book

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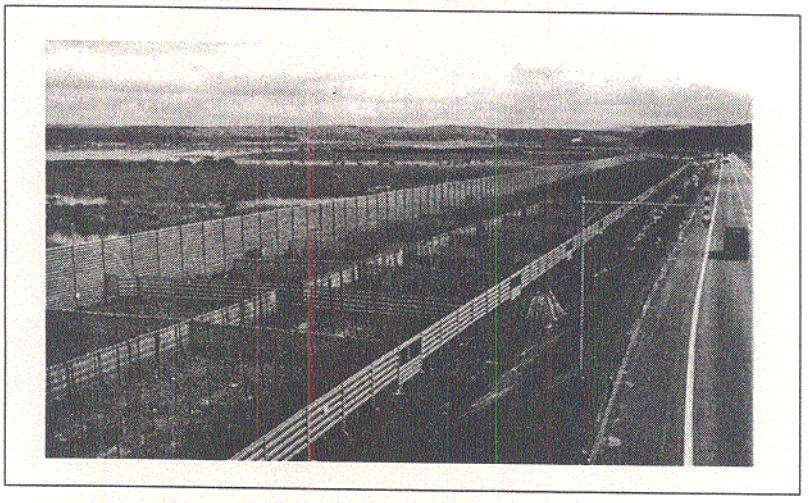
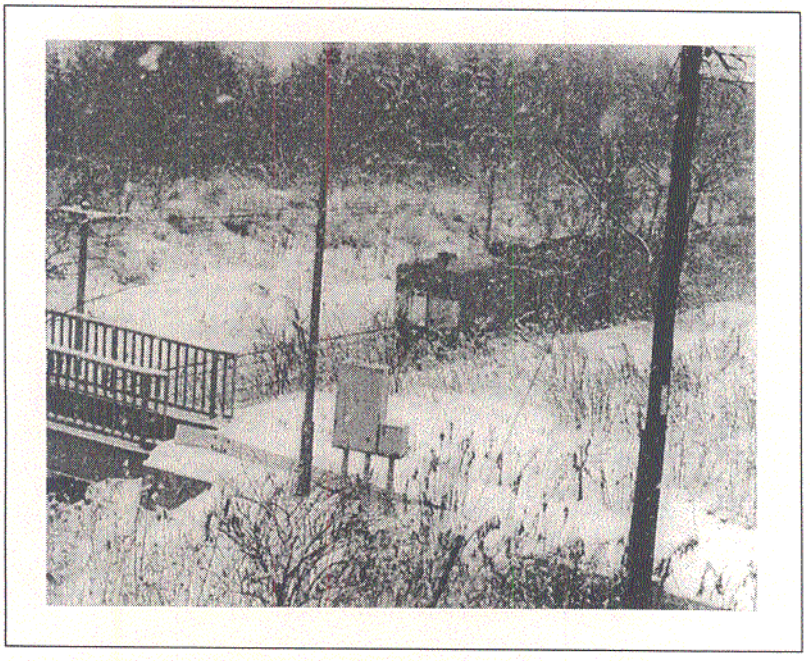
1. Ordinary National Highway Number 12, Iwamizawa City, Okayama. Highway snowbreak forest. (Hokkaido Development Department)

2. Ordinary National Highway Number 40, Nakagawacho, Kokufu. Highway snowbreak forest under construction. (Hokkaido Development Department)



3. Ordinary National Highway Number 40, Sarakitomanai. Highway snowbreak forest under construction. (Hokkaido Development Department)

4. Hokkaido Jukan Highway, Sapporo-Iwamizawa. Highway snowbreak forest under construction. (Japan Highway Public Corporation, Sapporo Construction Department)



5. Hakodate Main Line Ooasa Railroad. Snowbreak forest. (JR Hokkaido)

Foreword

Because maintaining the flow of highway traffic in Hokkaido during the winter season is extremely important, preparations on the main roads are necessary to overcome snowdrifts, freezing and blowing snow, avalanches, and all kinds of weather related obstructions if the lives of the prefecture's residents are to continue normally.

The main reason for traffic obstructions during the winter season traces to poor visibility created when snowdrifts provide the source for blowing snow. To counteract this, the Bureau has promoted the preparation of snow shelters, snowbreak fences, snowbreak forests, snowbreak land cuts, snowbreak earthen mounds, and highway traffic information systems, etc.

Highway snowbreak forests are highly valued for their endurance and their contribution to the highway view in addition to their effect as snowbreaks. Furthermore, it should not be forgotten that the "live thing construction method" is fundamentally different from that of the civil engineering method used up until now. For this reason, the preparation of a general technical standard is called for to properly promote the creation of highway snowbreak forests in Hokkaido, and we established the "research group to study how to create roads that overcome snow and winter." Studies have continued to create guidelines for facilities to counter blowing snow. This book was compiled from our research and resources on snowbreak forests.

A large number of technicians, not just highway managers, discussed this manual. In addition to hoping that it will be of great help "in the creation of safe and comfortable winter roads," I would like to thank all the committee members and secretaries who helped with its creation as well as Dr. Shinichiro Saito of the Hokkaido Forest Research Institute for his guidance.

Hokkaido Development Bureau
Highway Planning Section Chief
Hideyaki, Toshima

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Chapter 1 General Rules

1-1 The Purpose of the Snowbreak Forest Book

This manual explains the fundamental approaches to the planning, design, execution of construction, and continued maintenance-management of the snowbreak forest countermeasures and sets forth the related technical materials and standards.

Commentary

The evaluation and selection of the sections where blowing snow countermeasure are necessary, the degree of danger from blowing snow, as well as the choices of countermeasure construction methods are set forth in the *Highway Blowing Snow Countermeasures Manual - Companion Volume.* This book is, mainly, a guide to the planning, design, execution of construction, and maintenance-management of the snowbreak forest providing a blowing snow countermeasure facility.

1-2 The Applicable Scope of the Snowbreak Forest Book

This manual prepared by the Hokkaido Development Bureau applies to the highway snowbreak forests which are highway snow blowing countermeasure facilities.

Commentary

This manual prepared by the Hokkaido Development Bureau applies to highway snowbreak forests. For information concerning forests planted as blowing snow countermeasures with the main expectation of encouraging line of sight refer to Hokkaido's *Highway Afforestation Guide*, March, 1987, Hokkaido Development Bureau. For information concerning planting to improve the view and afforestation refer to *Highway Construction Design Standards*, Hokkaido Development Bureau, *Summary of the Design and Execution of Highway Construction*, Hokkaido Development Bureau, *Highway Afforestation Technical Standards*, July 26, 1976, Construction Ministry Highway Plans Development, Number 40, and Hokkaido's *Highway Afforestation Guide*, March, 1987, Hokkaido Development Bureau.

This manual sets forth the general technical standards used in Hokkaido and does not preclude the need for a separate study if it is decided that the manual does not apply to weather and land forms with extremely different characteristics.

Chapter 2 Characteristics of Highway Snowbreak Forests

2-1 Definition of a Highway Snowbreak Forest

A highway snowbreak forest is a forest zone which is created on the windward side of a road or on both sides that causes the wind speed to decrease and the snow to pile up inside the forest as well as in front of and behind it.

Commentary

The highway construction law (September 25, 1982, Government Ordinance Number 256) in Article 33, Paragraph 1, stipulates the following concerning snowbreaks:

"In places where there is the danger of a hindrance to traffic due to avalanches, flying snow or accumulated snow, snow cover construction, flowing snow gutters, and melting snow, other similar facilities shall be

established as stipulated by the Construction Ministry law."

In the Highway Construction Law Execution Rule (March 31, 1971, Construction Ministry, Law Number 7) Article 4, the following are defined as other snowbreak facilities.

"The following are mentioned as facilities stipulated by Construction Ministry Law, Article 33, Paragraph 1.

1. Snowdrift prevention facilities
2. Avalanche prevention facilities"

According to the Highway Construction Law's explanation and application (February 1983, Japan Highway Association), the following explains snowdrift prevention facilities.

"In places where there is the danger of the occurrence of snowdrifts due to the land form, the conditions of the weather, etc., snowdrift prevention facilities should be set up, such as snow shelters, snowbreak fences, snowbreak forests, etc., in a straight alignment or crosscutting shape corresponding to the construction of the road."

The law also stipulates about a snowbreak forest: "since it is something which is set up on the windward side of a road to decrease wind speed and to cause snow to accumulate, there is the snowbreak forest where the snow accumulates among the trees and a snowbreak hedge that causes accumulation between the forest and the road. Since the snowbreak effect of a snowbreak forest is permanent, if land acquisition is easy, it is a more desirable facility than a windbreak fence."

There are two types of snowbreak forests: the "forest to prevent blowing snow" and the "forest to prevent avalanches." Normally, when they are simply called snowbreak forests, it means forests to protect against blowing snow. In the Highway Construction Law's commentary and application the term "snowbreak forest" is used when referring to snowdrift prevention facilities. In the following, when "snowbreak forest" is used it indicates "a forest to prevent blowing snow." Furthermore, a "highway snowbreak forest" indicates a forest zone that maintains the highway function of preventing blowing snow with the creation of a "snowbreak forest."

A highway snowbreak forest is created on the windward side of places where there is the danger of hindrances to visibility as well as snowdrifts. Because it is a long, narrow zone or row of trees, rather than a forest, it should be regarded as a forest zone. Snowbreaks are set up to use the ability of this forest zone to reduce the strength of the wind and to cause the wind carried snow to accumulate inside the trees to prevent blowing snow from invading the highway.

A forest of narrow width (normally one row), mainly planted with the expectation of inducing a line of sight, is called a "line of sight inducing forest."

2-2 History of Highway Snowbreak Forests

The making of snowbreak forests in Japan began in 1894 on the former Japan National Railroad Tohoku main line between Mizusawa and Aomori under the guidance of Mr. Seiroku Honda. After that, due to deliberate creation and systematic maintenance and management, they spread and became the main snowbreak countermeasure on all the Tohoku, Hokuriku, Yamakage, as well as Hokkaido lines. For the railroad snowbreak forests carry out avalanche prevention besides

blowing snow prevention, and a railroad snowbreak forest is the general term used for blowing snow prevention forests and avalanche prevention forests.

In 1978 the Hokkaido Development Department's Sapporo Development Construction Department created a narrow highway snowbreak forest zone of trees using full-grown trees in the Iwamizawa district on the Ordinary National Highway Number 12 and began to investigate its effect. After that the Japan Highway Public Corporation Sapporo Construction Department in 1978 established a trial snowbreak forest and snowbreak fence on an experimental raised bed at Iwamizawa on a highway in the center of Hokkaido where they carried out an investigation to follow the effects of the demonstration snow- break forest Furthermore, in 1983 the creation of a full-scale highway snowbreak forest was started on the highway between Sapporo and Iwamizawa in the center of the prefecture. Now their creation has begun along national highways in every Japanese district.

Commentary

From the beginning of the Meiji period or late 19th century in Japan, the frequent snow damage that accompanied the extension of the railroad lines in snow country gave rise to the necessity for snowbreak facilities. The former Japan National Railroad Tohoku main line as well as the Hakodate main line were protected in part from blowing snow and snowdrifts by snow covers, snowbreak fences, and earthworks that dated from the beginning of their operation, but the view from the car windows was always lacking, and limitations on the snowbreak function required improvement. In 1894 when Mr. Seiroku Honda returned to Japan following scholarly pursuits in Germany, he studied the Canadian Pacific Railroad's snowbreak forests under construction on his way home and gave guidance in the creation of snowbreak forests at 37 places between Mizusawa and Aomori. This was the beginning of railroad snowbreak forests in Japan. After this, forests were created one after the other on the Oou main line, Hakodate main line, etc., and snowbreak forests were successively created in every district where snow damage occurred. Snow covers and other snowbreak facilities were removed because maintenance expenses were unnecessary in forest zones and, in addition, there was the indirect benefit: "the added aesthetic beauty of the forest colors along the railroad line with the removal of the snow covers and snowbreak fences served to soothe the travel weariness of the passengers."

Originally sites followed the German width of 20 meters, but after that they were widened to between 60 and 80 meters to match the actual situation of the amount of snow accumulation in Japan. The types of trees used are mostly black pine and Norway spruce. In addition, 20 other mentionable types include European red pine, yachidamo (in the sweet osmanthus family), and the popular Japanese locust.

In 1910, Honda created the *Snowbreak Forest Planning Guide* and the establishment and maintenance management of snowbreak forests proceeded systematically. In that year in Hokkaido, the first 35-hectare Japanese larch snowbreak forest appeared between Shioya and Ranshima on the Hakodate main line. In 1913, the specific method for planning snowbreak forests suitable for Hokkaido was described in the *Hokkaido Snowbreak Forest Management Summary.*

Furthermore, the avalanche prevention forest planted on the Hakodate main line in 1914 also spread as a snowbreak countermeasure for trains going through mountainous areas. Along with the snowbreak forest, the railroad forest became the main snowbreak facility. Because the purpose of the railroad snowbreak forest is disaster prevention, they are established in places where the conditions discourage the growth of trees. While the initial economic value of the forest is low, the period when the afforestation begins is fast, especially for snowbreak forests. Eventually the lumber income from logging, etc., during the mature growth process is a valuable economic resource.

After 1981 the railroad snowbreak forests stretched from the backside of Japan up to the mountainous districts and now amount to a facility length of 1,650 kilometers (snowbreak forests are about 1,400 kilometers of this).

The first highway snowbreak forest was on the Ordinary National Highway Number 12 in Iwamizawa City. Iwamizawa City is known for having heavy snow. The trees were planted as a trial in a place that receives seasonal winds because its west side directly faces a wide field so the frequency of blowing snow and surface blowing snow is high. Due to reduced visibility, there are many traffic accidents and traffic jams in this area. For that reason, the Hokkaido Development Department's Sapporo Development Construction Department on the occasion of the secondary rebuilding of the national highway test, planted 100 meters of highway snowbreak forest in 1978. In 1979, following an investigation, it was extended another 420 meters. The main object was to secure traffic safety with improvements to visibility, but the mediating greenery was also expected to provide shade trees along the highway. The trees were mainly European spruce, and one row of fir trees with nice shapes was planted. The planting method of dense triangular trees spaced 1 meter apart was intended to increase the effectiveness of the narrow trees, reduce the amount of wind passing through, and heighten the wind protection effect. The problems of melting snow from the snow hill that accumulates on the windward side of the forest, the spread of weeds to the neighboring fields, and the snowbreak forest mediating margin were considered. The group decided to locate a highway snowbreak forest 10 meters from the edge of the walkway and to plant three rows and four rows each 50 meters long as a test in a 100-meter area. After that, various tests determined the effects.

In preparation for the extension of the prefectural highways north from Sapporo in 1978, a special committee in the Japan Highway Public Corporation Sapporo Construction Department started to study snowbreak countermeasures. In the winter of 1978, based on the proposals of this committee, a three-row snowbreak forest and snowbreak fence, each 60-meters long, were set up at Iwamizawa's soft experimental raised bed. In three places, the effect of the reduction of obstructions to visibility and the absence of countermeasures were examined. The snowbreak forest was judged the most effective. Furthermore, in the winter of 1982, an investigation performed an economic comparison of the approximately 10-year period it takes for a snowbreak forest to mature and demonstrate its effectiveness versus the various types of snowbreak countermeasures. These investigation results were compiled, and a snowbreak countermeasure plan included snowbreak forests and temporary snowbreak fences used simultaneously to ensure safe winter

traveling between Sapporo and Iwamizawa and to improve visibility.

Planting, the studies revealed, demonstrated the greatest effect on improving visibility caused by blowing snow. The width of the planted area varies depending on the place, and, since there is a 5-meter space from the shoulder of the road that allows for snow removal as well as a snowdrift area, there are the following two modes of planting: 1. in a place where five rows of trees or more are able to be planted, plant in an equilateral triangle with 1.4 meters on a side, 2. in places with less than the above space, plant in a square 1.0 meter on a side. Do not plant in places that will not allow for three rows. The rule is to select seedlings, because when considering severe weather conditions and a large number of planted trees, there is uncertainty about planting tall trees. On the other hand, seedlings have the advantages of: 1. low price, 2. comparative ease of acquisition, 3. ease of keeping alive, and 4. a high probability of growing to maturity if the initial period of management is good.

If the planting area is narrow, use evergreen trees with needle leaves. There are two types of trees in Hokkaido that are socially and marketably attractive: the European spruce and fir.

2-3 Characteristics of Highway Snowbreak Forests

Highway snowbreak forests improve visibility in areas of blowing snow and prevent snowdrifts. When a highway snowbreak forest is completed, it is possible to protect a highway from snow that blows along the ground. Furthermore, it provides a beautiful view while maintaining the natural environment.

On the other hand, snowbreak forests require a large site compared to other snowbreak facilities and growing time before they can demonstrate their effectiveness. It is necessary that they are appropriately created as well as maintained and managed in accordance with the local conditions.

Commentary

Snowbreak forests are snowbreak facilities that improve visibility in areas of blowing snow and prevent snowdrifts. When the tree height is tall enough, they form a large weak wind area that is better than snowbreak fences, which enhance improved visibility. Furthermore, even though there is a raising and cultivating process, their snowbreak effectiveness can be affirmed. The creation of highway snowbreak forests creates beautiful roadside scenery.

However, the creation of a highway snowbreak forest requires a large site compared to other facilities.

Creating a highway snowbreak forest requires "a living material method of construction" that is fundamentally different from the civil engineering method of construction used up until now. Yearly guidance of forest zone creation through cultivation management must correspond to the local conditions. Generally, because forest zone creation takes place in severe environments for growing trees, the method of creating a disaster prevention forest is different from the gardening method traditionally used for planting roadside trees in the highway industry.

2-4 Function of Highway Snowbreak Forests

(1) The Function of Highway Snowbreak Forests

Eighty percent of the highway closures in Hokkaido due to snow are caused by blowing snow and have a great influence on the economy as well as life in the area. For this reason, ensuring safe and comfortable movement of road traffic during the winter has become an important topic. Snowbreak forests are excellent snowbreak countermeasure that have the secondary effect of preserving the roadside environment besides reducing snowdrifts, improving visibility, and inducing lines of sight.

Commentary

Recently, accompanying the concentration of metropolitan populations, an appreciation for the value of roads that form the basis for economic circulation has greatly increased. In addition to recognizing the economic and functional nature of roadways, emphasis has focused on the environment and traffic accident prevention.

The greatest hindrance to the flow of road traffic during the winter season in Hokkaido is snow. There were an average of 40 highway closures on the approximately 5,800 kilometers of ordinary national highways in the snow removal area from 1979 to 1988 during the winters. Accidents have steadily decreased annually along with the development of snow removal and other prevention measures. However, reduced visibility, in particular, causes the majority of accidents to occur, and approximately 80 percent of them are due to reduced visibility from blowing snow and snowdrifts.

Snowdrifts form in places where the flow of the wind changes and the wind speed is reduced, such as around structures and non-continuous or cut and shaped land forms. Because the saturated blowing snow amount (the maximum amount of snow that the wind can carry) is proportional to the wind speed as the power n (n = 2-5), when the wind speed reduces from V1 to V2, the amount of snow proportional to $(V_1^n - V_2^n)$ is left as a snowdrift. If the snow's spatial density is high and the wind speed strong, visibility worsens. The decreased visibility varies over time, and snowbanks along the side of the road at the driver's eye level are a main factor magnifying the obstacles to visibility. Snowbreak forests that prevent snowdrifts and the railroads have a long history. But roadways have site limitations, and snowbreak forests have been planted in a comparatively narrow width to weaken the wind speed and scatter the snowflakes as well as reduce the amount of blowing snow at the driver's eye level and perform according to their size and depth.

(2) Secondary Functions

A highway snowbreak forest is related to the land shape, the line of the highway, and the land use conditions in the vicinity. The main functions of highway afforestation that relate to highway snowbreak forests include the following.

1. Function of Improving the Landscape
    - harmonizing the view
2. Function of Conserving the Environment
    - air purification
    - noise reduction
    - windbreak factor
    - fog prevention
    - conservation of vegetation

Commentary

1. Function of Improving the Landscape

Besides improving the scenic beauty along the road, forest zones bring the entire area into conformity with the neighboring environment, provide shade, improve the microclimate, and make traveling down the road more comfortable. They also mask unpleasant, inharmonious landmarks along the road, harmonize the view, and create architectonic beauty through afforestation.

2. Function of Conserving the Environment

The function of nurturing the environment, in addition to protecting the roadside from harmful influences, contributes to conservation of the area.

The functions that trees provide in the purification of air that absorbs exhaust gases and soot from cars, etc., and protection against sounds through noise reduction have both gained attention in recent years. Furthermore, because wind protection conserves an area's environment through reducing the force of the wind, an increase in the crop production on adjacent cultivated land is a recognized benefit. A fourth benefit is fog protection. Fog particles are captured when they collide with the tree's foliage, which raises the surrounding and ground temperature near the trees and dissipates the fog through evaporation. Planting snowbreak forests helps the conservation of animals, makes practical use of the existing vegetation, and aims to provide an abundant, natural environment.

2-5 Snow Protection Effect of Highway Snowbreak Forests

(1) Reduction of Wind Speed

Highway snowbreak forests reduce wind speed below the limit for the occurrence of blowing snow which results in reducing the amount of blowing snow, improving visibility, and preventing snowdrifts.

Commentary

Diagram 2-5-1 is the horizontal distribution of the wind speed measured at the Okayama snowbreak forest (three rows, 520 meters in length) on the Ordinary National Highway, Number 12 at Iwamizawa City. In the area immediately behind the snowbank formed from the snowbreak forest and the side of the road, the wind speed decreased to 10 percent of that on the windward side. Furthermore, in the road divider in the center of the road, the wind speed recovered about 50 percent and increased the reduction.

The reduction of wind speed is extremely important to counteract hindrances to highway visibility. Highway snowbreak forests that reduce the wind speed below the limit for the occurrence of blowing snow cause a reduction in the wind speed above snowbanks on the sides of a road, which is effective in improving visibility.

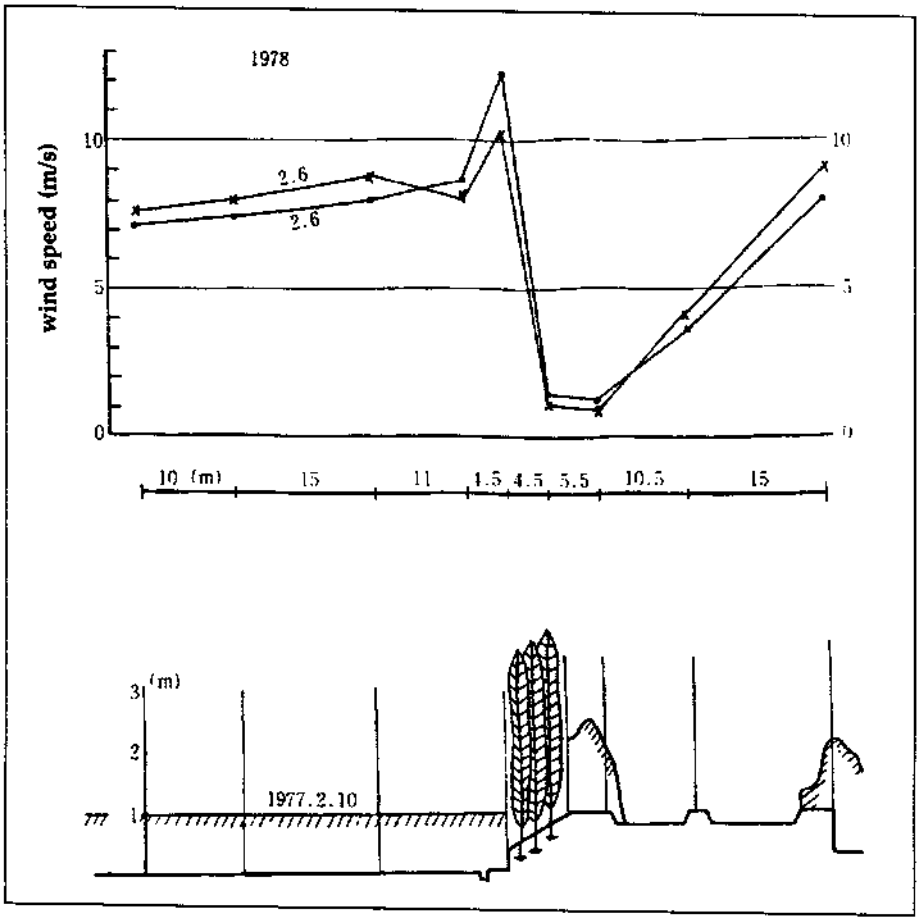


Diagram 2-5-1 The horizontal distribution of wind speed at 1 meter above the surface of the snow[6] (snowbreak forest length 520 meters with 3 rows of trees)

called the "snow hill." The place where this snow hill appears depends on the amount of snow captured in the forest zone and varies with the height of the tree's branches from the ground and the width and the sparseness or luxuriance of the foliage. Snowdrifts are created inside and on both sides of the forest zone. If the following conditions exist, the forest zone functions well as a snowbreak forest: the tree crowns are high, the zone is wide, the height of the branches above the ground is low, and the snow hill forms on the windward side. A variety of forest conditions are exhibited that depend on how these various formation elements are combined, which causes the place where the snow hill is formed to change shape.

(2) Prevention of Snowdrifts

Highway snowbreak forests cause the speed of the wind blowing snow to decrease and snow to accumulate in front of, behind, and inside the forest, which prevents the accumulation of snow on the road.

An actual survey of the effectiveness of forest zones for preventing snowdrifts is shown in Diagram 2-5-3. This investigation, carried out in the Sasaro District on January 17, 1977, examined 100 meters in front of and behind a six-meter wide forest zone to

Commentary

The relationship between the situation of the forest zone and the wind speed reduction and the situation of snow accumulation is shown by Diagram 2-5-2. The place where the snow has accumulated to the highest level is

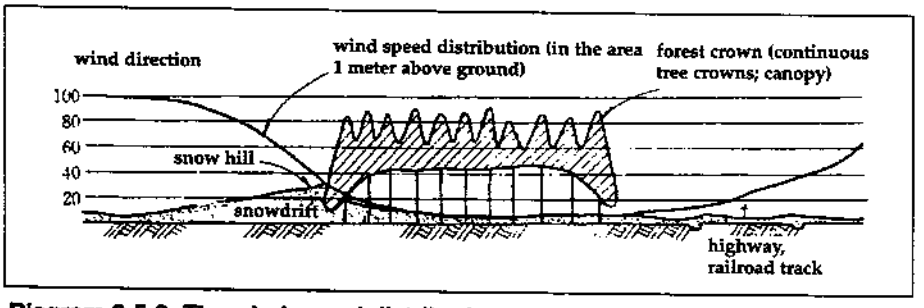


Diagram 2-5-2 The wind speed distribution and snow pile distribution of a snowbreak forest [31]

investigate the depth and the amount of water in the accumulated snow.

(3) Improving Visibility

Improving visibility is an important issue for ensuring highway traffic flow during the winter season. Snowbreak forests decrease wind speed, reduce the amount of blowing snow, ease the abrupt changes in visibility, and increase visibility.

Commentary

In order to make clear the kind of effectiveness provided from the setting up of snowbreak forests with respect to improving visibility, an investigation that measured and compared the visibility conditions in a place with and without a snowbreak forest is shown in the following diagram.

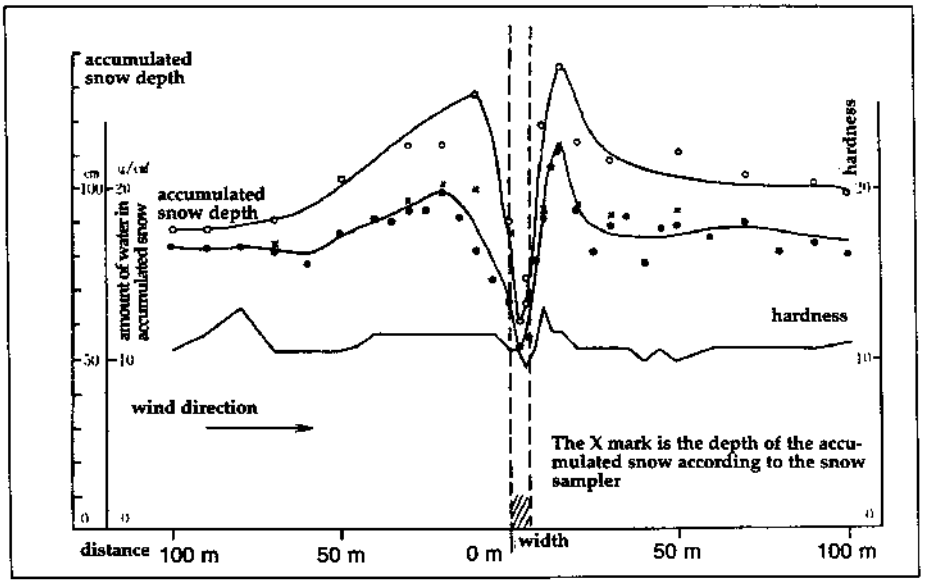


Diagram 2-5-3 Investigation of the depth of accumulated snow and amount of water in the accumulated snow at the six-meter wide Shinoro D forest

Diagram 2-5-4 compares the frequency of average visibility for one kilometer, more or less, and visibility over one kilometer during a 34-minute period, and Diagram 2-5-5 compares the frequency of average visibility of 300 meters, more or less, and visibility less than 300 meters during a 10-minute period in areas with and without countermeasures.

area	areas without countermeasures	areas with a snowbreak forest
average visibility (m)	1,090	1,200
frequency (%) when visibility is less than 1,000 m	4.6	2.1

Diagram 2-5-4 Visibility in areas with snowbreak forests and in places without countermeasures (where the average visibility is 1,000 meters)

area	areas without countermeasures	areas with a snowbreak forest
average visibility (m)	290	480
frequency (%) when visibility is less than 300 m	95.6	58.3

Diagram 2-5-5 Visibility in areas with snowbreak forests and in places without countermeasures (where the average visibility is 300 meters)

Snowbreak forest areas have better average visibility below a set standard; this tendency markedly continues as the visibility decreases.

Severe changes in visibility over a short period of time when the wind is blowing depend on the quality of accumulated snow, whether or not snow is falling, changes in the wind speed, and so forth. There is a striking difference between hindrances to visibility due to blowing snow and hindrances to visibility due to

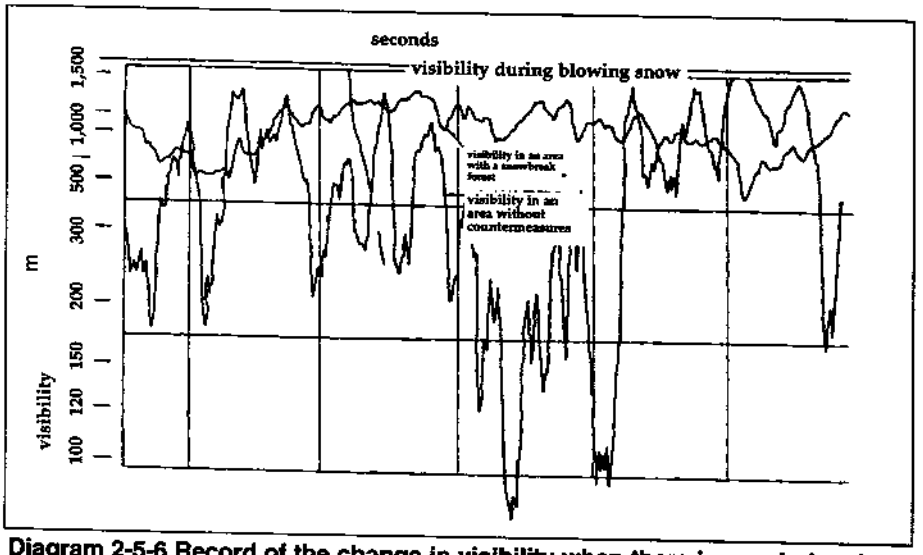


Diagram 2-5-6 Record of the change in visibility when there is no wind and when there is blowing snow[6]

fog even though the average visibility is the same.

Diagram 2-5-6 is a record of change in the permeability rate. When compared to a place without countermeasures, a place with a snowbreak fence has fewer changes in visibility, and stable visibility can be ensured.

Chapter 3 Surveys and Designs of Highway Snowbreak Forests

3-1 The Fundamental Aim and Procedure of the Surveys and Designs

When planning and designing a highway snowbreak forest, it is necessary to study all the conditions and sufficiently grasp the degree of danger from the blowing snow to ensure a corresponding snowbreak function. Furthermore, a sufficient snowbreak function predicts the growing environment of the trees and studies the necessary countermeasures during the planning and design stages.

To produce the effect of creating a snowbreak forest, it is necessary to properly interpret the area's degree of danger from blowing snow and the future growing environment before implementing the planning and design stages. Diagram 3-1-1 shows the general flow of the snowbreak forest surveys and designs, but from the macro basic plan until the execution of the design, it is necessary to relate the comprehensive and particular conditions to each other through repeated feedback and revisions.

3-2 Survey of Highway Snowbreak Forests

3-2-1 Interpreting the Degree of Danger Due to Blowing Snow

(1)Preliminary Survey

In the preliminary investigations, the sections are selected and measured and priorities are evaluated using existing data about the conditions where obstructions to traffic occur. Diagrams documenting the frequency of blowing snow and the amount of snowdrifts are made.

Commentary

1. Selection and Measurement of All the Sections Where Any of the Following Conditions Apply or Are Necessary.

a. In flat areas, sections where according to diagrams, the frequency of blowing snow exceeds 10 percent.

b. In flat areas, sections where according to diagrams, the amount of snowdrifts exceeds 20 m^3/m on the snowdrift amounts.

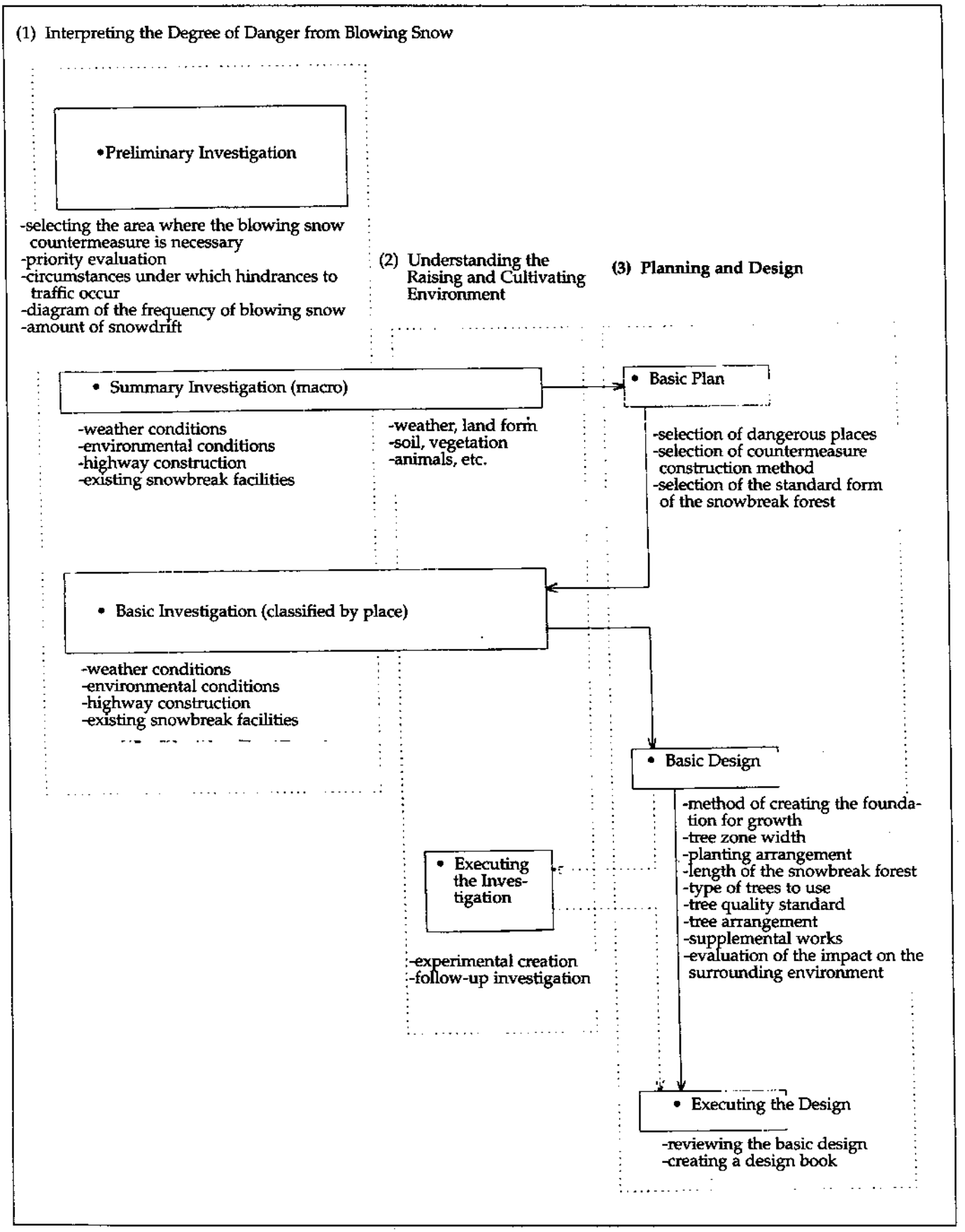


Diagram 3-1-1 Survey and design flow for highway snowbreak forests

c. In mountainous areas, sections that include places where the largest local snowdrift amount exceeds 20 m3/m.

d. Sections where traffic jams due to blowing snow occurred 10 or more times duing the past 10 years.

e. Sections where traffic jams constitute a hindrance to traffic when the snow blows.

f. Sections where several traffic accidents occur when the snow blows.

g. Sections where snowplowing work is hindered from snowdrifts.

2. Evaluation (establishment of the priorities for sections where blowing snow hazards occur.)

The sections are selected according to the previous conditions, and the extent of reduced visibility and extent of the consequences are considered.

a. Index of the extent of reduced visibility – frequency of blowing snow, amount of snowdrifts, number of times traffic has been stopped.

b. Index of extent of consequences -- amount of traffic, trip length, whether or not there is an alternate route.

For more extensive details on the selection of sections where blowing snow countermeasures are necessary and the priority evaluation of those sections, refer to the *Companion Volume.*

(2) Summary Investigation (macro evaluation of the degree of danger due to blowing snow)

In the summary investigation, the maximum snowdrift amount in the areas is estimated, and the degree of danger caused from blowing snow is evaluated using existing data, including weather conditions, environmental conditions, road construction, and simple local surveys.

Commentary

In the summary survey the items listed in Table 3-2-1 are investigated using existing data and simple local surveys. From these survey items, the maximum snowdrift amount in the local area can be estimated and the degree of danger from blowing snow evaluated. For details about the evaluation of the degree of danger from blowing snow refer to the *Companion Volume.*

(3) Basic Survey (classified by place)

The basic survey (classified by place) is the gathering of actual survey data at the site and combining it with the existing data in the summary survey to comprehensively evaluate the degree of danger from blowing snow.

Commentary

According to the existing data in the summary survey, the influence of the changes in the amount of snowdrift from year to year is small, and it is difficult for it to sufficiently reflect the influence of the environmental conditions of the area, including length of snow field, vegetation circumstances, and land form. On the other hand, the value of an actual survey of the amount of maximum snowdrift in a local area sufficiently reflects

Survey Items		Survey Method	Survey Content
weather conditions	frequency of blowing snow	diagram of frequency of blowing snow	frequency of blowing snow
	amount of snowdrifts	diagram of amount of snowdrifts	amount of snowdrifts
	depth of accumulated snow	existing weather observation data	depth of accumulated snow
environmental conditions	land form	diagram of land form, aerial photographs	flat land, hilly land, mountainous land
	vegetation	plan of vegetation	existence of vegetation vegetation density (sparse, medium, dense) tree type (needle-leafed trees, broad-leafed trees) tree height
	length of snow field	diagram of land form, aerial photographs, plan of vegetation	distance from the highway to obstacles such as the forest etc.
Road construction, etc.	form of cut and ground level	management chart completion chart	flat, shallow-cut ground; deeply cut ground; low raised ground; high raised ground; half-cut, half-raised ground
	width	management chart completion chart	number of car lanes
existing snowbreak		management chart completion chart	existence of snowbreak facilities construction type, effect

Table 3-2-1 Items and outline of the summary survey

the influence of the environmental conditions, but to consider the changes in the annual snowdrift amount, it is necessary to measure for an extremely long period of time.

For this reason, in a basic survey (Table 3-2-2) an actual survey of the amount of snowdrift in the local area is conducted for as long as three years, and to make a comprehensive evaluation, this is combined with the estimates from the existing data. In cases where it is difficult to make an actual survey at the local area for three years, it is desirable to either make an actual survey of the local area for one or two years, or to collect values of an actual survey of a local place nearby that is determined to have the same circumstances. Refer to the *Companion Volume* for survey methods. If there is an existing forest nearby, investigate the circumstances under which it is growing and the circumstances of snow damage (height of broken branches) and add this data to the fundamental survey.

	Survey Item	Survey Method	Survey Content	Survey Purpose	Degree of Importance (See Note)
	wind direction	wind direction wind speed measurements	principal wind direction	forest zone length	00
weather conditions	frequency of blowing snow	diagram of frequency of blowing snow visibility measurement wind direction wind speed measurement air temperature measurement	frequency of blowing snow time of continuous blowing snow average wind speed maximum wind speed average, highest, lowest air temperatures	degree of danger from blowing snow temporary snowbreak facilities	0
	amount of snowdrift	diagram of amount of snowdrift temporary snowdrift fence	amount of snowdrift	degree of danger from blowing snow forest zone width forest zone length temporary snowbreak facilities	00
	depth of accumulated snow	measure depth of accumulated snow	depth of accumulated snow	degree of danger from blowing snow temporary snowbreak facilities	0
environmental conditions	land form	diagram of land form aerial photography actual survey	land form	degree of danger from blowing snow forest zone length temporary snowbreak facilities	0
	vegetation	diagram of vegetation actual survey	tree type tree height width of forest zone height of branches from ground tree crown density snow damage circumstances	degree of danger from blowing snow forest zone length temporary snowbreak facilities	00

Note: The 00 mark is an item for which it is necessary to conduct an actual survey in the local area. The 0 mark is an item for which an actual survey should be carried out if the occasion demands.

Table 3-2-2 Items and outline of the basis survey (Page 1)

	Survey Item	Survey Method	Survey Content	Survey Purpose	Degree of Importance
	length of snow field	diagram of land form aerial photograph diagram of vegetation actual survey	distance from highway to an obstacle such as the forest	degree of danger from blowing snow forest zone length temporary snowbreak facilities	0
highway construction	raised ground	management chart completion chart actual survey	height of raised ground method, surface shape	degree of danger from blowing snow forest zone length temporary snowbreak facilities	0
	cut ground	management chart completion chart actual survey	depth of cut ground method, surface shape	degree of danger from blowing snow forest zone length temporary snowbreak facilities	0
	half-cut half raised ground	management chart completion chart actual survey	height of raised ground depth of cut ground method, surface shape	degree of danger from blowing snow forest zone length temporary snowbreak facilities	0
	construction of road cross section	management chart completion chart actual survey	total width shape of road cross section	degree of danger from blowing snow forest zone length temporary snowbreak facilities	0
existing snowbreak facilities		management chart completion chart actual survey	construction type standards effects	degree of danger from blowing snow forest zone length temporary snowbreak facilities	0

Table 3-2-2 Items and outline of the basis survey (Page 2)

3-2-2 Understanding the Growth Environment

(1) The Flow of the Survey

1. Summary Survey (macro)

The content of the summary survey includes the weather (air temperature, wind direction, wind speed, precipitation, snowfall and snowpack, sunshine, humidity), land form, soil, vegetation, animals, and special conditions (i.e., coastal and other areas with strong winds, warm zones, soil not suitable for planting, etc.) that should be considered using existing data and simple local area surveys as resources.

In a summary survey the following items are surveyed using existing data and simple local area surveys (refer to Table 3-2-3).

2. Basic Survey (classified by place)

To scrutinize the selection of trees, planting density, arrangement, forest zone width, growth foundation (soil), and other facilities and maintenance management plans, it is necessary to understand the tree growing environment of the local area. For this reason, survey the weather (air temperature, wind direction, wind speed, precipitation, snowfall and snowpack, sunshine, humidity), land form, soil, vegetation, and animals in the area.

The survey items at the basic survey stage are shown in Table 3-2-4. First, gather and compile the existing data and then carry out a detailed survey of the local area for items that require further study.

Survey Item	Survey Content		Survey Method	Relation to Highway Snowbreak Forests
weather	wind direction wind speed	average monthly wind speed most common monthly wind direction	use existing data from the meteorological agency, regional weather observation posts, etc. (5-10 years or more) or local observations	careful selection of region and ground width during creation
	other	salt air damage	existing data survey of examples	careful selection of region and ground width during creation
soil	soil profile underground water situation		survey of local area	careful selection of region and ground width during creation
vegetation	forest aspect		interpretation of existing data, such as a map of vegetation, aerial photographs	to make use of existing trees

Table 3-2-3 Summary of the weather and environmental investigations in the summary survey

Survey Items	Survey Content		Degree of Importance (See Note)	Survey Method	Relation to Highway Snowbreak Forests
weather	-air temperature	-monthly average -monthly average of the highest daily temperatures -highest temperature in the month -monthly average of the lowest temperatures -lowest temperature in the month -first day of fog and winter days	00 0 0 0 0 00	use existing data from the meteorological agency, regional weather observation posts, etc. (5-10 years or more) or local observation	selection of tree type
	wind direction - wind speed	-average monthly wind speed -commonest monthly wind direction -highest monthly wind speed -wind direction when the wind is the strongest	00 00 00 00	use existing data from the meteorological agency, regional weather observation posts, etc. (5-10 years or more) or local observation	selection of tree type wind protection facilities
	precipitation	-amount of monthly precipitation -greatest amount of precipitation on one day in a month -number of days of precipitation	00 0 00	use existing data from the meteorological agency, regional weather observation posts, etc. (5-10 years or more) or local observation	degree of growth of trees to plant planting time drainage construction

Note: The 00 mark indicates an item that requires investigation. The 0 mark indicates an item whose investigation is desirable.

Table 3-2-4 (Page 1) Summary of the weather and environmental investigations in the basic survey

Survey Items	Survey Content		Degree of Importance (See Note)	Survey Method	Relation to Highway Snowbreak Forests
	snowfall and snowpack	10 year established maximum depth of snow accumulation	00	use existing data from the meteorological agency, regional weather observation posts, etc. (5-10 years or more) or local observation	selection of tree type
	sunshine	total hours of sunshine in a month number of days without sunshine	0 0	use existing data from the meteorological agency, regional weather observation posts, etc.	selection of tree type
	humidity	monthly average of the daily lowest humidity	0	local area observation	drainage construction
	other	salt air damage, air pollution occurrence of fog	00 00	existing data, survey of examples, word of mouth survey	selection of tree type
land form	water catchment land form		00	interpretation of aerial photographs land form maps local area surveys other existing data	selection of tree type drainage construction
soil	soil profile physical analysis of the soil chemical analysis of the soil underground water situation		00 00 0 00	local area surveys and analysis of local area samples	selection of tree type fertilization, drainage construction ground preparation method ground patching ensuring an effective ground layer ground layer improvement soil improvement

Table 3-2-4 (Page 2)

Survey Items	Survey Content		Degree of Importance (See Note)	Survey Method	Relation to Highway Snowbreak Forests
vegetation	present vegetation forest aspect		◎◎ ◎◎	vegetation, etc. existing data interpretation of aerial photographs local area survey	selection of tree type to make use of existing trees
animals	mammals bird types insect types		◎◎	existing data local area survey	selection of tree type maintenance management

Table 3-2-4 (Page 3)

(2) Executing the Survey

Before proceeding to the step of executing the design of the highway snowbreak forest creation, if there are still uncertain or negative factors remaining, it is desirable to make a trial creation and conduct follow-up surveys that determine its compatibility with the local area.

Commentary

As the need arises, carry out a trial creation and follow-up surveys based on the basic plan. To confirm the creation method including tree type, planting density, arrangement, forest zone width, planting method, wind protection measures, planting foundation, suitable time for growth, etc., establish several kinds of "highway snowbreak forest model plans" and carry them out. When carrying out the trial creation, select a representative place within the region for the project and make it 150 m to 200 m long. Within this section, carry out trial creations of several model plans. Plant more than 30 of each type of tree.

During the trial creation follow-up survey, examine the problem points using an analysis of local area surveys and sample surveys, and in addition to a comprehensive consideration, carry out concrete proposals concerning the creation method, the foundation, the selection of tree type, the suitable planting time, and the subsequent maintenance management, and clarify the problem points of the design. It is necessary to continue the trial creation follow-up surveys for three or more years to determine whether the model plan is suitable for the local area.

(3) Survey Content

1. Air Temperature

Air temperature is a fundamental factor that controls the raising and nurturing of plants and planted trees. Furthermore, the winter season's cold, in connection with wind and land form conditions, becomes a source of damage. (See Table 3-2-5.)

For surveying trees it is possible to use the existing data from the nearest meteorological agency or regional weather observation places. Consolidate it statistically to study the planting conditions. However, because high mountain areas and places that receive

Type			Period of Occurrence	Main Damage Circumstances
freezing damage	frost damage	late frost	just before the leaves come out-period when the leaves are out	tree's winter sprouts die of freezing
		early frost	before and after growth stops	very young tree's current year's trunk growth dies of freezing
	freezing damage	ground freezing damage	early winter-before snowpack early spring-just after snow melts	very young tree's trunk near the ground is damaged by freezing
		blight type freezing damage	late winter-early spring	freezing damage on part of trunk near snow surface
		freezing cracking	severe cold period that freezes trunk	large diameter tree's trunk splits lengthwise
drying damage	cold wind damage		severe cold period, when the soil or part of trunk is usually frozen	branches and leaves or entire trunk of trees that get the brunt of the wind wither and die
	cold drying damage		when the soil freezes and clear weather continues	trees on southern slope of areas with little snow wither and die

Table 3-2-5 Classification of cold damage

the brunt of the wind are usually sites for which existing data does not exist, it is necessary to carry out local area observations. Air temperature is also a major factor in the occurrence of blowing snow. It is desirable to conduct local area observations, especially during winter, and to add them to existing data to obtain more accurate material.

When conducting local area observations, select a place that is not affected by snowdrifts and set up a maximum-minimum thermometer in a simple roof type shelter. The observation should be conducted daily at the same time, but for expense reasons, commission observations are often organized. For cost-effective reasons, it is advisable to set up a simple recording device that records the temperature weekly.

2. Wind Direction, Wind Speed

Wind direction and wind speed are two main factors in the occurrence of blowing snow but others include snowfall, snowpack, and air temperature, all of which are closely related to the width, length, and planting density of a snowbreak forest. Because wind direction and wind speed change swiftly locally, land forms and obstacles affect them,

so it is necessary that the survey method perform a statistical analysis composed of the existing data and local winter observations.

The wind during the tree growing season (roughly April to September) is a main factor hindering growth according to documented surveys. The wind speed of about 5 m/sec and over is a main factor hindering growth. Strong winds, besides causing tree trunks and branches to break, is a cause of cold wind damage. Because it is possible to use existing tree data, statistically compile the planting conditions that include the introduction of wind protection facilities. It is also possible to estimate the prevailing wind from the shape and direction of the tree crowns in the vicinity. See Diagram 3-2-1.

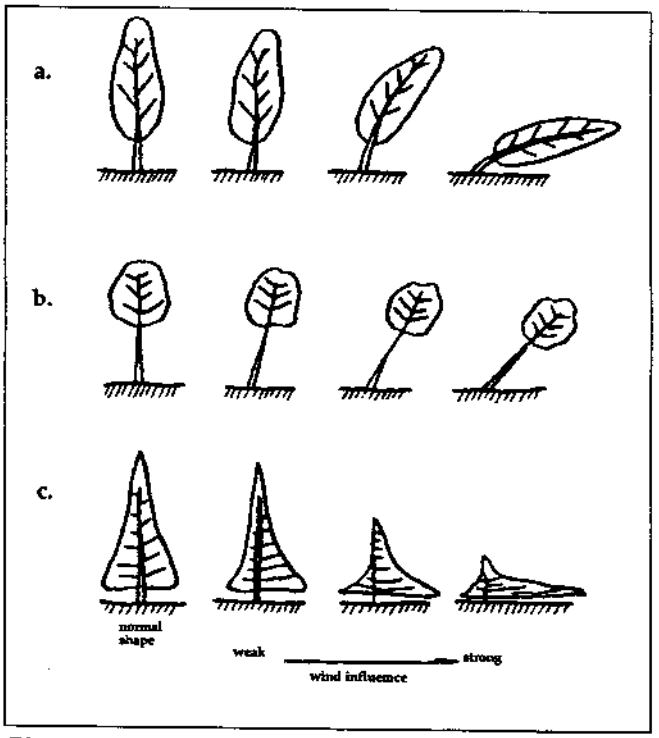


Diagram 3-2-1 Classification of tree type from deformities caused by the wind[54]

For local area observations, one method is using a simple anemometer, but other measuring devices, such as an aerovane that records wind direction and speed is better suited to continuous observation. In either case, select a place that is not influenced with obstacles, such as the raised ground of the highway or near buildings.

3. Precipitation

Precipitation, along with air temperature, controls the growth of plants. Under conditions of low precipitation, damage to the tree trunk from dryness (parching) occurs. For the raising and nurturing of trees, a precipitation amount of 400 mm per year or more is necessary. In the weather conditions in Hokkaido, there is little worry about damage due to dryness (parching) in trees that have reached maturity. However, in Hokkaido in the spring season, there is little precipitation and parching is a problem. So tree planting time occurs in the spring. During a year if it is dry, irrigation is necessary. Conversely, during short periods of concentrated precipitation, the top soil might flow or become excessively wet. It is best to use existing data concerning precipitation, and there are methods, such as using an inverted type rain gauge, to record the amount of rain.

4. Snowfall and Snowpack

There is a close relationship between snowfall, snow pack, and blowing snow. The nearest weather agency or weather observation post will have data concerning the depth of the snowfall and snow pack, but differences in areas, do not just differ with the year because the influence of the land form factor is fundamental.

Physical and physiological damage to trees as shown in Diagram 3-2-2 and Table 3-2-6 can occur in areas of heavy snowfall, so selecting a type of tree that can withstand snow damage is important.

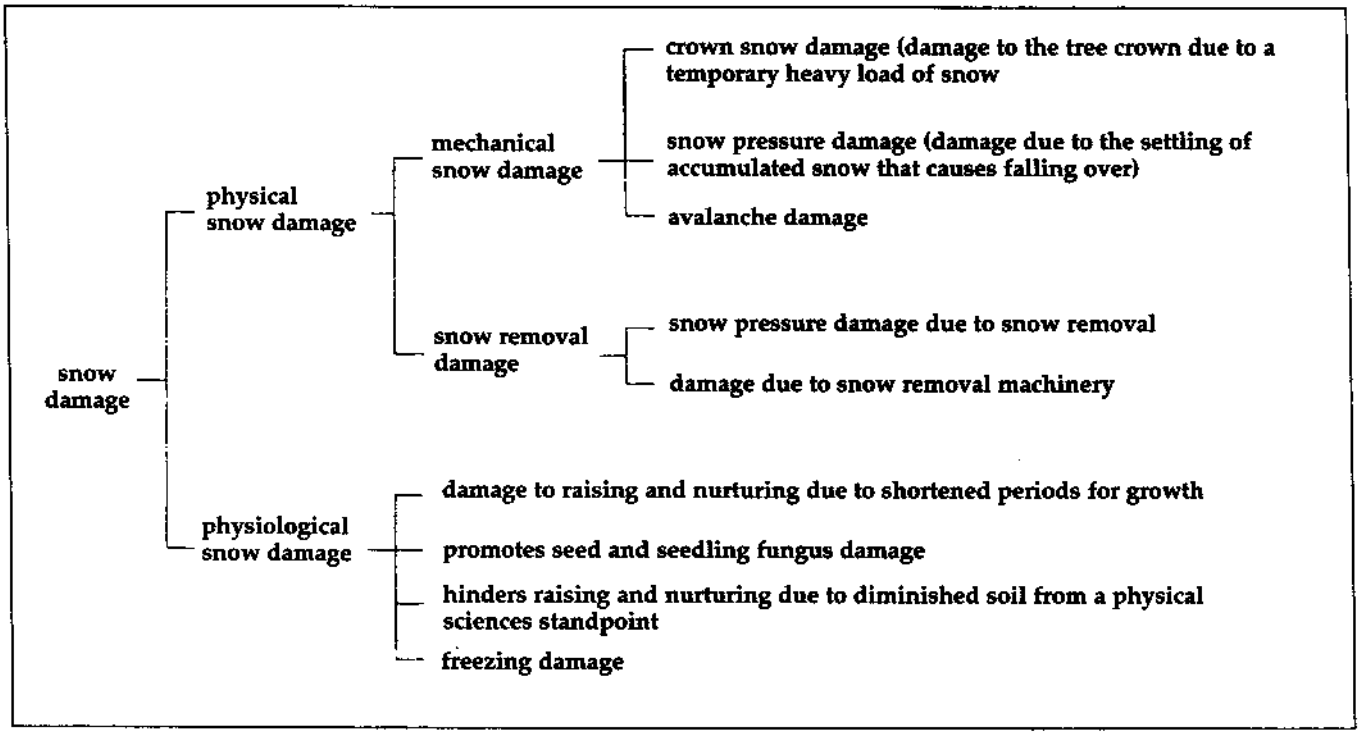


Diagram 3-2-2 Classification of snow damage[48]

Classification	Tree that is Easily Damaged	Damage Condition
crown snow damage	among needle-leafed evergreens, pines are the weakest; next weakest are the larch	trunk breaking, branch removal
snow pressure damage	tree type that is easily buried in snow by heavy snowfall in early winter trees with large turns near the base; if the trunk leans, the tree crown is offset the tree crown is heavy or the shape is comparatively large	trunk breaks trunk bends uprooting branch removal
snow removal damage	needle-leafed trees are easily damaged	trunk breaks, trunk bends

Table 3-2-6 Main physical snow damage[48]

For the local area observation there is the method of simply sticking in a depth measuring pole and reading the scale and the method of automatically recording with a snow camera a scale on a snow measure set up in advance. In this case set it up on flat land where there are no obstacles in a place that shows the representative snow depth in the area.

5. Sunshine

Since there are cases when the hours of sunshine, besides being related to the selection of the type of tree, exert influence on land use in the vicinity, conduct the study using existing data.

6. Humidity

Since humidity is related to drying when the trees are transplanted, simply measure with a ventilation humidity meter and refer to it when planning transplanting.

7. Other

Salt air damage occurs in areas along the sea coast. Since chemical and physiological damage occurs to tree leaves, etc. when salt is in solution in minute water drops, there are differences in the ability of types of trees to withstand salt. Consequently, refer to past survey examples and, if necessary, measure the attached amount of salt and soil salt density. Appraise this result and study the fitness of the creation of a snowbreak forest and countermeasures.

Exhaust gas from factories, cars, etc. is a cause of air pollution. Tree types vary in the ease with which they are damaged. If it can be forecast that damage will occur, refer to examples form past surveys and, if necessary, measure the density of harmful substances.

The occurrence of fog in coastal areas is closely related to damage from salt air. Study the number of foggy days by using existing data.

8. Soil Profile Survey and Analysis

Because soil provides the foundation for the raising and nurturing of plants, when preparing the creation plan, consider soil improvement, selection of tree type, and a future maintenance-management plan. Determining the characteristics of the soil is an important factor from the time of the creation stage that continues through the maintenance stage.

To survey a soil cross section from a local area, collect the necessary samples and analyze them using indoor experiments. The following is a summary of soil characteristics that will assist in tree planting.

When creating the actual snowbreak forest, ground preparation, soil improvement, fertilization, and drainage construction are the factors to consider. During the local area survey, a soil profile is established, and the underground water situation that is vital to growth is carried out.

A soil cross section that has been cultivated or artificially disturbed during human activity will often be dry. In this case dig a test hole to an effective depth and survey the soil thickness, including decaying vegetation, the surface layer and structure, the bottom layers, the underground water situation, and so forth. During the physical survey, a simple distinction is performed using sign and touch to determine the water content condition, soil hardness, and the nature of the soil (Table 3-2-7).

Soil analysis is devided into physical and chemical methods. General characteristics for physical analysis are the compositional graininess (nature of the ground), the three-phase comparison, the pF-hydration rate, etc. See Table 3-2-8. For the chemical analysis, such items as pH (H2O), KC1), displacement acidity, lime neutralization amount, total carbon (decayed plants), total nitrogen, and base displacement capacity are considered. See Table 3-2-9. It is important that a suitable diagnosis is made and reflected in the creation plan because it is difficult to make improvement after planting. When determining the scientific nature of the planting foundation at the site, gather and study past data while striving to make a

Classification	Diagnosis item/ Diagnosis	Good Soil Conditions	Normal Soil Conditions	Bad Soil Conditions	Remarks
soil profile composition generally survey the condition of a soil cross section	surface ground layer's soil thickness ground including decaying vegetation	soil thickness 30 cm or more	soil thickness 10-30 cm	soil thickness 10 cm or less	
	effective ground layer	depth 1.5 m or more	depth 1-0.6 m	depth 0.3 m or less	
	ground water situation (condition of the nature of drainage)	depth 2 m or more color of black wool	depth 1-2 m brown	depth 1 m or less gray-green	water gushing up from underground stagnant water, etc.
	soil structure	has group grain structure	nongroup grain ground	cracked ground hardened ground	
physical nature	water condition (hydration rate) 28) half dry	half dry feels moist to the hand	wet The palm of the hand gets slightly wet when it is squeezed.	dry does not feel moist even if squeezed damp The palm of the hand gets completely wet when it is squeezed.	changes depending on the weather conditions before the survey
	hardness (Nakayama type hardness measure)	hardness 20 or less even if cultivated, it soon crumbles	hardness 20-24	hardness 25 or more (very difficult to cultivate)	related to root extension be especially careful if it is packed down
	nature of ground	clay soil (CL) amount of clay content 15-20% soil (L) amount of clay content 0-15% amount of sand content 55-65%	sand soil (SL) amount of clay content 0-15% amount of sand content 65-85%	ground with piled up plants (HC) amount of clay content 45% or more light plant ground (LiC) amount of clay content 25-45% sandy soil (S) amount of clay content 0-15% amount of sand content 85% or more	

Table 3-2-7 Simple method of diagnosing the composition and physical nature of a soil profile of soil.

comprehensive judgment that will also apply to forecasting future conditions.

9. Vegetation

Since it takes many years for a tree to grow, restoring a forest is not easy either from the standpoint of time or economics. Existing forests should be handled with discretion because they express the latent ability of nature and the efforts of ancestors to shape the natural features and cultural climate of and area.

Item	Content	Standards, etc.
degree of graininess, composition (nature of the ground)	The nature of the ground is determined by the percentage of inorganic substance ground particles (sand, silt, clay) in the composition of the soil according to the international soil science academic method. The nature of the ground is an important characteristic that influences its ability to allow the passage of water and air and retain fertilizer.	Ground nature SL (sandy soil), L (soil), CL (clay soil) and SCL (sandy clay soil) are good. SiCL (silty clay soil) SiL (silty soil), LiC (light clay soil) and SC (sandy clay ground) are mid-level.
three-phase comparison	Under piled-up conditions at the local area, the percentage of soil content (hard phase), water content (liquid phase), and air content (air phase) can be measured to determine the ease or difficulty of the extension of a plant's root system, the total crevice percentage from which the quality of the water and oxygen supply is found, and the degree of water saturation.	total crevice percentage: 55 volume % or more is good 55-40 volume % mid-level degree of water saturation: 70-40 volume % moderate
pF - hydration rate	pF indicates the strength of the union of soil and water and the relation between the various pF values and hydration rates shown in the pF-hydration rate curved line. This curved line shows the soil's water retaining characteristics and the amount of water plants use can be estimated.	a beneficial, efficient amount of water of 25 volume % or more is good 25-15 volume % is mid-level

Table 3-2-8 Items in the physical analysis of soil

An existing forest, compared to a planted one, may have greater diversity, and many have an effective existence. A method for surveying an existing forest generally uses the techniques from the *Vegetation Survey* that studied greenery and the *Forest Aspect Survey* that studied forests. The person who created the *Forest Aspect Survey* integrated the present situation and devised a plan that efficiently uses an existing forest. The factors for interpreting the forest aspect chart from the survey form a combination as shown in Table 3-2-10 and Table 3-2-11.

To find the amount of tree height, carry out a survey of the yearly growth of the existing forest at the planned site.

When a forest exists in the vicinity of the planned highway snowbreak forest, try to avoid changing the growing environment of the existing forest. If possible, do not cut the ground or install raised earth beds in the existing forest's conservation area. Consider conditions, such as maintaining the traditional ground foundation, sunshine, ventilation, drainage, and ground water, and apply the forest aspect survey results in the overall plan. It is desirable to keep as much forest land as possible and to create a plan that organically unites the current landscape with the planned highway snowbreak forest. During the period of initial tree growth, it is necessary to consider the influence of the wind, therefore it is practical to use the

Item		Content	Evaluation, etc
pH (H_2O, KCℓ)		shows the strength of acidity, generally trees like weak acidity-minute acidity (pH (H_2O) 5.5-6.5)	pH (H_2O): 5.5-6.0 weak acidity, 6.0-6.5 minute acidity pH (KCl): 5.0-5.5 weak acidity, 5.5-6.0 minute acidity
displacement acidity		The measure to determine the amount of acidity, even if it is the same pH, depends on amount of neutralizer.	3 and less minute acidity, 3-6 weak acidity
ammount of lime neutrization		Indicates the amount of calcium carbonate ($CaCo_3$) that can neutralizes dry ground 10 g pH 6.5 and determines the amount of neutralizer to use	for general soil mostly use 300-500 g/m^2 of calcium carbonate
all carbon (decaying plants)		Basis for calculating the amount of decaying plants. Evaluation is carried out on the amount of decaying plants. Decaying plants, besides being a source of nutrition, are an important characteristic that influences the scientific nature.	amount of decaying plants>10% strikingly abundant, 5-10% abundant.
total nitrogen		One of the three requisites of fertilizer that shows the total amount of the organic condition and the inorganic condition in the decaying plants.	0.4% and more is excessive, 0.4-0.15 is mid-level
base displacement capacity		Shows the maximum amount of positive ions that the soil can hold; it becomes a guideline for the soil's ability to hold fertilizer.	20 me/100 g is large, 20-6 me/100 g is mid-level
displacement characteristic base	calcium	indicates the amount of ions each soil type holds. All the nitrogen, along with the effective state phosphorus, indicates whether there is an abundance or lack of nutrition in the soil.	7.0 me/100 g or more is excessive, 7.0-3.5 me/100 g is mid-level
	magnesium		1.2 me/ 100g or more is excessive, 1.2-0.5 me/100 g is mid-level
	potassium		0.4 me/100 g or more is excessive, 0.4-0.2 me/100g is mid-level
phosphorus absorption coefficient		indicates the strength of the connection between soil and phosphorus. If it is too great, the plants will not be able to absorb most of the fertilizer.	500-1,00 mg/100 g is suitable
effective state phosphorus		indicates the amount of phosphorus that plants in the soil can use. Generally it is comparatively small in proportion to the increasing phosphorus absorption coefficient.	10 mg/ 100 g is excessive, 10-4 g/100 g is mid-level

Table 3-2-9 Items in the chemical analysis of soil

existing forest as a wind protection measure. The nature of the trees left standing should include not just tall, healthy evergreens with needle leaves, but willow-type, level trees of 1.5 m or taller that will contribute to a larger, cohesive protection pattern.

10. Animals

When raising a healthy highway snowbreak forest, insect and animal damage are an important issue, and there are also broader issues concerning how the birds and animals that live in the forest influence the land and facilities in the vicinity. To study the selection of the tree type and maintenance-management plan of a highway snowbreak forest, conduct a survey of the birth and breeding distribution of the mammals, birds, and insects. See Table 3-2-12.

In Hokkaido tree damage is often due to mice and jackrabbits eating the leaves, branches, and sprouts. Mice mainly damage trees by stripping the bark before eating it. Through existing data and methods that depend on local area surveys, an outline of the types and distribution of mammals is obtainable.

Natural Forest	Mark	Sections	Mark	Degree of Sparseness and Luxuriant Growth
	T y B	natural forest seedling area (under 6 cm) no tree area	dense middle sparse scattered	dense (degree of tree crown luxuriance 70% or more) middle (degree of tree crown luxuriance 40-69%) sparse (degree of tree crown luxuriance 10-39%) scattered (degree of tree crown luxuriance 3-9%)
	mark	tree crown increase	mark	tree height rank
	I II III	single-layer forest (artificial forest-like) 2-stage forest multiple-layer forest	H3 H2 H1	average tree height of upper layer forests 15 m or more average tree height of upper layer forests 7-14 m average tree height of upper layer forests 6 m or less
	mark	tree type group		
	N M L	needle-leafed tree forest mixed forest broad-leafed tree forest		

Note: Example of interpretation of forest aspect: T III L dense H2 —> natural forest - multiple-layer forest - broad-leafed forest-dense (degree of luxuriance of tree crown 70% or more) - average height if trees of upper layer forest are 7-14 m

Table 3-2-10 Factors used to interpret the forest aspect chart of a natural forest[21]

Planted Forest	Mark	Sections	Mark	Degree of Spareness and Luxuriant Growth
	J	afforestation land	dense middle sparse scattered	dense (degree of tree crown luxuriance 70% or more) middle (degree of tree crown luxuriance 40-69%) sparse (degree of tree crown luxuriance 10-39%) scattered (degree of tree crown luxuriance 3-9%)
	mark	classified by age	mark	tree height rank
	y s r	very young (1-10 years) prime (11-50 years) old (51- years or older	H3 H2 H1	average tree height of upper layer forests 15 m or more average tree height of upper layer forests 7-14 m average tree height of upper layer forests 6 m or less
	mark	classified by tree type	mark	classified by tree type
	to ka su e	fir Japanese larch Eastern White pine spruce white birch	ba sugi tou go	Jack pine Japanese cedar Norway spruc Korean pine hinio arbor vitae white cedar

Note: example of forest aspect interpretation: J y to middle H1 –> afforestation land - very young (1-10 years) - (todomatsu) fir - middle (degree of tree crown luxuriance 40-69%) - average tree height of upper layer forests 6 m or less

Table 3-2-11 Factors to interpret the forest aspect of a planted forest[21]

There are many beneficial birds that eat harmful insects, but there are others in the forest that are fond of eating the tree's seeds or insects under the tree's bark. Information on birds can derive from damage to neighboring crops and fruit, electricity pole or aerial wire punctures, and collisions with airplanes. Carry out local surveys and interviews to find the sources of potential problems.

Insects that eat the leaves of healthy growing plants can debilitate and injure trees through boring behavior or eating their leaves. Generally damage is conspicuous from very young lepidopterous insects called caterpillars. Boring insects damge trees when they attack the tissue structure under the bark, which affects the twigs and cones.

1) section	2) content of survey
3) hare and other mammals	4) Confirm the appearance. Find field signs, such as footprints and feces.
5) field mice	6) Find field signs, such as nest holes, footprints, feces, and food traces. Capture animals with traps.
7) birds	8) Carry out fixed-point observation and road census.
9) insects	10) Capture using sweeping bait trap or light trap, etc.

Table 3-2-12 Content of the local area survey

Notes: **Correcting methods:**

1) Field signs: footprints, feces, food traces, antler scratches, or other visible signs of animal activity.

2) Trap: trap

3) Fixed-point observation: bird types appear in the same place annually, which presents a recording opportunity

4) Road census: birds encountered along the route offer recording opportunities to observers

5) Sweeping: In grassy areas, an insect catching net is waved horizontally and gathers or scoops up the insects

6) Bait trap: luring the insects using bait as an inducement

7) Light trap: using a light, generally for collecting moths that are active at night

3-3 Planning and Designing a Highway Snowbreak Forest

3-3-1 Basic Plan

(1) Procedure of the Basic Plan

In the basic plan, based on preliminary surveys and summary surveys, dangerous places and countermeasure building methods are selected and a highway snowbreak forest standard model is produced.

Commentary

In the basic plan the selection of the dangerous places is concluded, and it is determined whether a highway snowbreak forest is appropriate. If a highway snowbreak forest is selected as the countermeasure, the forest zone width is decided, and the highway snowbreak forest standard model is chosen. Diagram 3-3-1 shows the flow of the basic plan.

1. Selection of the Dangerous Places

Based on the results of a summary survey, select the dangerous places where blowing snow countermeasures are necessary. For details see the *Companion Volume.*

2. Selection of the Method of Building the Countermeasure

Thoroughly appraise the special characteristics of each building method and select the most suitable construction method, or the most suitable combination, based on the weather in the local area, the environmental conditions, the highway structure, and any other important issues. The *Companion Volume* explains the techniques for selecting the countermeasure building method, and this book explains the conditions that are applicable to snowbreak forests.

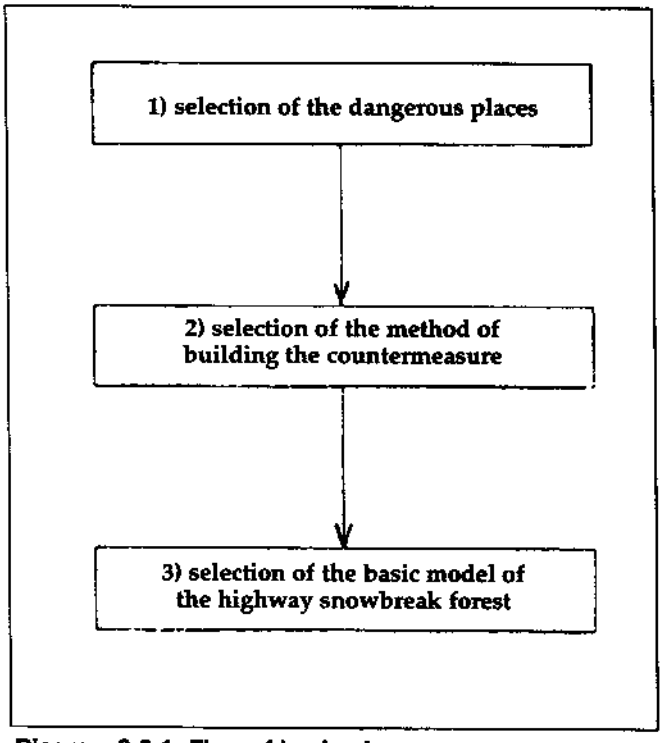


Diagram 3-3-1 Flow of basic plan

3. Selection of the Basic Model of the Highway Snowbreak Forest

The width of the forest zone is divided into three types depending upon the maximum amount of snowdrift in the local area. Select from among the three types: the 10 m type, the 20 m type, and the 30 m type. There are four techniques of creation: the landscape gardening technique used in conservation zone forests, the ecological technique, the disaster prevention technique, and the environmental technique. Use the disaster prevention technique as the basis and modify as needed with the environmental technique.

The standard model of a snowbreak forest is divided into a total of 12 types. There are three types – 10 m 20 m, and 30 m types – depending on the forest zone width. There are four types of zones, which require special consideration during the creation of the standard zone: the swampy zone, the sea coast and strong wind zones, and the zone where the soil is unsuitable for planting. These are strictly standard patterns so it is necessary to reform the basic design and execution stages to reflect the environmental conditions of the local area.

(2) Conditions Applicable to Highway Snowbreak Forests

Whether or not a snowbreak forest is suitable must be comprehensively decided after considering the land use conditions along the road, the degree of importance of the road that should be maintained, and the degree of hindrance to traffic.

Commentary

Conditions which are and are not compatible with highway snowbreak forests and conditions follow.

1. Conditions Which Are Compatible with Highway Snowbreak Forest

a. Places where the local land prices are inexpensive and obtaining sites is relatively easy.

b. Places where conserving the view alongside roads is considered important.

c. Places where the alternative prospects for land use alongside the road are restricted or remote.

d. Places where the existing forest can be sufficiently incorporated.

e. Places where snowbreak fences and other countermeasures exist, but where even greater results can be expected from changing to a snowbreak forest.

2. Conditions Which Are Not Compatible with Highway Snowbreak Forests

a. Places in large metropolitan areas where site acquisition is difficult due to high land prices.

b . Places where there are plans to use the land alongside a road in the future, and there is the danger that the creation of a snowbreak forest would hinder the land development.

c. In an environment where the raising and nurturing of trees is not desirable.

d. Places where there would be no particular problem with snowbreak effectiveness and maintenance management as well as view, etc., when using a lower-priced countermeasure construction method.

(3) Primary Factors for Deciding the Effectiveness of Snowbreaks

The width of the forest zone, the density of the tree crowns, the tree type, the tree height, and the height of the branches above the ground are primary factors in deciding the snowbreak effectiveness of highway snowbreak forests.

Commentary

The snowbreak effectiveness of highway snowbreak forests is controlled by the forest zone's structural circumstances (forest zone width, tree crown density, tree height, height of branches above the ground). Diagram 3-3-2 shows the relationship between the structural circumstances of a forest zone and the location of a snow hill, which reveals that to the extent that a snow hill forms on the downwind side, the amount of snow that blows through the forest zone is proportional. From this fact it is understood that the snowbreak effectiveness is proportional to the density of the tree crowns, the tree zone width, the tree height, and the distance of the branches from the ground.

If the width of the forest zone is narrow, it should sustain 80 to 120 percent of the range of the snowbreak function as well as the forest zone raising. Before the density of the tree crowns exceeds the 120 percent upper limit value, it is necessary to execute maintenance management including thinning and clear-cutting trees to the 80 percent lower limit.

For determining the tree type, select an evergreen needle-leafed tree that can demonstrate winter snowbreak effectiveness, but also select a tree type that corresponds to the rearing environment. There are cases in which deciduous, broad-leafed trees are used as a protective forest on the upwind and the downwind sides.

Concerning tree height, the snowbreak effectiveness increases with growth, but even during the growth process, snowbreak effectiveness is evident. The height of the branches above the ground (especially at the edge of the forest) affects the snowbreak function. It is necessary to carry out density management so that the bottom branches do not wither and die.

Generally, there are experienced approaches to tree crown density, tree type, tree height, and the height of branches from the ground. It is first important to inquire into a forest zone width that corresponds to the local area conditions.

(4) Deciding the Width of the Forest Zone

Since the forest zone width of the snowbreak forest is related to the maximum amount of snowdrift in the local area, select a standard to determine the forest zone width that corresponds to the conditions of the planned creation site.

At the basic planning stage, estimate the maximum snowdrift amount in the local area by considering the influence of environmental conditions and highway structure using the snowdrift amount chart (Table 3-3-1) as a basis.

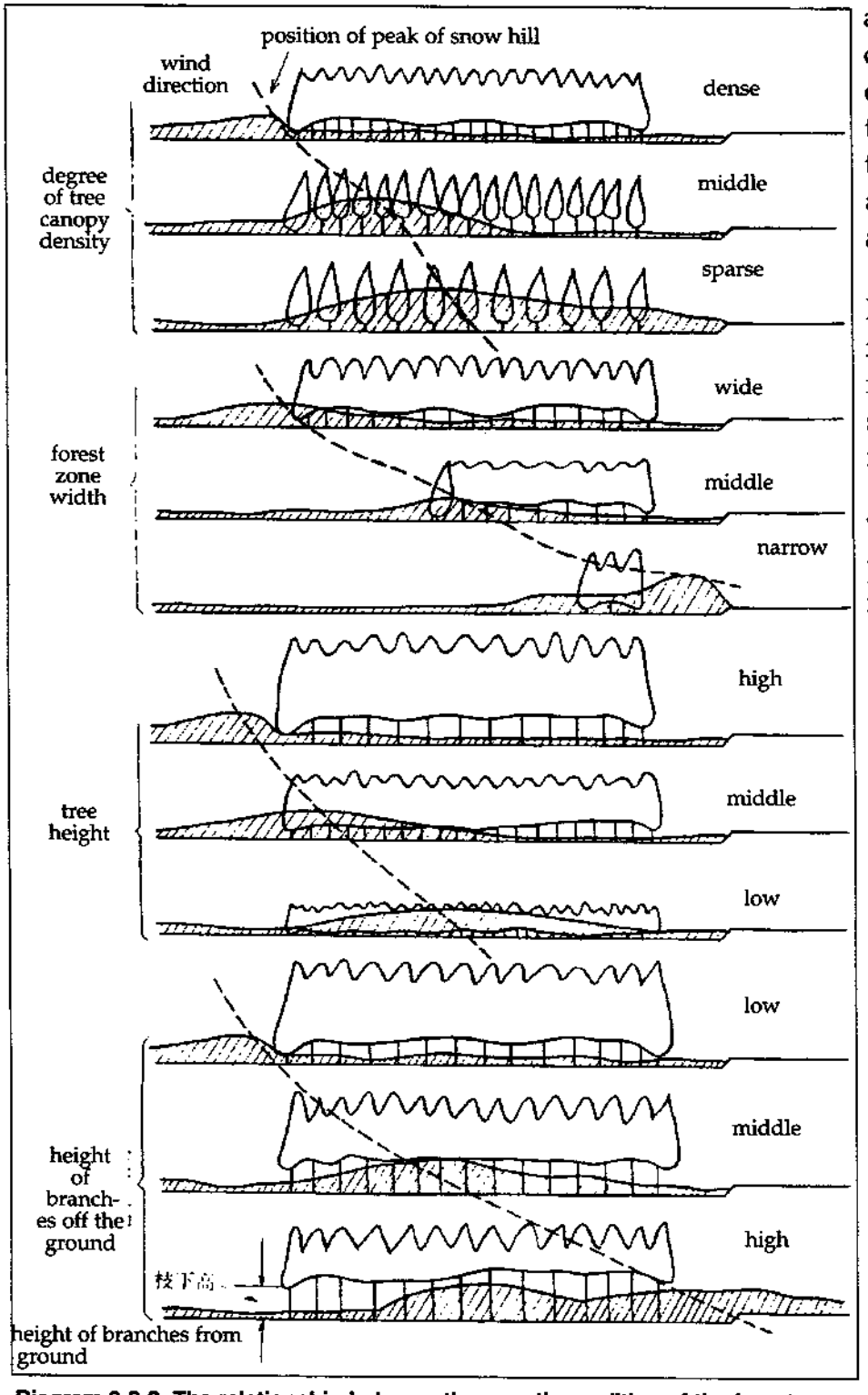


Diagram 3-3-2 The relationship between the growth condition of the forest zone and the position of a snow hill.[31]

For the space between the forest zone and the road, maintain 7.5 m to allow for snow deposits from snow removal equipment.

To improve visibility and prevent snowdrifts, it is necessary to decide on a forest zone width so that the snow hills on the downwind side of the snowbreak forest do not reach the road.

In order to cope with this, it is necessary for the forest zone to be wide enough to accommodate the snowdrift.

Railroad snowbreak forests are usually constructed of two zones, a forest zone that serves as a snowbreak and a forest zone for renewal. For purposes of snowbreak, as well as for purposes of construction, 50 m is the standard desirable forest zone width.

Type	Local area maximum snowdrift amount	Forest zone width
10 m	20-30 m^3/m	10 m
20 m	30-50 m^3/m	22 m
30 m	50 - m^3/m	32 m

Table 3-3-1 Snowdrift Amount Chart

If acquiring a site proves difficult, execute a narrow snowbreak forest zone and ensure the snowbreak function by raising the density of the tree canopy.

The snowbreak effectiveness of highway snowbreak forests changes with conditions, such as the number of rows of trees (width), the planting density, the condition of the leaves and branches, and the height of the trees. Even if the width is narrow (about 10-30 m), with the increase in the density of the tree canopy, it is possible to ensure satisfactory snowbreak effectiveness.

Often, in the case of highway snowbreak forests, it is difficult to acquire wide sites. If that problem arises, make the forest zone about 10-30 m and the tree canopy density comparatively high. If the tree canopy density is increased, there is the danger of the lower branches drying up and falling, but with the proper selection of tree type, arrangement, creation of the growing foundation, maintenance management, etc., it is possible to achieve a satisfactory snowbreak function. It is important in the maintenance-management stage, particularly with cutting and felling, etc., to reach a proper range of tree canopy density of 80 to 120 percent.

(5) Creation Technique Decision

For the highway snowbreak forest creation technique, use the disaster technique as a basis and modify it accordingly with the environmental technique.

Commentary

The creation of a conservation zone forest that contains a highway snowbreak forest requires a technique for first raising each type of tree. This creation technique can be divided into the four types: the landscape gardening technique, the ecological technique, the disaster prevention technique, and the environmental technique.
See Table 3-3-2.

For creating a highway snowbreak forest, use the disaster prevention technique as a basic and modify it with the environmental technique.

- Definitions
  - landscape gardening technique: a technique for locations with mild environmental conditions. Full-grown trees are used where severe environmental conditions exist because young planted trees lack adaptability.

  - ecological technique: three years after creation, the forest zone begins the transition back to nature without management. Ultimately, the aim is for long-lasting, stable evergreen broad leafed trees, but it takes an extremely long time period until it is finished and the possibility of failure is high.

  - disaster prevention technique: a technique that gives sea coast and windbreak-snowbreak forests a disaster

Technique Divisions	Purpose	Time	When Completed	Construction Expenses	Technique	Tree Type	Maintenance Management	Conflict Among Trees	Suitable Site (Case studies in Hokkaido)
landscape gardening technique	afforestation on to improve the view	short time	forest to improve the view	large as necessity requires	landscape gardening technique	something which has great view improving value	carry out maintenance management with thorough, scrupulous care for the purpose of improving the view	restrain conflict	park green areas park, factory landscape, roadside trees (Sapporo City, NakajimaPark)
environmental technique	conflict adjustment and control	rather long time	environmental forest	cheaper than landscape gardening technique, more expensive than disaster protection technique	apply forest industry techniques in the landscape gardening area	ones that endure very severe conditions and ones that have great value for improving the view	protection measures as necessary and, in part, view improving considerations	conflict adjustment and control	residential forest, development area planting, highway planting park, green area's special environmental planting area, median green area windbreak-snowbreak forest, disaster protection forest (Hakodate City and airport median green areas)
disaster protection technique	disaster protection forest creation	rather long time	disaster protection forest	minimum	forest industry technique	ones that endure very severe conditions	positive protective, measure, artificial nature transition	conflict adjustment	noncutlivated land, windbreak snowbreak forest, disaster protection forest, forest to protect against all types of disaster (Esashi town, Sunaban Coast forest)
ecological technique	restore vegetation	extremely long time	environmental conservation forest	minute quantity	not systematized	composed of natural vegetation	left to transition to natural vegetation	conflict left alone	natural vegetation area, natural park area, high cold area. (Shintolu town, Hokkaido Electric Tomura electricity generating plant afforestation

Table 3-3-2 Classification of conservation zone forest creation techniques[22] (Page 1)

protection function. Since seedlings are sed, adaptability to the environment is high.

- environmental technique: a technique of starting trees that serves a disaster protection function and improves the landscape through afforestation. It is an appropriate technique when considering the view.

(6) Degree of Growth of the Planted Trees

When the division study is carried out according to the degree of planted tree growth, the results of such a project appear as in Table 3-3-3.

The transplanting technology regarding half-grown trees is incomplete. In places with severe environmental conditions like those surrounding highway snowbreak forests, it is difficult for full-grown trees to adapt. Often their growth rate is diminished and the death rate due to dryness is high. On the other hand, the adaptability of seedlings to the environment is successful, and because the construction cost is low, seedlings are planted when creating highway snowbreak forests. Why seedlings have a greater ability to adapt to the environmental conditions than do grown trees follows.

1. Seedlings have smaller root systems (*T/R ratio is small), and few roots must be cut off when transplanting. Tree types that have deep roots are particularly susceptible to root loss.

2. Seedlings have a power destruction range in the proportional balance of the above-ground part and the below-ground part.

Division	Advantages	Shortcoming
seedling 4-years old	shows acclimatization to environmental conditions and a high rooting rate, rapid growth – seedlings have marketability – because growth is fast, 7-8 years snowbreak effectiveness close to that of a full-grown tree can be expected – construction costs are low	In the early period no snowbreak effectiveness can be expected.
half-grown tree 8-9 years old	When it roots and acclimatizes to the environment and shows prosperous growth, some snowbreak effectiveness can be expected in the early period.	Development is necessary concerning the market for half-grown trees and transplanting techniques. Construction costs are comparatively high.
full-grown tree 12-years old and over		When it does not acclimatize to the environment, the rate of death due to drying is high. Growth over a long time cannot be expected. There are types of trees for which there is no market. Transplanting technology development is necessary.

Note: The spruce is the standard type of tree in the "Divisions according to the degree of growth of the planted trees".

Table 3-3-3 The advantages and disadvantages of the divisions according to the degree of growth in the planted trees

3. Seedlings sway less in the wind, therefore the damage is less.

4. If windbreak measures are necessary during the growth period, it is necessary to plant trees that are shorter than the windbreak fence.

(7) Standard Model of a Snowbreak Forest

In selecting the standard model of a snowbreak forest, study the degree of danger from blowing snow and the creation technique that corresponds to the growing environment, the forest zone width, and the shape of the planted trees.

Commentary

Before selecting the standard model of highway snowbreak forest, clarify the environmental conditions of the planned site and study the creation techniques shown in Tables 3-3-4 and 3-3-5: the highway snowbreak forest width, the shape of the planted trees, and the environment of the creation site. A highway snowbreak forest's standard model cross section diagrams corresponding to these conditions are shown in Diagrams 3-3-3 to 3-3-6.

Item	Creation Condition	Remarks
highway snowbreak forest zone width	10 m, 22 m, 32 m,	selection according to an estimate of the value of the maximum amount of snowdrift in the local area
construction technique	disaster protection technique	environmental technique as necessary
shape of planted trees	seedlings	4-6 years
environment of creation site	general land, swampy land, etc.; sea coast and strong wind area zones, etc.; zones where the soil is not suitable for planting	selection according to summary survey

Table 3-3-4 Basic items in the division of the standard model of the highway snowbreak forest

*T/R ratio: The ratio of the weight of the seedling's top part to the bottom part. The ratio provides an index for superior seedlings, particularly of rooting quality.

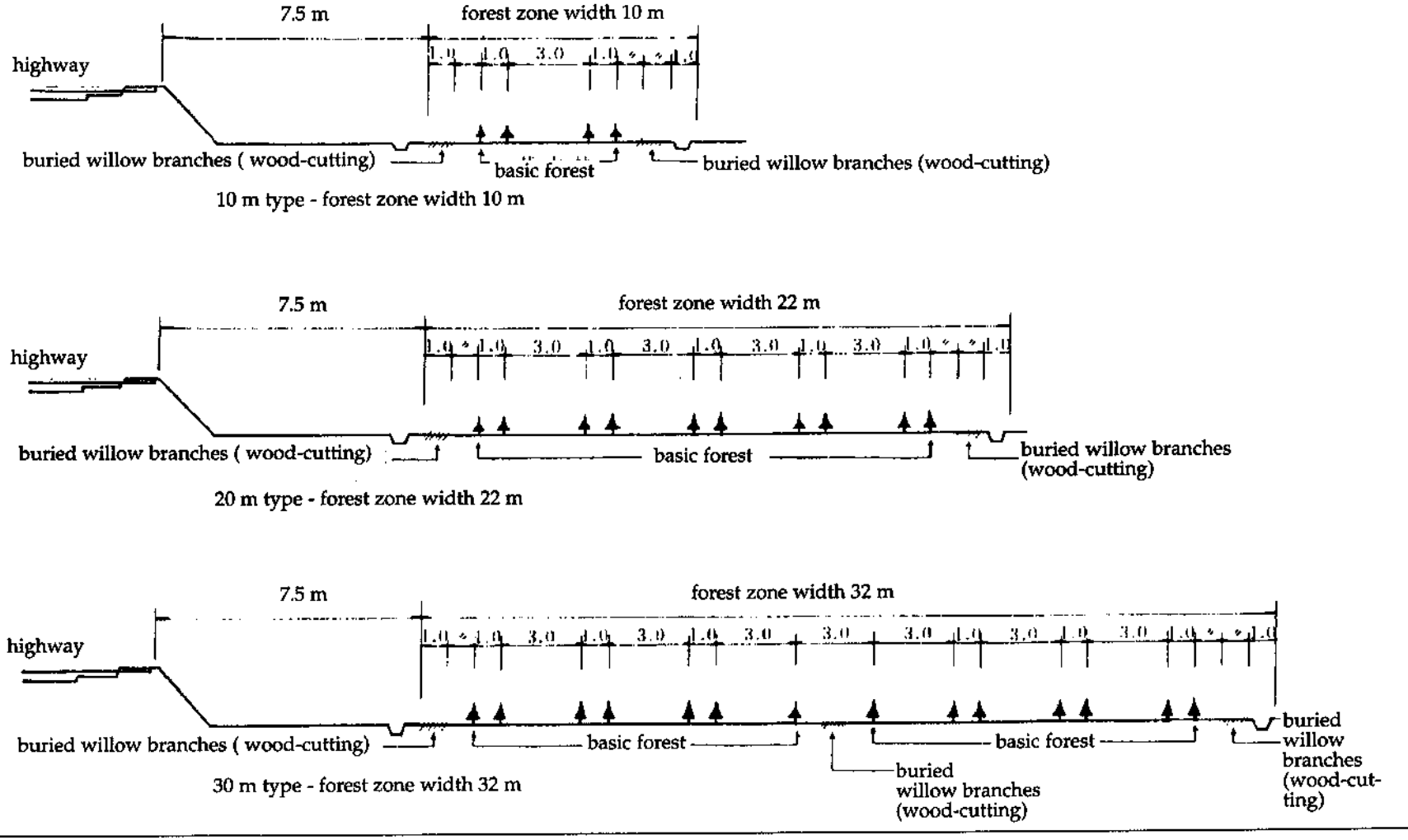


Diagram 3-3-3 Highway snowbreak forest standard model (general land) diagram of fixed rules (scale 1:200) (planting time)

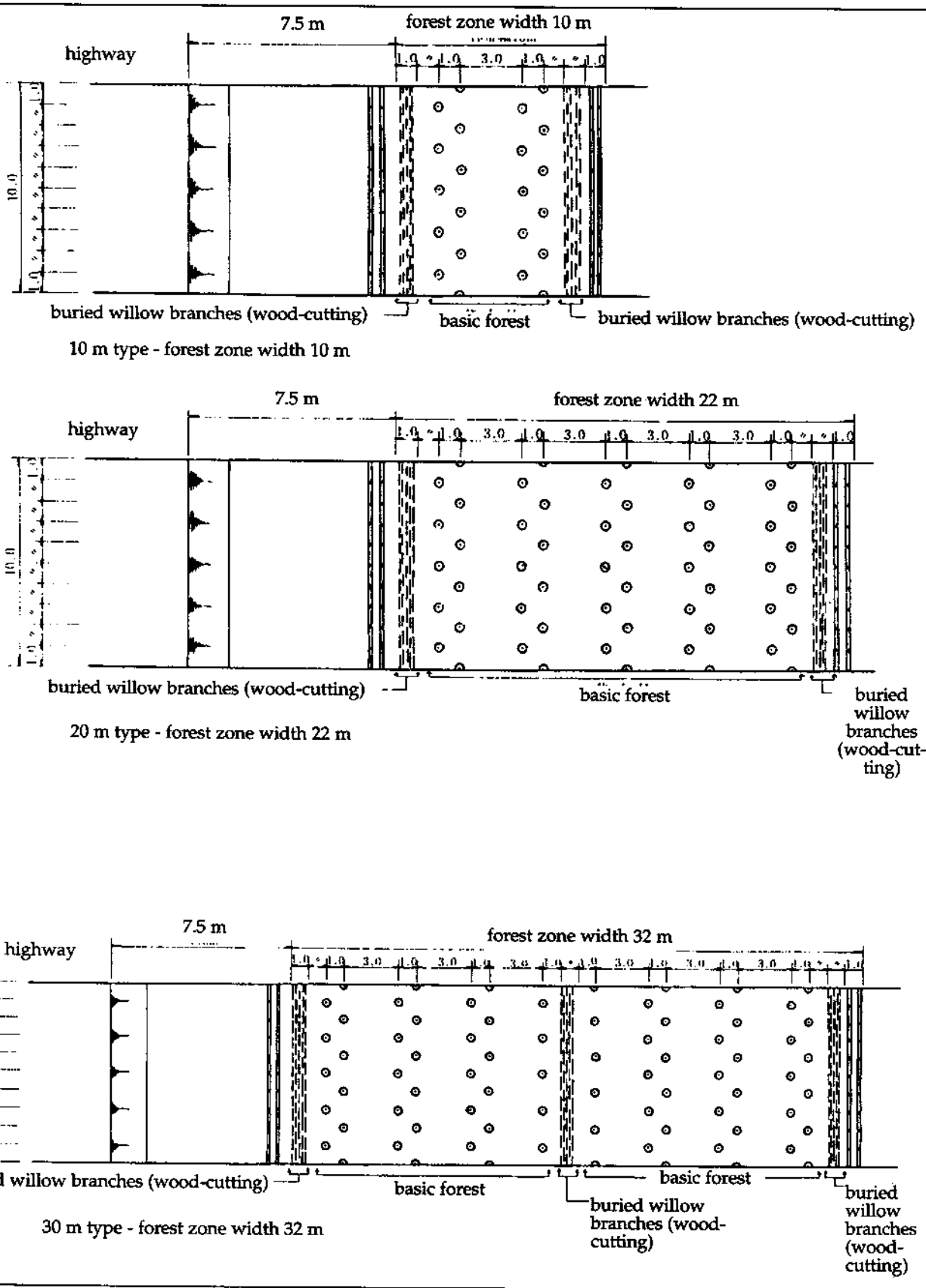


Diagram 3-3-4 Highway snowbreak forest standard model (general land) diagram of fixed rules profile diagram (planting time)

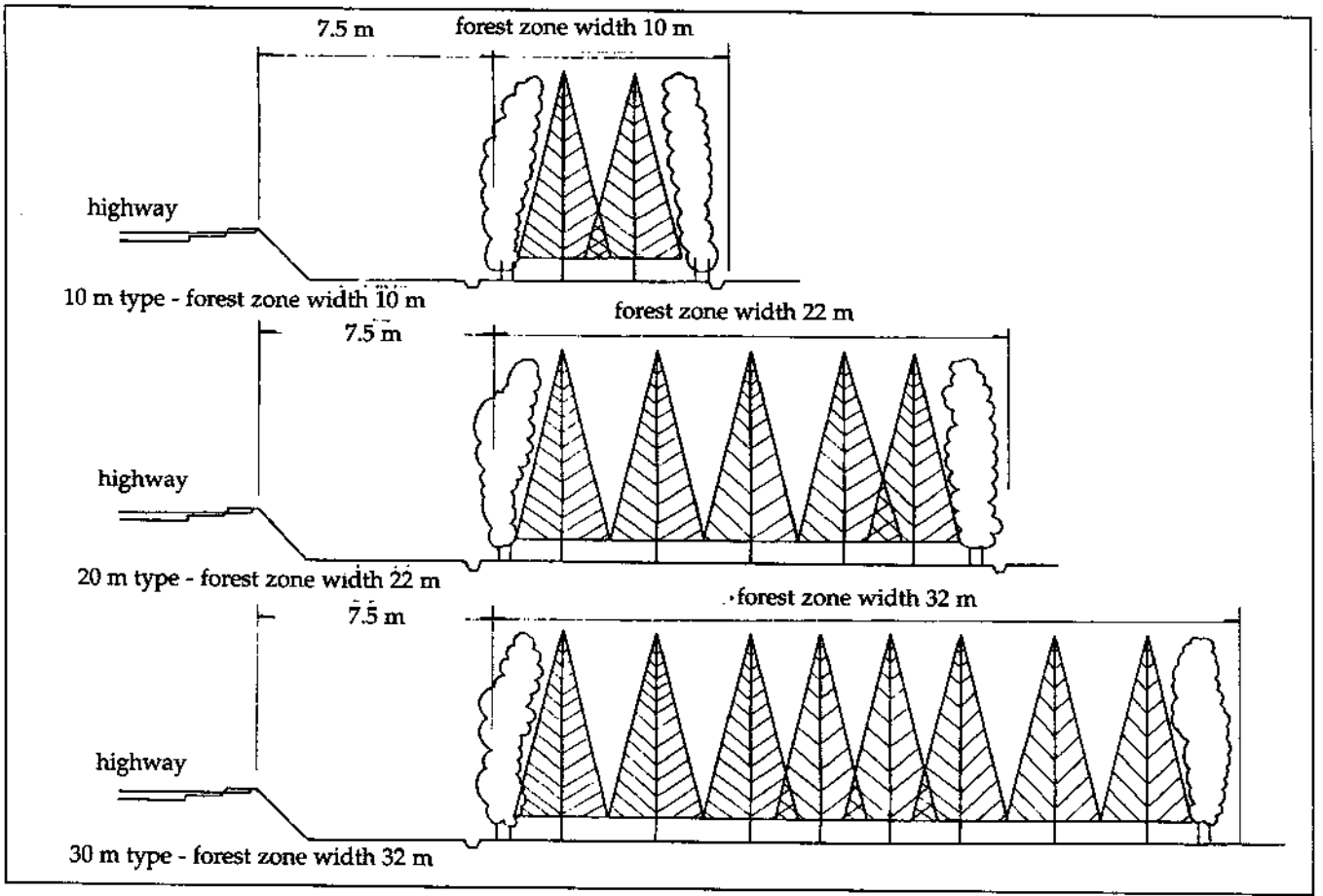


Diagram 3-3-5 Highway snowbreak forest standard model (general) diagram of fixed rules (scale 1:200) (completion time)

Region and Zone	Content	Measures
swampy zone	Swampy zones and regions where it is necessary to drain water, peat bogs, slimy ground, and regions that collect water or where excessive moisture hinders the growth of trees.	During the creation foundation preparations, drainage construction*, land raising construction. bringing in topsoil, and administering the neutralization agent should all be considered. Select trees that can withstand swampy ground well like those in the pine family, spruce, sweet osmanthus family, Japanese poplar, and willow.
sea coast and strong wind zones	Sea coast and strong wind zones are regions where there are strong winds that blow at speeds of 5 m and above that frequently hinder the growth of trees.	Sufficiently consider windbreak countermeasures. In consideration of the strong winds, make the planting high density. Make the tree width of the protection forest the standard fixed rule diagram yet wider.
zone where the soil is not suitable planting	Regions where the creation foundation must be improved because the soil is not suitable for planting trees.	During the creation foundation preparations, consider bringing in topsoil, upper layer construction, drainage construction, ground quality, improvement, and adminstering the neutralization agent.

Note: The asterisk (*) refers to the drainage construction as slected from surface drainage, open drainage, and drainage through an underground culvert.

Table 3-3-5 Zones that require special consideration during creation.

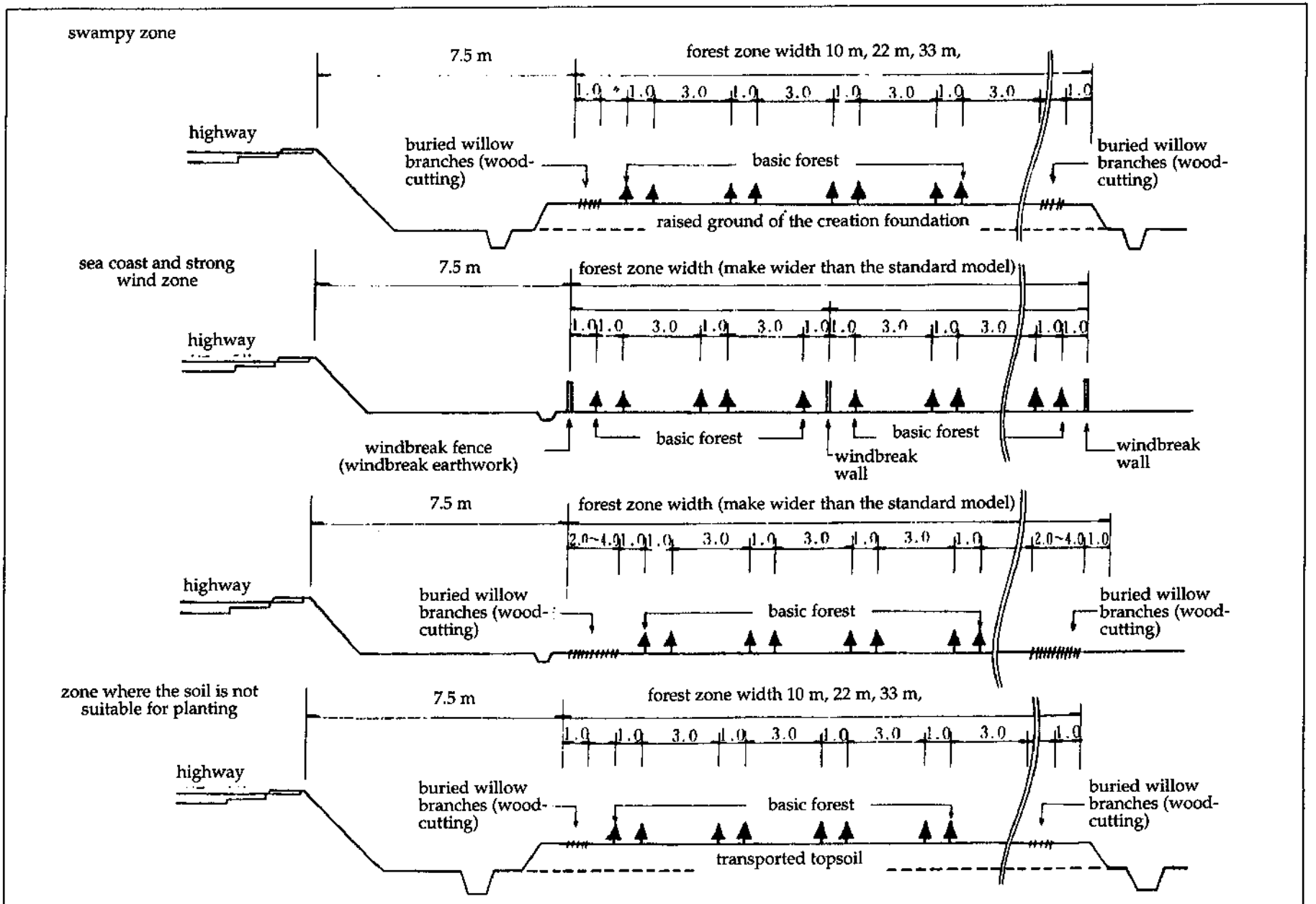


Diagram 3-3-6 Highway snowbreak forest (regions and zones that require special consideration during construction) standard model cross section diagram (scale 1:200) (planting time)

3-3-2 Basic Design

(1) Basic Design Procedure

In the basic design, the growth foundation's creation technique based on the survey results is studied, and the forest zone width and plant arrangement is determined corresponding to the maximum amount of snowfall (comprehensive evaluation of the estimated value and actual observation value) in the local area.

Next, the snowbreak forest's length, tree type, tree quality standards, tree arrangement, and supplemental works are decided. Finally, the impact on the surrounding environment is evaluated.

Commentary

In the basic plan, based on the results of existing data and simple local area surveys, the growth foundation's creation technique and forest zone width are decided, and the highway snowbreak forest's standard model is selected. But at this stage, the creation method, forest zone width, and plant arrangement are reviewed. The details concerning the unsettled snowbreak forest's length, tree type, tree quality standard, tree arrangement, and supplemental works are also decided. Finally, whether the effect on the surrounding environment will be positive or negative is forecast, and the necessary countermeasures are identified. The flow of the basic plan is shown in Diagram 3-3-7.

When carrying out a highway snowbreak forest creation plan under severe environmental conditions like those in Hokkaido, the selection of a suitable tree type and the creation method are important topics.

Basically, the issues include protection from strong wind, cold wind, and salty air during the tree's growth period (April to september), and the preparation of a creation foundation with good conditions for tree growth. For protecting the trees from seasonal or regional damage in the growing period, there are planting methods, placement techniques, and preliminary steps that prepare and exert a large influence on the growth of the trees.

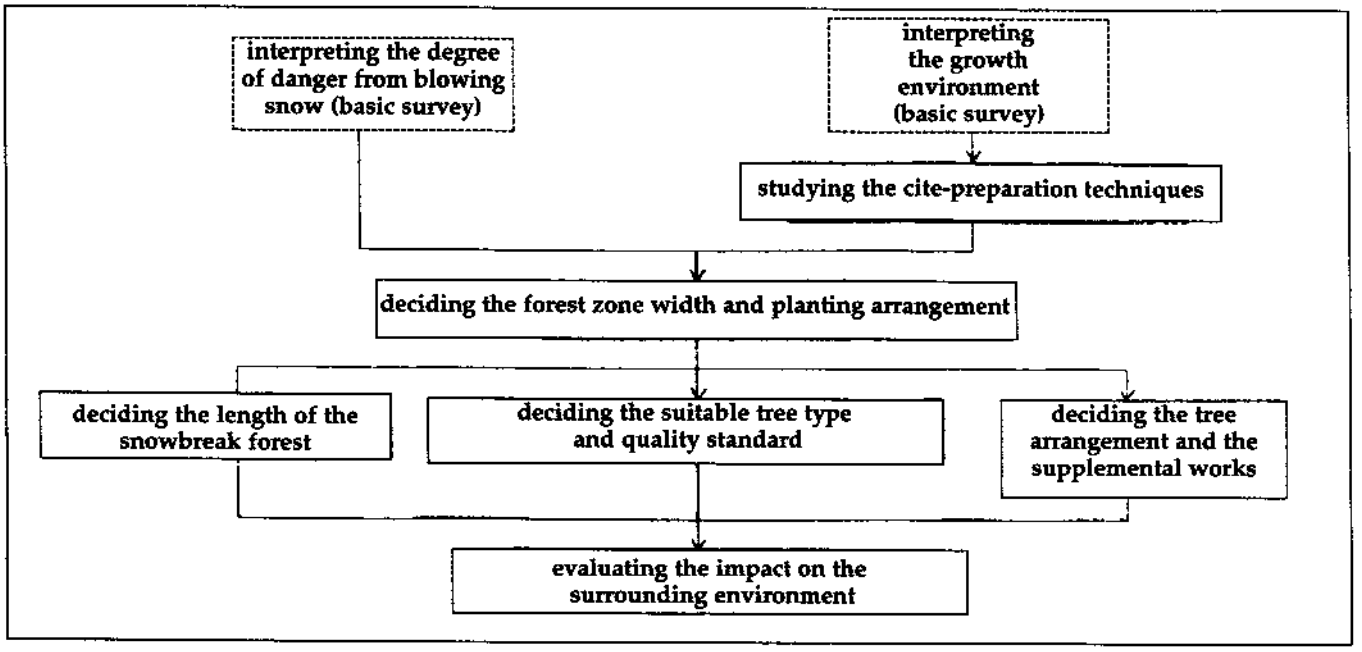


Diagram 3-3-7 Basic flow plan

(2) Forest Zone Width and Planting Arrangement

In the site plan, the forest zone width is decided according to the maximum snowdrift amount in the local area (a comprehensive evaluation of the estimated value and the actual observation value) as well as on the growing environment. The composition of the forest and the tree types are decided according to various environmental conditions characteristic of the place.

The standard widths of the forest zone are 10 m, 22 m, and 32 m. But, in consideration of environmental conditions, and in regions where the growing conditions for trees are poor, such as where there is a strong wind, etc., as a countermeasure they are further widened.

Commentary

1. Review of the Standard Forest Zone Width

In the basic plan, the forest zone width is decided according to the estimated value of the maximum snowdrift amount (a value based on a comprehensive evaluation of the estimated values and the actual observation values) in the local area. The forest zone width is selected according to the details in Table 3-3-6. In places where tree growing conditions are not good, such as on the sea coast and where there are strong winds, countermeasures, such as widening the protection forests are necessary and add to the forest zone width. If it is difficult to acquire the standard forest zone width due to the land use or the shape of the land, etc., use another construction technique simultaneously.

2. Deciding the Zoning Type According to Various Kinds of Environmental Conditions

In deciding the zoning type according to various kinds of environmental conditions, it is necessary to investigate the wind speed and wind direction during the April to September tree growing period. These details are determined from the weather and environmental survey results in the previous chapter. There are two zoning types: a. places where the wind conditions are severe and b. places where the wind conditions are normal. However, in the research area data is not yet given and many years of experience are required; therefore, an expert's judgment is necessary.

3. Tree Composition According to Zoning Type

The two blocks – "protection forest" and "basic forest"– are the basic units used either singly or in combination to determine the basic zoning type. As shown in Diagram 3-3-8, the degree of adversity in the local environmental conditions, especially wind speed and wind direction, collected from local area surveys and existing data contribute to the selection of zoning types A through D.

Type	10 m	20 m	30 m
Maximum snowdrift amount in the local area (m^3/m)	20 to 30	30 to 50	50 or more
Forest zone width (m)	10	22	32

Table 3-3-6 Standard forest zone widths of highway snowbreak forests

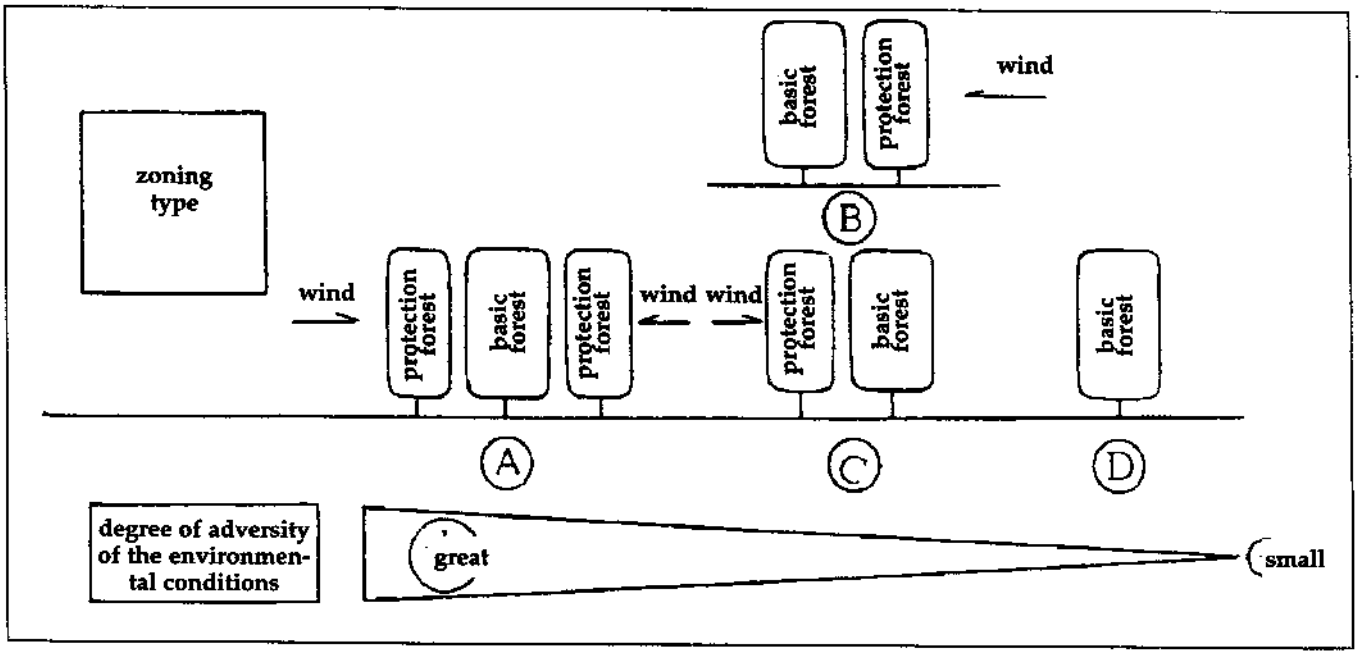


Diagram 3-3-8 Zoning type classifications according to the degree of adversity of the environmental conditions[24]

4. Planting Density

For the planting density of a highway snowbreak forest at the time of its creation, consider as the standard 4,000 trees per hectare in a zone. In strong wind areas, it becomes 5,000 trees per hectare to 8,000 trees per hectare in high-density planting. Generally, the planting density increases relative to the wind.

5. Composition of Tree Types

There are two large divisions of trees suitable for the zoning types: those that provide protection forest use and those that provide basic forest use. When necessary, trees that improve the view are used.

• Protection forest use: a tree that exhibits a protective function, because the growth of the basic forest is hindered by wind, etc., grows fast initially and is strong.

• Basic forest use: use a combination of tree types centering on evergreen needle-leafed trees that exhibit a snowbreak function. There are also cases when deciduous broad-leafed and deciduous needle-leafed trees are mixed in for ecological balance.

• View improvement: in regions where the environmental conditions are comparatively mild use ornamental tree types when the view is an aesthetic requirement.

6. Planting Arrangement

The planting arrangement method in the creation of a disaster protection forest is generally divided into square planting or row planting. A comparison of the two types is shown in Table 3-3-7. In the creation of a highway snowbreak forest, the forest zone width is comparatively narrow, and, because it is necessary for the snowbreak effect to manifest early, plant in rows. The special characteristics of row planting include: 1. the early manifestation of a snowbreak effect, 2. even one row is effective, 3. it is difficult to lose competition with weeds, 4. machines can be used for mowing and cultivating, 5. wind damage to the trees is small, 6. amount of growth in the initial period is great,

Item	Row Planting	Square Planting
site preparation	zonal or the whole surface	the whole surface between seedlings
plant	narrow between seedlings, wide between rows	and between the rows is about the same distance for hand mowing, easy to be overcome by
mow	difficult to be overcome by machine mowing, cultivating, herbs	herbs
trees growing together	fast, effectiveness is given in units of rows	slow
manifestation of effect	light	slow
snow damage	mostly unnecessary, able to do mechanically	easily suffers snow damage to the crown and damage due to snowdrifts
periodic thinning	easy to do, renewal planting between the rows	it is necessary to do it often and difficult to do, cutting the zone is necessary
renewal		

Table 3-3-7 Comparison of row planting and square planting in disaster protection forest creation[16]

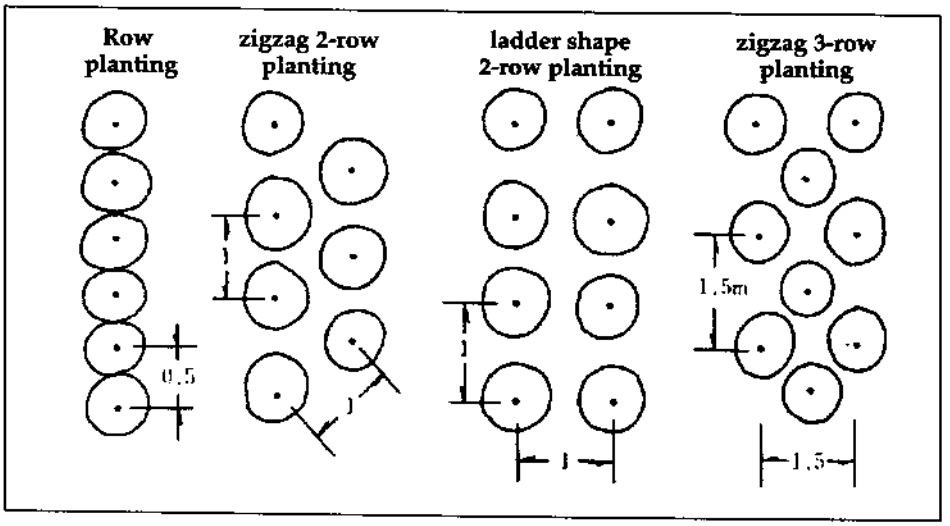


Diagram 3-3-9 Main types of row planting[16]

7. the root systems intertwine underground, 8. the space between wide rows becomes a place where snowdrifts form, 9. snow damage to planted trees is small, 10. growth management between rows is convenient, 11. the zone becomes a place for renewal. Most of the types of row planting arrangements are shown in Diagram 3-3-9.

(3) The Length of Highway Snowbreak Forests

Even if the highway snowbreak forest forms right angles to the main wind direction, the blowing snow can come around both ends of the forest. If the wind direction is diagonal, it is necessary to make the forest zone rather long in consideration of this blowing snow.

For this reason, the length of highway snowbreak forests and the total range and extension required are based on the main wind direction.

The range necessary for a snowbreak is judged according to the degree of danger from blowing snow, but the final selections change with the environmental conditions: length of snow field, vegetation circumstances, and land shape; highway construction (raised dirt, cut, half-cut and half-raised dirt road width); and existing snowbreak facilities. The extension length is based on the main wind direction as shown in Diagram 3-3-10. When the road width is made 25 m, the space between the forest zone and the road is made 7.5 m, and the angle between the main wind direction and the roads is 30 degrees, it is necessary to further extend the forest zone 56.3 m plus alpha, at 45 degrees 32.5 m plus alpha, and at 60 degrees 18.8 m plus alpha.

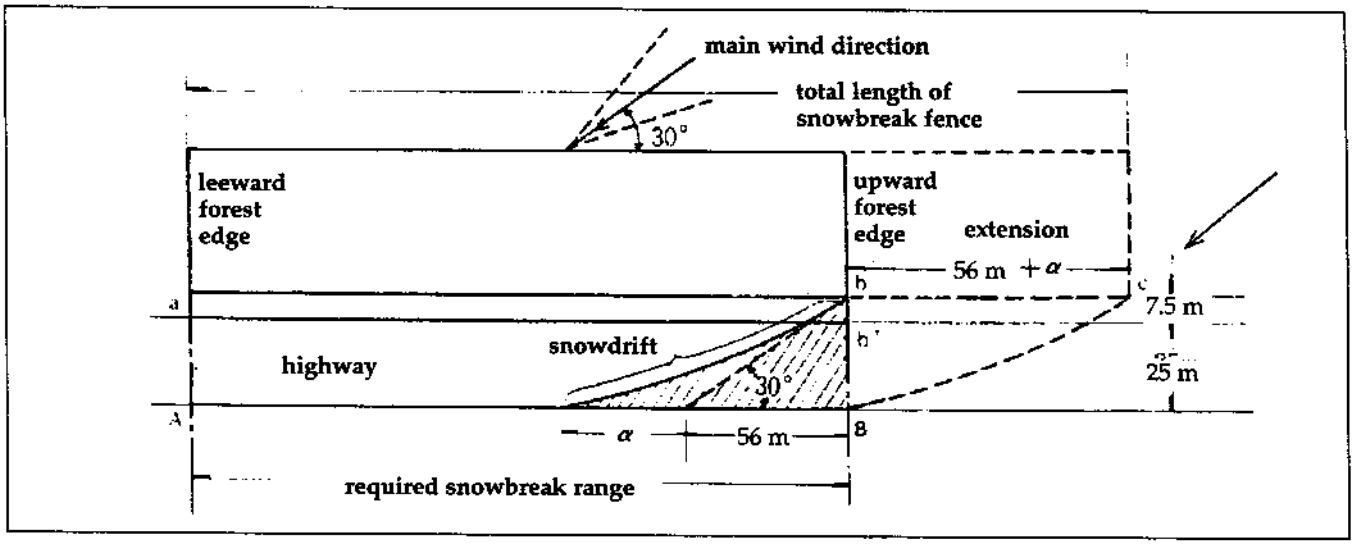


Diagram 3-3-10 Extension of the forest zone when the main wind direction is at an oblique angle (when the main wind direction is 30 degrees)[40]

1. Ground Stripping

Ground stripping is one of the growth foundation construction techniques that removes the former vegetation, or the roots and seeds on the surface down to between 5 and 10 cm, which creates bare ground so that the planted trees will not compete with the former vegetation. (See Diagram 3-3-11.) The dirt removed can be used to make a wind protection earthwork.

With ground stripping there is no competition with the former plants and good growth can be expected of the planted trees. Along with the early weathering of the lower ground layer, stripping produces a soil ondition similar to farm land and can cope with large environmental problems. It is effective in handling special soils, such as sea coast regions, areas of low moisture, peat bogs, etc.

2. Root Spreading Space

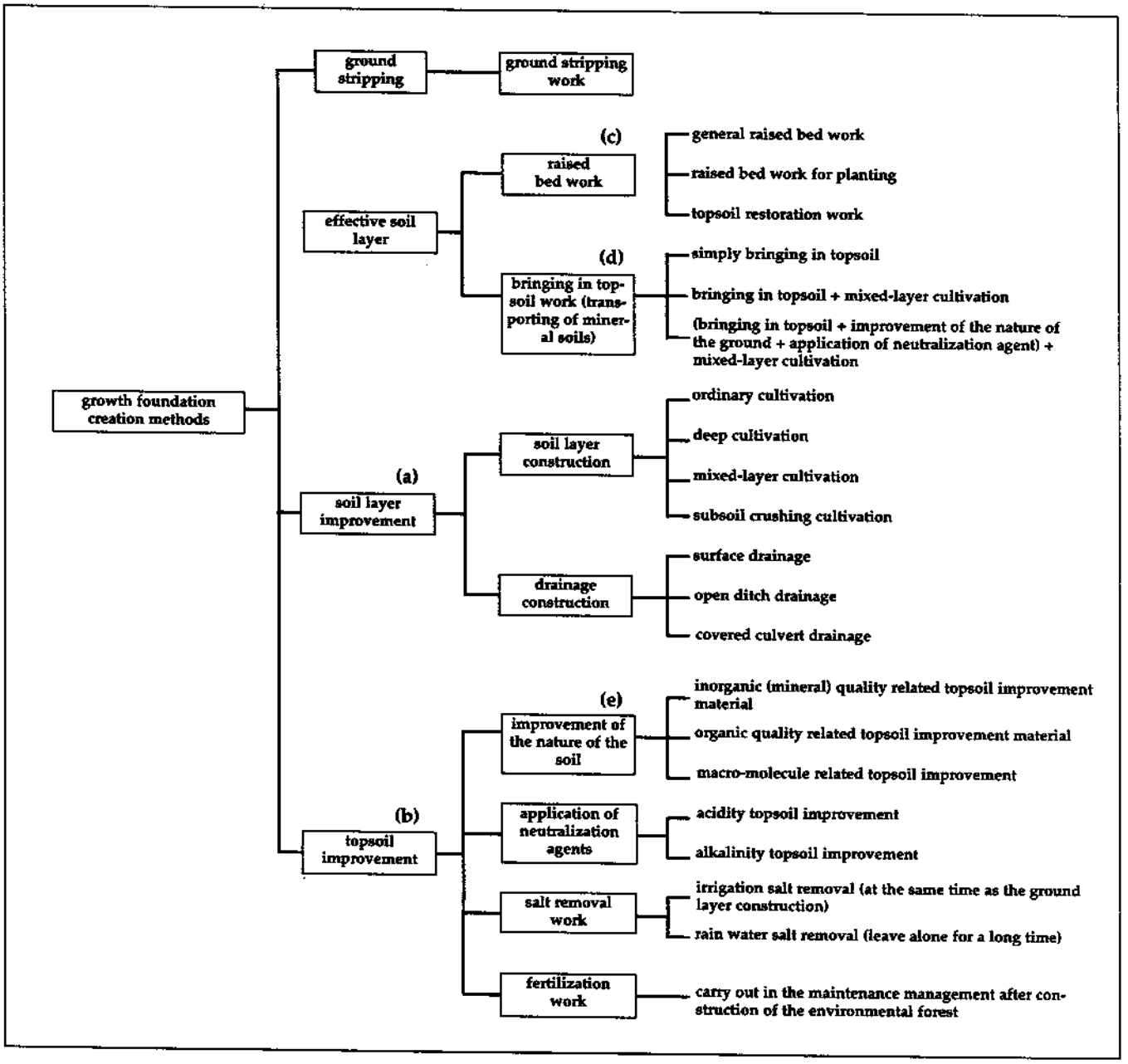
An effective ground layer allows for the growth of the root system that supports the tree and functions to hold fast and to absorb nourishing moisture. The thickness of an effective ground layer is determined from the characteristics of the distribution of the tree's root system and the soil's physical nature. The maximum ground layer necessary for plant growth is shown in Diagram 3-3-12. Decide to increase the thickness after considering environmental conditions and economic efficiency.

In Hokkaido there is little rain during the tree growing season from April to July. Because the soil dries out when improving the ground and the underlying soil, it is necessary to ensure that the effective ground layer is sufficiently thick.

The construction methods that ensure an effective ground layer in the preparation of the growing foundation are classified into raised bed construction and bringing in topsoil construction.

a. Raised bed construction

Raised bed construction, as shown in Diagram 3-3-13, is, generally, a method of ensuring a good quality, effective ground layer that involves replacing the soil at the site. After the civil engineering of ordinary



(a) A method of improving, mainly, the physical nature, down to the botton ground layer using chemical means to create a rough foundation.
(b) A method of chemical improvement using native soil mixed with improvement material for the planting foundation.
(c) Large scale use of topsoil to cover the entire surface including the raised planting beds.
(d) Good dirt is carried in from off the site (bringing in topsoil) and is only put on the planting sections.
(e) The mixing of the soil improvement material is observed for a short time to assure the soil composition and grain formation is directly improved.

Diagram 3-3-11 Divisions and types of growing foundation construction methods [24]

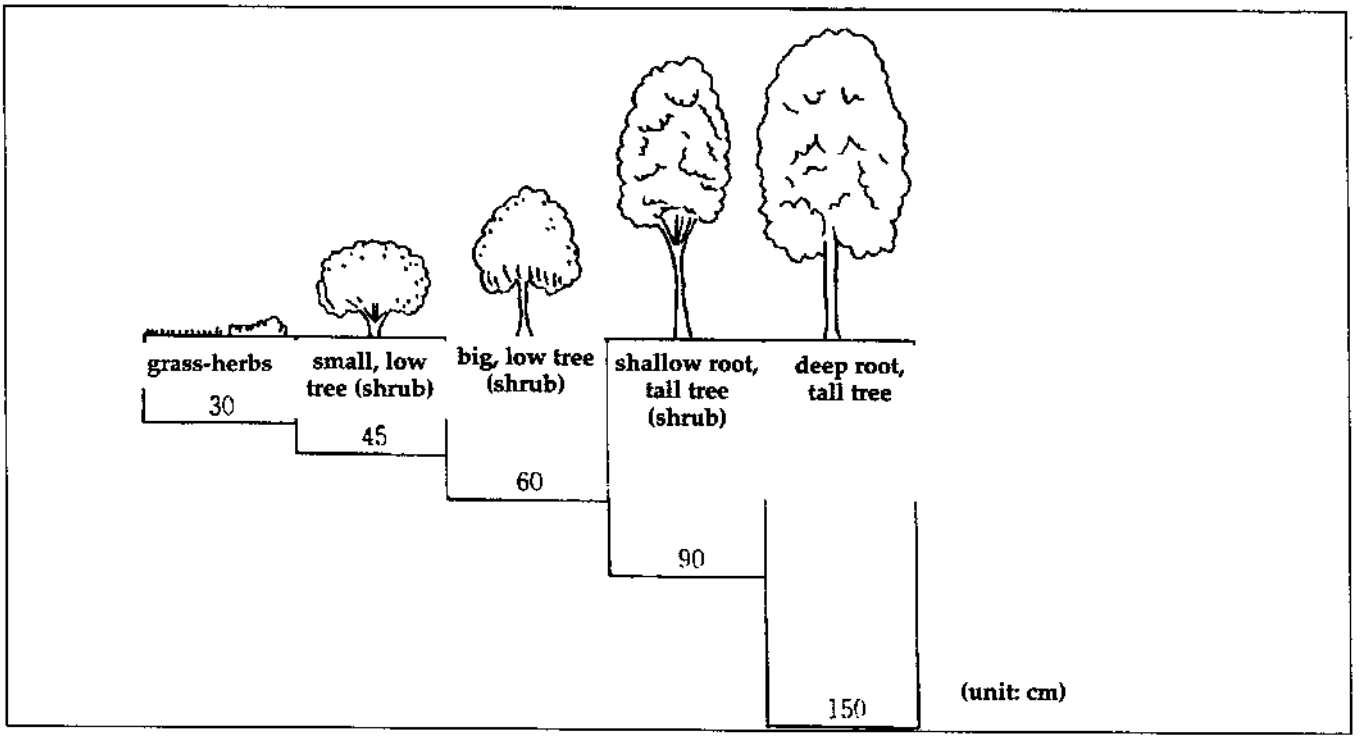


Diagram 3-3-12 Maximum ground layer thickness necessary for the growth of plants[14, 30]

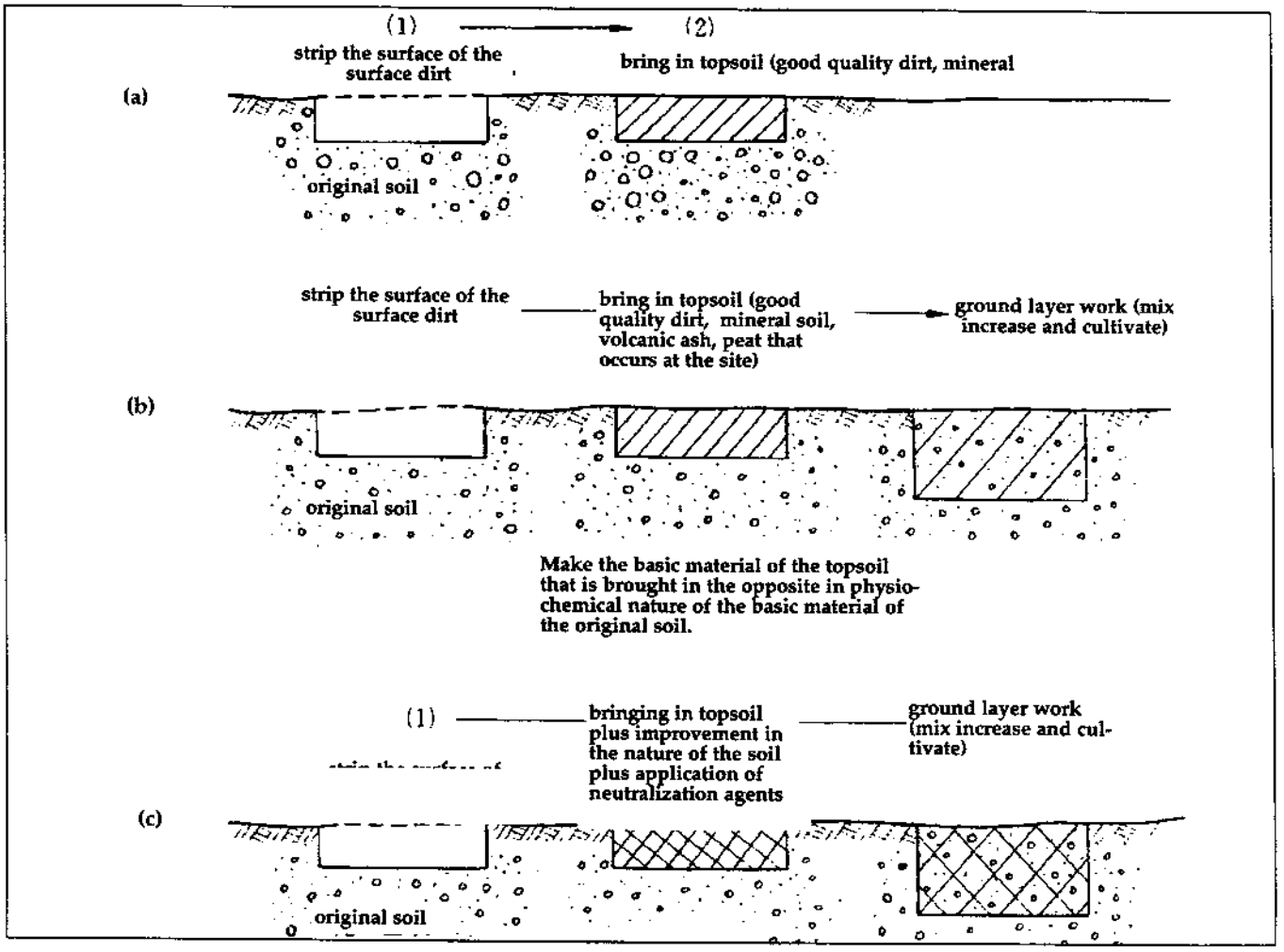


Diagram 3-3-14 Bringing in topsoil construction - ground layer work of the preparation of the growth foundation[24]

Item	Needle-leafed trees – Broad-leafed trees	Broad-leafed trees	
seedling length	40 cm and over	50 cm and over	60 cm and over
root diameter	12 mm and over	14 mm and over	15 mm and over
H/D	42 and less	43 and less	47 and less
weight	130 g	160 g	200 g
percentage of growth in current year	1/2.5 or less of the length of the seedling	1/3 or less of the length of the seedling	1/3 or less of the length of the seedling

Table 3 - 3 - 8 Seedling's quality standard (fresh from the mountains) objective

Explanation of the terms

(1) seedling length: The length of the seedling in the seed bed from near the ground to the tip of its tope sprout.

(2) root diameter: The diameter of the seedling's root near the ground.

(3) H/D: H is the length of the seedling. D is the diameter of the root. A seedling length to root diameter ratio of 4:2 or less is the objective. It may be regarded as small, but this is a good tendency for the development of a robust, healthy root system.

(4) weight: The weight of the entire seedling with the dirt carefully removed from the roots.

(5) percentage of growth in current year: The amount of the year's growth and the length above ground.

site creation, the raised bed construction begins. The surface soil is procured in advance and rehabilitation requires that new dirt is mixed with the surface dirt and humus. At this time it is necessary to remove from the surface dirt the former plants, root stems, and fallen seeds, etc.

b. Bringing in topsoil construction

The work of bringing in topsoil involves transporting in good quality dirt from outside the site to ensure an effective ground layer. The ground layer work that corresponds to the physiochemical nature of the basic material of the soil is removed. When preparing the growth foundation, the methods shown in Diagram 3-3-14 can be considered.

(4) Tree Quality Standard

Trees used in highway snowbreak forests are classified according to the degree of tree growth, so use seedlings. These must fulfill a set quality standard and insect damage must be absent.

Commentary

a. Use seedlings raised in a seedbed near the site of the planned snowbreak forest. Do not use seedlings brought in from elsewhere.

b. Use seeds that are not damaged by insects, animals, or the weather.

c. The seedlings should have proportional balance with no extra long branches and be easy to plant.

d. Both the large and small roots should have well developed whisker-like roots.

e. The seedling's trunk should be straight, thick, and hard, but not overly long. It should be large in diameter at the roots and not forked.

1. Tree Appearance

Item	Standard
tree shape	a natural shape corresponding to the tree type; well-formed tree shape
trunk (only applies to tall trees)	trunk generally straight, single trunked (however, this does not apply to many stems coming from one root and trees whose trunks slant naturally)
apportionment of branches and leaves	square and even
density of branches and leaves	not grown to a useless length; the area between the verticillated branches is filled in; the side branches are long; the leaf density is good
beneath the branches and leaves	The height of the lowest branch that forms the tree crown is at a suitable height

2. Tree Influence

raising	It is substantial, vital raising and growing that creates roots that are easy to transplant.
roots	The root system is well developed. It is square and distribution is equal. There are many small roots in the root ball, and it is not dry.
root ball	Possesses an appropriate root ball and root stump corresponding to the type of tree. Wrap the roots firmly so that the ball does not crumble and dry. While digging and shaking, make sure that the root part, especially, has sufficient recuperative ability (not too dry). Maintain the health of the roots and do not damage them.
leaves	Maintain proper leaf shape, leaf color, and density (leaves on tree.) Avoid wilting (change of color, change of shape) and weak leaves (fresh and full of life).
tree bark (skin)	Avoid damaged trees or traces of damage and maintain in a proper condition.
branches	Maintain the appearance of natural branches through proper care of branches damaged by dryness, broken branches, etc., and perform the proper pruning.
insect damage	Avoid insect damage and trees where damage occurred in the past even if the occurrence was insigificant, and its traces are barely recognized.

According to the Ministry of Construction's "quality measurement standards for the trees used in public afforestation"

Explanation of the terms

(1) tree shape: The shape unique to the trunk and crown that has arisen due to the characteristics of the tree, the age, and how it was cared for.

(2) trunk: The part that rises perpendicular to the ground and produces branches. Branches are stems that divide off from the trunk and oppose it.

(3) apportionment of branches and leaves: The total balance of the tree's branches and leaves.

(4) density of branches and leaves: The distribution and proportion of the tree's branches and leaves.

(5) beneath the branches: The height from the top edge of the roots to the lowest important branch (one that influences the composition of the tree crown).

Table 3 - 3 - 9 Standards for trees planted along the highway[12]

Seedling Farm Survey	For special trees, the raising area is limited when it is necessary to pay special attention to high price and quality.
	For special specifications, it is necessary to have a consistent management process from the seedling field and afterwards.
	A large amount (including year-to-year) of seedling material of equal quality might be necessary.
	When a seedling field survey is necessary, other requirements may arise.
Seedling Field Survey Methods	Sample the material at more than 20% rate and the below ground part at about 3%. (However, in the case of special trees, survey each tree.)
On Site Survey Methods	Investigate each tree before planting. However, check the appearance of the trees again after finishing planting

Table 3-3-10 Survey standards for trees planted along a highway

f. The objective for five-year old fir trees is the 2-2-1 tree age pattern (two years after planting the seeds in a bed, change the bed; two years later, change it again; and one year later, use them).

g. The objective for six-year old spruce trees is the seedling pattern 2-2-2 (change beds two years after planting the seeds and again after another two years, use them two years later), and a seedling pattern of 2-2-1-1 (change beds two years after planting the seeds and change beds again after another two years, change the beds one year later, and use them one year after that).

h. Table 3-3-8 shows the seedling quality standard. Avoid using seedlings that fail to meet the standard. Table 3-3-9 and 3-3-10 show standards and survey methods for trees planted along the highway.

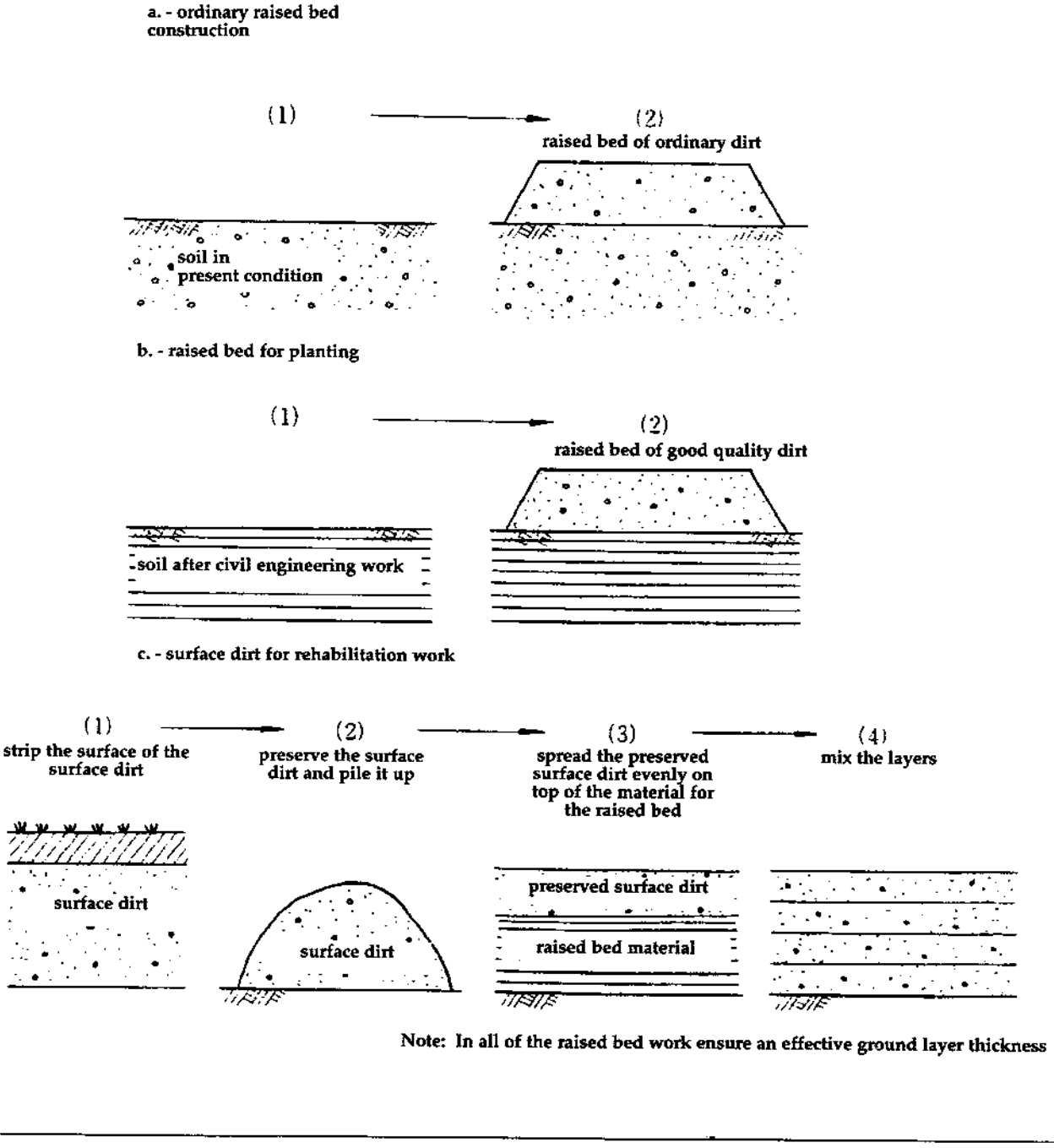
(5) Creation of the Growth Foundation

When creating a highway snowbreak forest whose trees grow under severe environmental conditions, it is necessary to create a foundation for growth to ensure that there is an interval between the root systems and to encourage satisfactory growth. The details of the creation of a growth foundation include the items: ground stripping, ensuring an effective ground layer, ground layer, and soil improvement. These methods are performed following the results of environmental surveys. It is important to investigate drainage in connection to ground layer improvement.

Commentary

The weather, land shape, soil, existing vegetation, and insect damage are among the primary factors hindering the planting of trees. The preparation of a growth foundation to improve the environmental and soil conditions is the easiest method and most reliable to exeute.

The divisions and types of growth foundation creation methods are shown in Table 3-3-11. Whichever method is chosen, when creating a highway snowbreak forest, aim for the growth of a forest zone, carry out improvements on the surface of the entire zone or region that is planned for planting, and avoid merely the planting of void spaces.



a. is a method in which soil that matches the quality standard in Table 3-3-11, ore quality dirt, and volcanic ash are each carried to the stripped site as a resource for the topsoil material.
b. is a method that mixes the topsoil material of a with the locally occurring peat that is physiochemically opposite to the soil's basic material. Subsequently the mixtures are cultivated.
c. is a method in which a soil improving agent is mixed in with the topsoil that is brought in to improve the soil's acidity; a neutralization agent is also mixed in and cultivated.

Diagram 3-3-13 Growth foundation preparation's raised bed construction

Item	Standard
ground nature sandy soil, soil, clay soil	sandy soil, soil, clay soil amount of clay includes 15% or more amount of silt included 0-45% amount of sand included 30-85% small stones (diameter 2-20 mm) 50% or less group grain composition is visible to some extent
grain diameter distribution	10 cm/sec or more
structure	801/m 3 or more
	pH about 5.5-7.0 0
	3% or more
	6 me/100 g or more
	water permeability coefficient
effective water content	1,500 mg/100 g or more
soil acidity amount of peat contained base displacement capacity phosphoric acid absorption coefficient other	Does not contain harmful impurities, such as weeds, stones, plants, etc.

Table 3-3-11 Brought in topsoil quality standard[48]

Work Type	Content of Work Method	Effect
normal cultivation	Break up approximately 20 cm of the surface layer with a disc harrow and begin to plow with a farm tractor.	work type, work method improves ventilation and water permeability destroys the root systems of the former plants
deep cultivation	When you want to ensure a deep, effective ground layer, carry out the cultivation just before the raised ground work. Begin to cultivate a 40-60 cm section with machinery for deep cultivation using a back hoe for reverse excavation.	makes a new, deep effective layer improves ventilation and water permeability
mixed-layer cultivation	A construction method designed to make the composition of the ground layer continuous by reversing the surface layer and bottom layer that have different characters. Proceed with the objective of improving the ground layer 0.5-1.0 m below the surface of the ground.	makes a new effective layer improves ventilation and water permeability
subsoil crushing cultivation	When the bottom layer is likely to be dense, and the ventilation and water permeability are poor, this method crushes the foundation bottom layer and ensures an effective ground layer.	removes a layer with poor permeability

Table 3-3-12 The types, content, and effects of ground layer work[33]

1. Soil Improvement

Soil improvement physically improves the soil down to the bottom layer of the rough creation foundation and is divided into ground layer work and drainage work.

2. Ground Layer Work

Ground layer work heightens the physical nature of the soil's composition and ensures space for the root system. It improves ventilation and water permeability as shown in Table 3-3-12 and is classified as normal cultivation, deep cultivation, mixed-layer cultivation, and subsoil crushing cultivation.

3. Drainage Work

Drainage work is carried out with the objective of improving ventilation which causes the lowering of the ground water level and reduces exess moisture in the ground. As shown in Table 3-3-13 and Diagram 3-3-15, it is classified as surface drainage, open ditch drainage, and closed culvert drainage.

When executing drainage work, combine these processes as necessary.

4. Soil Improvement

Soil improvement is a method of physio-chemically improving the soil with a mixture of native soil and improvement materials for the growth foundation. It involves soil improvement, application of neutralization agents, and salt removal work.

It is possible to cope with the creation of the growing foundation using ground stripping, raised bed work, bringing in topsoil, ground layer work, drainage work, and applying the neutralization agent. With the further application of soil improvement materials, the environmental pressure on the planted trees is eased, and the physiochemical nature of the soil improves which promotes the maintenance of fertility so strong growth occurs.

Soil environment pressures include excessive dryness or wetness, concretion, nutritional insufficiency, inappropriate soil acidity, and

Work Type	Content of Work Method	Effect
surface drainage	Drains off surface water using an inclined surface. Make about a 5% slope at the soil preparation stage of the growth foundation preparations.	drains the surface water from the soil surface.
open ditch drainage	Around the edge of the site make an open ditch to drain the surface water and at the same time intercept water coming from outside.	naturally drains stagnant and flowing water the presence or absence of open ditch drainage exerts a large influence on the growth of planted trees especially in areas of low moisture.
closed culvert drains	At the site install at a depth of about 0.6-1.2 m a pipe with holes or a porous concrete pipe with a minimum diameter of 100 mm or more (water accumulation ditch of 150 mm or more) at a slope of about 1/500-1/100.	Drains the excess water from below the site or naturally drains water with the purpose of adjustment by laying an underground pipe with holes.

Table 3-3-13 Classification, content, and effectiveness of drainage work[33]

the presence of harmful substances. To counteract these and increase the capacity to maintain water, increase ventilation and water permeability as well as soften and prevent concretion, and increase the ability to retain nutrients, adjust the pH, and remove harmful substances. See Table 3-3-14 When improving the soil, first consider the nature of the improvement materials based on the specific character of the planting foundation from actual reports. Soil nature improvement is generally divided into three divisions according to the soil improvement materials used. See Table 3-3-15.

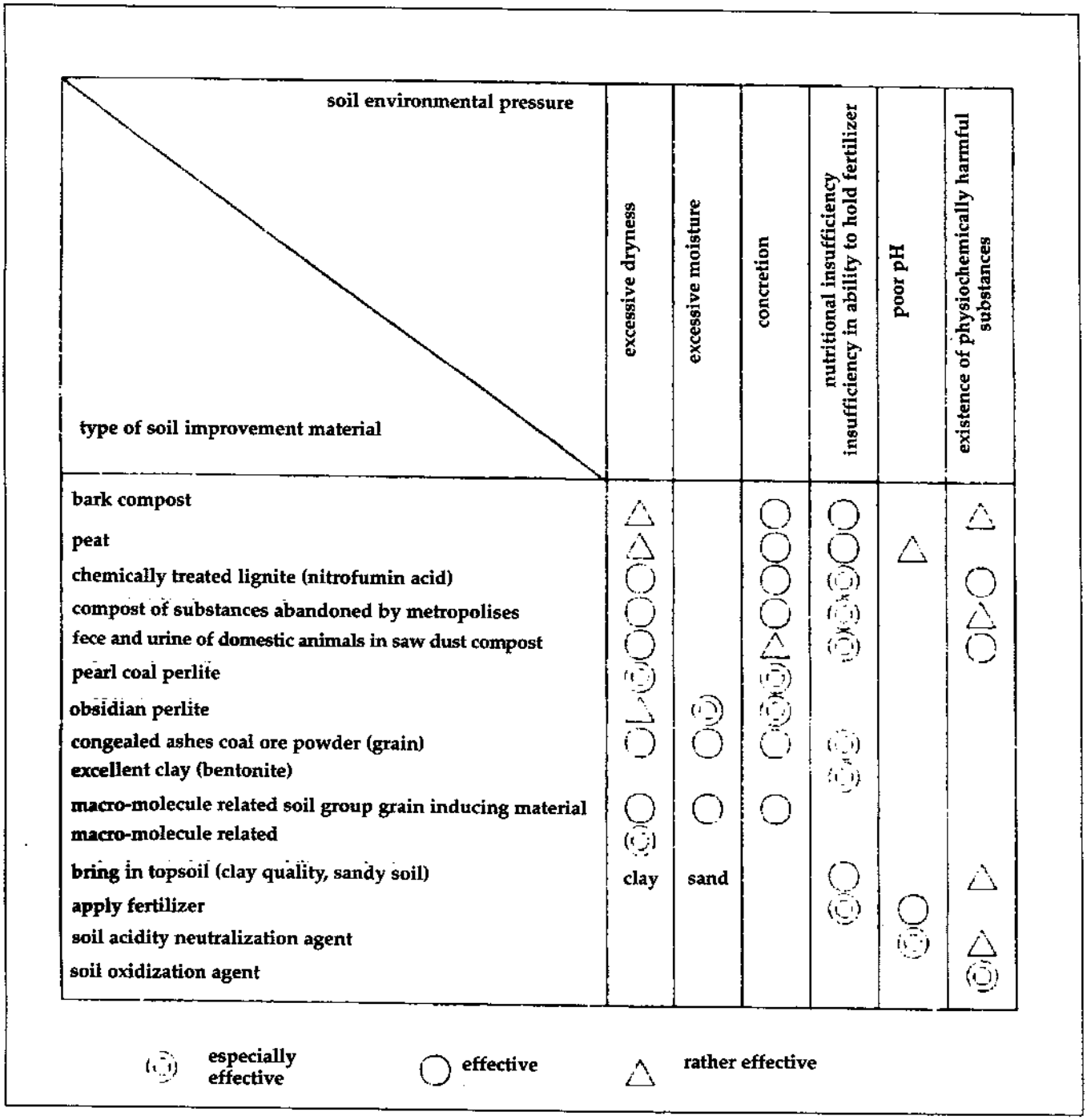


Table 3-3-14 The effect of various soil improvement materials for the relief of soil environmental pressure[33]

5. Application of Neutralization Agent

Apply neutralization agents in acidic and alkaline soil to correct the weak acidity or minute acidity (pH 5.5-6.5) that is proper for tree growth. For acidic soil use calcium carbonate, or calcium hydroxide, quick lime, etc., and for alkaline soil use stone dust, sulfur powder, etc. The amount and type of neutralization agent is determined from the neutralization curve.

6. Removing Salt Work

Salt removal work is performed when the growth foundation is created on reclaimed seaside land. The technique removes excess chlorine ions that are factors hindering tree growth. It is conducted during the ground layer work. Besides the irrigation salt removal method, there is the method of leaving it alone for a long period of time and simply letting the rain water remove the salt on the chemical treatment method.

In preparing a snowbreak forest growth foundation, it is necessary to properly combine the above techniques and work in response to the site's soil conditions. Table 3-3-16 shows an improvement example for a characteristic soil that is comparatively widely dispersed throughout Hokkaido.

(6) Tree Arrangement and Supplemental Work

The wind hinders tree growth. It is necessary to have sufficient wind protection measures during the early period so combining various wind protection facilities as

Division	Material	Application and Effect
inorganic substance related soil improvement material	perlite, mineral powder, clay, acid neutralization agent, etc.	The soil swells and softens and group grain composition is promoted. At the same time that it improves drainage qualities, the ability to hold water is also increased. Fertilizer ingredients also are maintained, and the improvement effect is heightened. Improvement is slow. About 10 % of the capacity ratio is the proper application amount. Apply to the surface of the root ball or ground surface.
organic substance related soil improvement material clay	bark compost, peat, and other compost types	Because porous material has a large surface area, besides heightening the ability to hold water, it has the effect of improving water permeability and ventilation. Mix in 2 -3% of the theweight ratio for types and about 5% of the capacity ratio is appropriate for calcination mineral types.
macro-molecule related soil improvement material	macro-molecule related soil group and grain making material, etc.	Causes soil particles to unite and make group grains. Use in clay soil or sandy soil. Increases ability to hold water, stimulates improvement in ventilation, water permeability, etc. The effect of these soil improvement materials on soil environmental pressure is shown in Table 3-3-17.

Table 3-3-15 Soil improvement divisions according to soil improvement material[48]

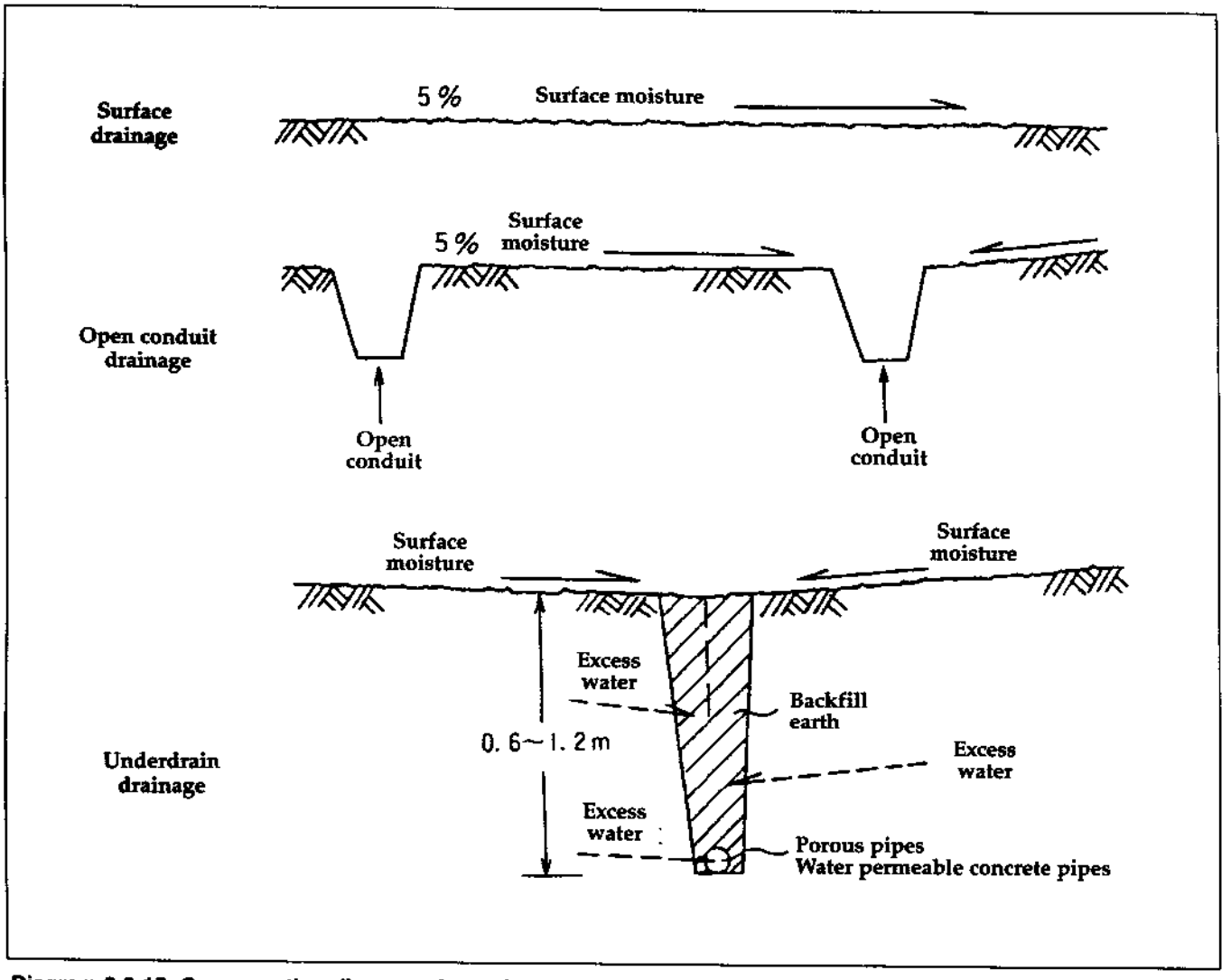


Diagram 3-3-15: Cross-section diagrams for various kinds of drainage works.

supplemental works and tree arrangement encourages stability.

Commentary

1. The Effect and Shortcomings of Installing Wind Protection Facilities

Surveys show that the wind during the tree growing season, April through September, is a factor in hindering the growth of trees. Generally, a wind speed of about 5 m/sec inhibits growth. Wind protection facilities from various place used to protect trees include earthworks, wind protection fences, and existing willow forests.

The installation of wind protection facilities suitable for a highway snowbreak forest appear in Table 3-3-17 and as shown in Diagram 3-3-16 following construction.

2. Handling Windbreak Countermeasures

The construction of a highway snowbreak forest begins with removing the factors that hinder tree growth. The creation design of a series of construction types organically combines the various windbreak countermeasures that are considered a supplemental method for tree growing as shown in Table 3-3-18.

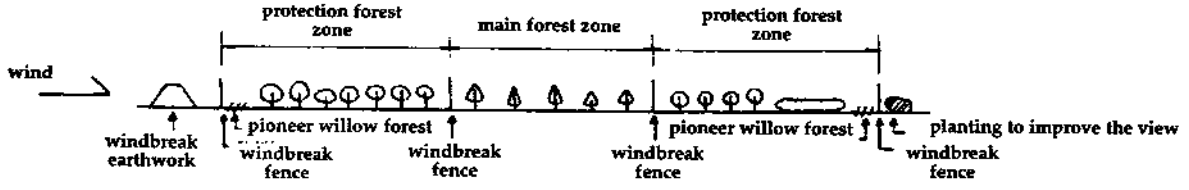
Soil	Nature - Characteristics	Soil Improvement Method
sandy soil	– ability to hold water, ability to hold fertilizer is strikingly poor – little ability to maintain nourishment – shortage of humus – easily becomes acidic	– bring in clay soil – apply a large amount of organic soil improvement material – apply fertilizer – irrigate
heavy clay soil	due to compactness, it lacks ventilation and water permeability – drainage is bad – cohesive power, adhesive power are excessive – shows strong acidity	– drain and improve ventilation and the situation of holding moisture – cultivate deeply, improve the passage of air – supplement the inorganic quality by bringing in clay and volcanic ash topsoil – fertilize- use neutral, base fertilizer – use compost that is sufficiently fermented
peat	– due to excessive moisture, the ventilation is poor – once dried, water absorption is poor – insufficient nutrients – shows strong acidity	– drain, improve ventilation – cultivate deeply, improve the passage of air – supplement the inorganic quality by bringing in clay and volcanic ash topsoil – correct acidity by using the proper amount of lime – fertilize- use neutral, base fertilizer – use compost that is sufficiently fermented
material emitted from a volcano raw dirt	– ventilation, water permeability is good – good ability to hold water, can endure early drought – excessive water from melting snow has a negative effect – because the ground layer differentiation is immature, it contains little humus – limited ability to hold nutrients – many holes and crevices in soil – acidity shows neutral, minute acidity	– bring in clay soil, increase the ability to hold nutrients – bring in clay soil, increase the ability to hold nutrients-tree arrangement and supplemental work - bring in clay soil, increase the ability to hold nutrients - bring in clay soil, increase the ability to hold nutrients - devise corrosion prevention methods – apply good quality organic soil improvement material – apply mainly phosphorous fertilizer – irrigate – bring in clay soil, increase the ability to hold nutrients

Table 3-3-18 Special soil's characteristics and soil improvement method[39]

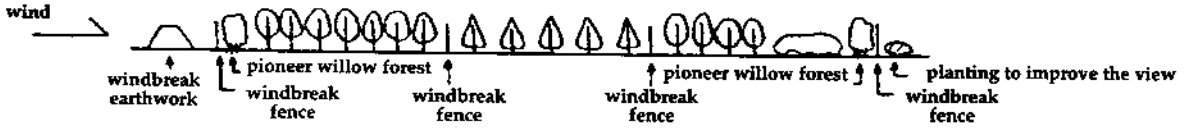
Effect of Installation	Shortcomings
- aids growth by protecting planted trees from wind during the initial period of growth - reduces wind pressure hitting trees and protects against trees falling down and damage from breaking - weakens the wind speed over the forest floor to suppress dispersion through evaporation of moisture from the soil - weakens the wind hitting the trees, suppresses the operation of excessive dispersion by evaporation - prevents cold air currents from entering the forest and protects against damage from cold air	- installing more wind protection than necessary makes the trees weak - If the windbreak facility is destroyed, the planted trees are damaged - If weeds grow excessively, they overcome the trees - Snowdrifts, etc. are created and cause snow damage to the planted trees - Construction expenses become great, windbreak fences do not last many years - The high-density installation of windbreak facilities hinders efficient management and maintenance

Table 3-3-17 The effect and shortcomings of installing wind protection facilities[23]

(1) When creating the snowbreak forest in various sites
-On the most upwind side where the wind is strong, establish a semipermanent windbreak earthwork.
-Within the planting area, for reasons of space and efficiency, set up windbreak fences in rows at 10 m intervals.
-A pioneer willow forest (future windbreak effect can be expected - substitute for windbreak fence), but at first it is not effective. It grows at first protected with the windbreak earthwork and windbreak fence.



(2) After creating the snowbreak forest 2 to 3 and 10 to 15 years
- The effect of the pioneer willow forest begins.
- With the passage of time, the danger of the windbreak fences failing increases, but through the protective effect of the semipermanent windbreak earthworks and repair they are preserved.



(3) After creating the snowbreak forest 10 to 15 years or more, the forest is almost complete.
- The windbreak fences are removed, the forest is formed with the protection of a windbreak earthwork, and behind it the pioneer willow forest on the most upwind side as well as a pioneer willow forest on the opposite side.
- The pioneer willow forest will become the substitute for the windbreak fence.
- The main forest zone will be further protected with forest zones on both sides.

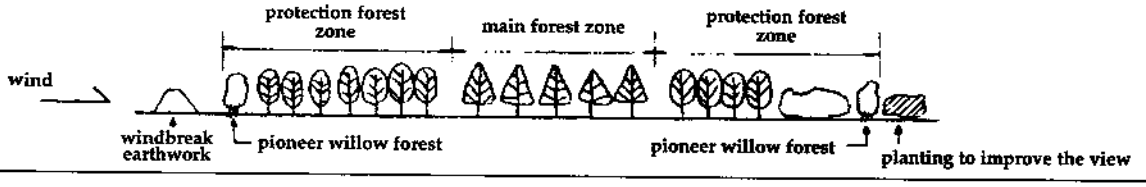


Diagram 3-3-16 Example of the changes in the windbreak effect due to previously existing or pioneer willow forests and windbreak fences[23]

windbreak countermeasure	specific content	advantage	shortcoming	time		expense	space	windbreak effect
				number of years it will last	demonstration of effect			
windbreak earthwork	set up on the windward side at the front surface of the forest zone at a standard height of 1.0 m	- exhibits great windbreak effect from the beginning - no danger of collapsing, is semipermanent - mechanization is easy in its operation	- it is necessary to obtain the materials for the earthwork, the construction costs are high. Try to obtain left over dirt, etc., from the site-raised bed. - it takes much space (a width of 2 m is necessary)	excellent	excellent	excellent (possible)	possible	large
windbreak fence (bamboo - board)	(bamboo) The standard is to set up a 1.2 m tall bent root bamboo net fence support in rows. (board) The standard is to set up on 4 m supports (2 m intervals) boards 20 cm wide with 10 cm between the boards held horizontally, with a 20-40 cm crack at the bottom, and supported with duplicate supports on both sides. Set up in rows.	- exhibits windbreak effectiveness from the time it is set up - takes relatively little space to set up	With time its durability decreases and the danger of it falling over increases. - Construction costs are high, maintenance costs mount up. - If it is set up in a square, construction and maintenance are difficult.	possible	excellent	possible	excellent	
pioneer willow forest	Set up around the edge for a windbreak; the construction depends on the type of willow branches that are buried.	- As a living thing construction method, it exhibits a long-term windbreak protection effect. - It grows as part of the forest zone. - It does not present any problems for the view.	- It does not exhibit an effect from the time of creation (1-2 years). - Differing from a fabricated item, there are uncertain elements in its creation. - It also depends on the place, but it is necessary to devise protection measures (windbreak measures) at the time of its initial creation.	good	possible	excellent	good	
high-density planting	If it is not necessary to have windbreak measures, plant seedlings in a high density. With a planting density of 5,000 trees/hectare to 10,000 trees/hectare the branches will touch in about 5 years.	- A special windbreak facility is not necessary - There are no problems with the view.	- Differing from a fabricated item, there are uncertain elements in its creation. - It is difficult to decide on this kind of construction method.	excellent	possible	excellent	excellent	small

Note: The windbreak earthwork x expense arises where it is not possible to obtain material produced at the ground raising site.

Table 3-3-18 The advantages and shortcomings of various windbreak countermeasures[23]

Within windbreak design, earthworks are used where the wind is especially strong and the conditions severe, but there are few occasions when they are used with highway snowbreak forests. See Diagram 3-3-17.
If windbreak fences are used as windbreak countermeasures, it is necessary to be careful of the placement of the facility and the rate of air passing through it.[2] See Diagram 3-3-18 and 3-3-19. The snow hills made on the downwind side of the windbreak facility can cause damage from the intense snow pressure.

3. Tree arrangement and windbreak countermeasures

When considering snowbreak forest or windbreak countermeasures, especially on the upwind side, or whether to establish a windbreak facility and preserve the forest edge, study the arrangement of the trees based on a combination of methods. One construction method is to plant trees and another is to create a windbreak facility including a snowbreak earthwork, a snowbreak fence, or a pioneer willow forest.

When planning a design in an area of strong winds, properly place the windbreak facility

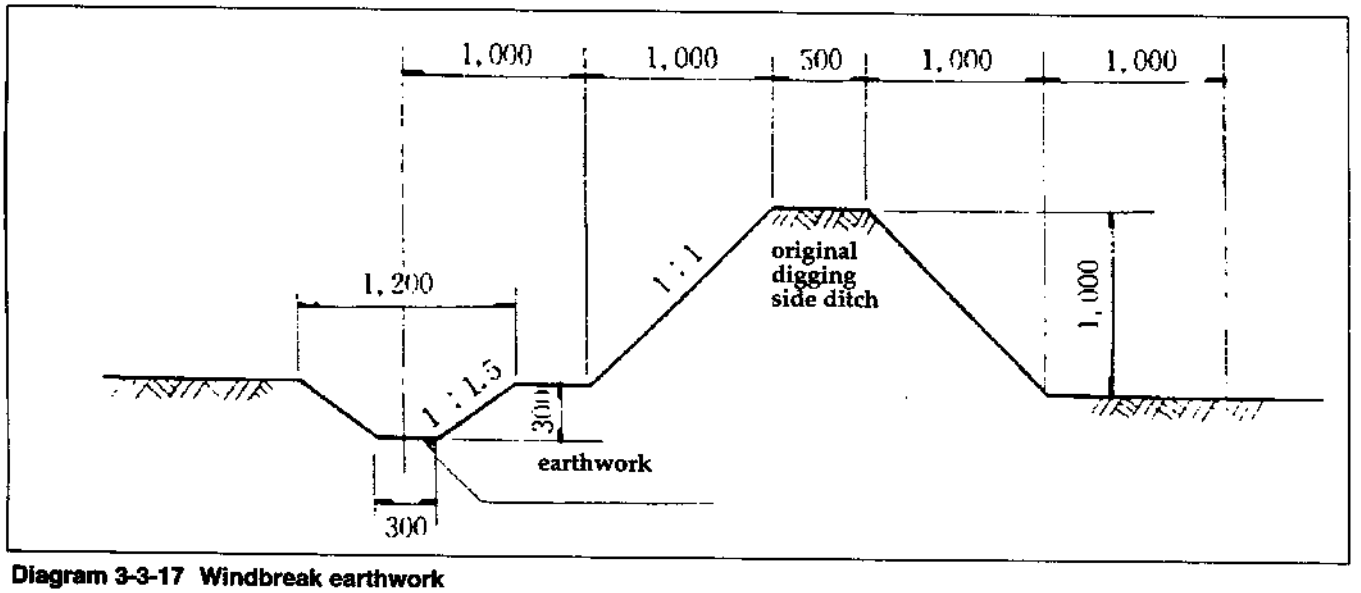


Diagram 3-3-17 Windbreak earthwork

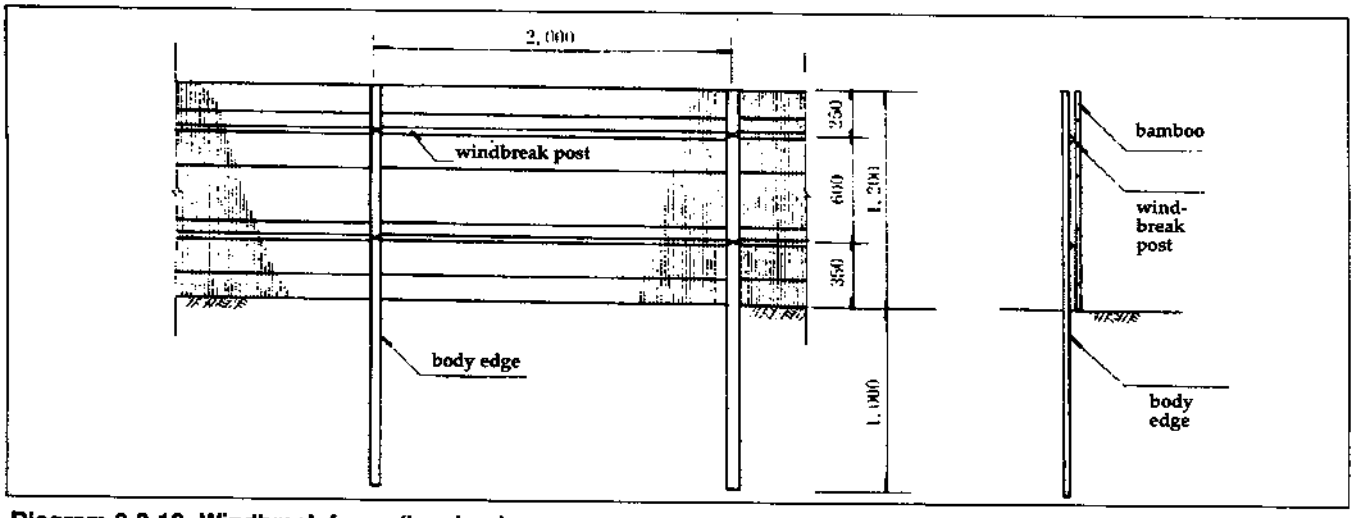


Diagram 3-3-18 Windbreak fence (bamboo)

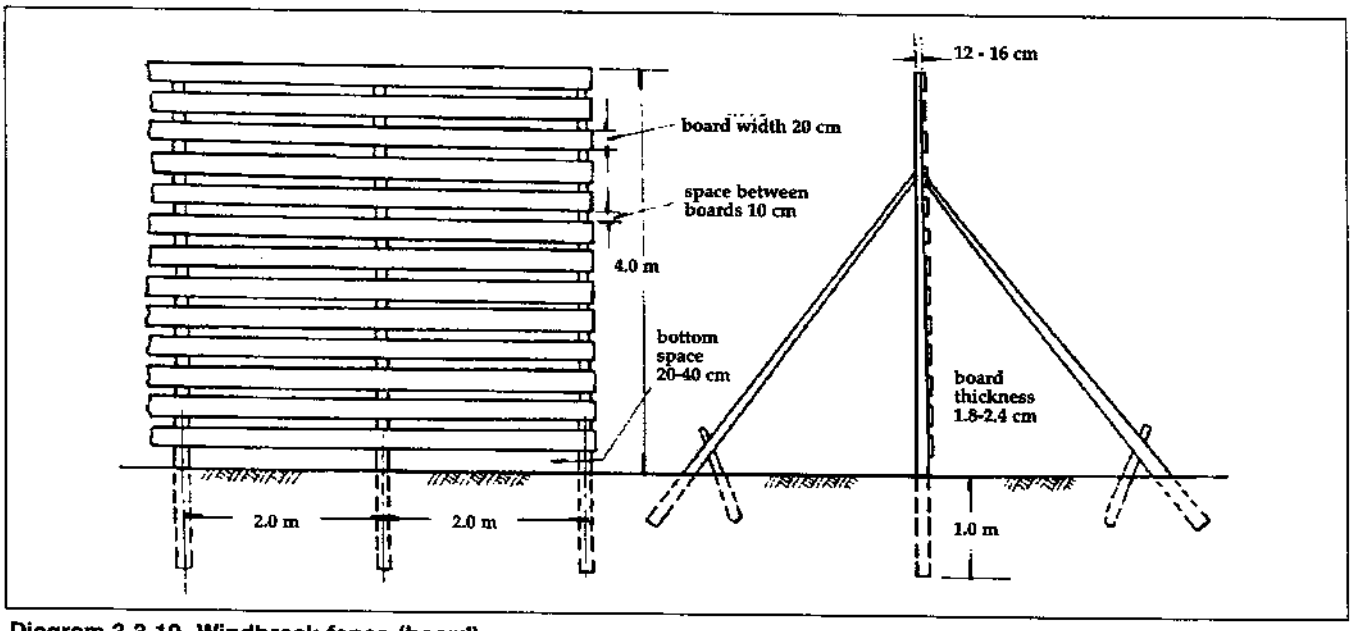


Diagram 3-3-19 Windbreak fence (board)

after considering the main wind direction during the tree growing season and the wind speed. Generally, the main wind direction during the summer and winter are different. It is especially necessary to pay attention to the strong wind during the growing season (April to September). Locate the facility according to the best possible combination given the specific conditions.

(7) Snowbreak Facilities Used Simultaneously

Snowbreak facilities are used simultaneously as a snowbreak countermeasure until the highway snowbreak forest is completed. When establishing the snowbreak facility consider a form and design location that do not hinder the growth of the snowbreak forest.

Commentary

1. Snowbreak Fence

A snowbreak fence is the most common snowbreak facility. Select the type of fence that corresponds to the local conditions based on the various characteristics that follow. A snowbreak fence can cause damage to the seedlings from the pressure of the snow that results from the formation of snow hills. For this reason, the placement of the facility should follow the standards in Diagram 3-3-20 so that as little damage as possible will occur in the snowbreak forest.

2. Blower Fence

A blower fence improves visibility by causing blowing snow to blow through the bottom of the fence and pass over the road surface. It is suitable for narrow roads where the main wind direction is fixed. Install it as close to the road as possible within a range that does not invade the vicinity of construction. Depending on the fence, no damage to the snowbreak forest should occur from snowdrifts, but the fence amplifies the summer wind and ruins the view so removing it seasonally is a consideration.

3. Wind Reducing Fence

A wind reducing fence causes the blowing snow to pile up in front of and behind the structure and reduces the amount of snow blowing across the highway. It is mainly a snowdrift countermeasure fence and greatly improves visibility. In the first stages of construction, the snowbreak forest seedlings located downwind from the snowdrift fence are buried in snow so there is the danger of damage from snow pressure. But if the fence is located too far from the forest, the snowbreak effect is reduced. If the peak areas of the snow hills located on the downwind sides are avoided, the danger of snow pressure damage can be regarded as small. Set up the wind reducing fence as shown in Diagram 3-3-20.

In this way, it is necessary to separate the wind reducing fence from the snowbreak forest and is not suitable in places where it is difficult to lease land.

4. Wind Stopping Fence

A wind stopping fence stops the snow from blowing towards the road on the upwind side of the fence, which causes a reduction in the amount of blowing snow reaching the road. The wind reduction effect is high, and it is not just a blowing wind countermeasure, it also exhibits excellent effects in improving visibility. Because the snow accumulates on the upwind side of the fence, it is unsuitable for places where there are fields, residences, or other land use. Locate the wind stopping fence about twice the height of the fence from the road. If the fence is high, and the space at the bottom has a small percentage of gaps, snowdrifts

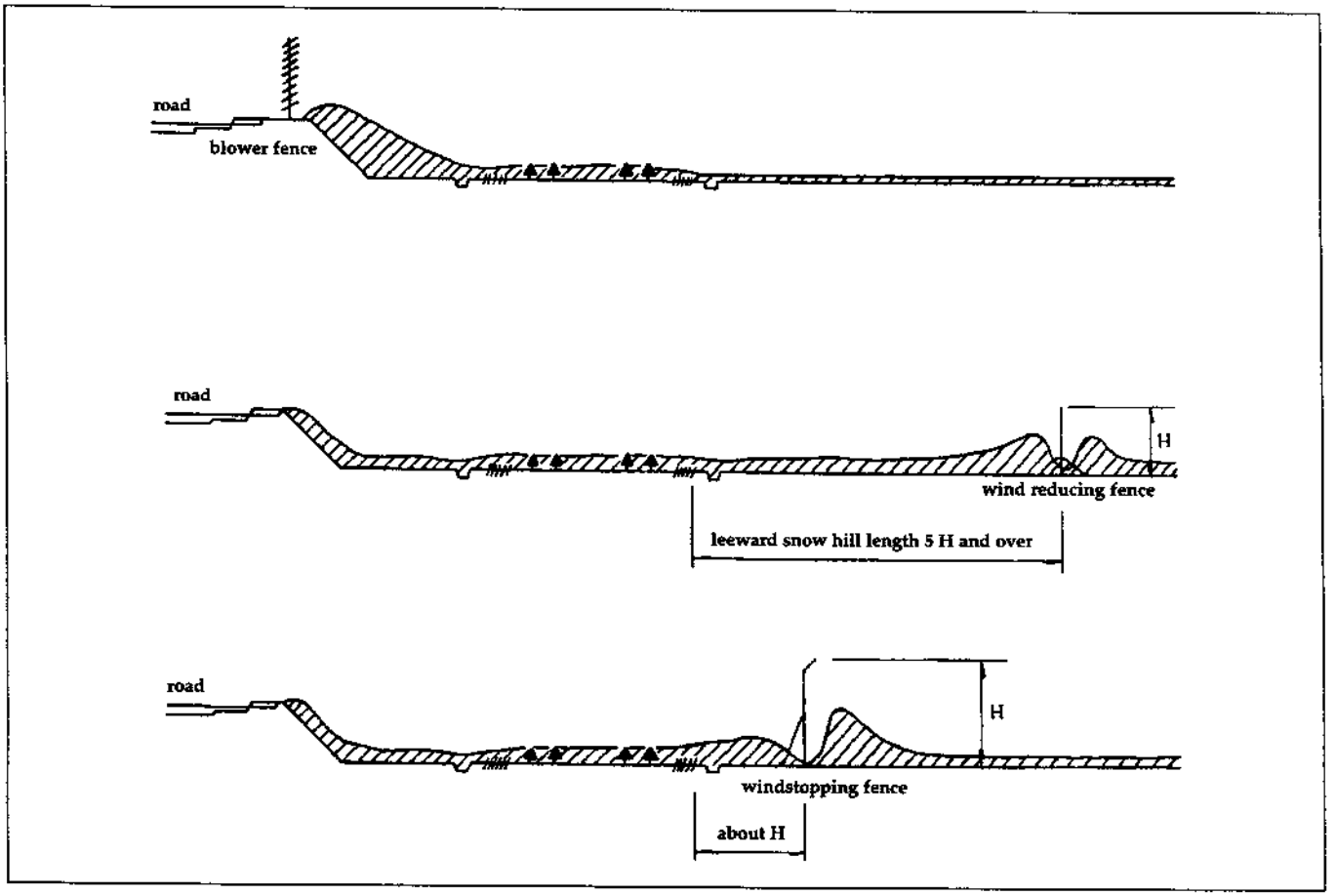


Diagram 3-3-20 Types of temporary snowbreak facilities

will form in front of the fence and the damage to trees from a settling force is reduced. It is a fence that conforms to the snowbreak fence type design and can be installed close to the trees (for details refer to the book on snowbreak fences).

5. Snowbreak Raised Ground

Ordinarily the density of blowing snow rapidly decreases as the distance from the ground increases. For this reason, it is known that raised ground construction relieves snowdrifts and hindrances to visibility. As the height of the raised ground increases, the snowbreak effectiveness increases, but if the height is raised too much, the difference between the tree height and the road surface height decreases, and the wind reduction effect of the snowbreak forest is reduced. Consequently, a raise ground height range of 1.2 x Hs (maximum snow accumulation depth) - 3.0 m is considered proper.

(8) Prospects of Influencing the Surroundings

Commentary

The positive effects and the negative effects of highway snowbreak forests are classified into weather related items, land use related items, and tree related items.
See Tables 3-3-19 and 3-3-20.

Item		Content
weather related items	– weakens wind speed – restrains reduction of air temperature, ground temperature,water temperature, – restrains dispersion through evaporation – fog prevention function – prevents plant friction, mechanical harm – prevents blowing sand	– a highway snowbreak forest accomplishes the role of a wind prevention forest during summer. – lowering the wind speed decreases the diffusion of heat energy. – the restriction on dispersion of evaporation has the effect of maintaining warmth. – trees capture fog droplets and cause dispersion of fog through evaporation. – protects crops against mechanical damage – prevents blowing sand, conserves the ground surface, and protects crops.
land use related items	– improves the living environment – increases the greenery ratio – increases crops – decreases noise – prevents dust	– prevents damage to livelihood caused from strong wind – Increases the volume of greenery producing a psychological effect – With a wind prevention effect, an increase in crop production can be anticipated. – With the sound prevention function of the trees, the noise from cars is decreased – captures the dust, sand, exhaust gases from the road.
tree related items	– line of sight inducing function – improving the landscape function – shelter function	– advantageous especially in winter for inducing a line of sight – causes an improvement in the scenic beauty of the combined region of the road and the surrounding environment – covers unpleasant natural features along the road

Table 3-3-19 Positive effects of highway snowbreak forests

Item		Content
weather related items	– the occurrence of shade – The lateness of the snow melting time – causes strong wind in the gaps (intervals)	– A reduction of crops, obstruction of the sunshine in life and low temperatures, lateness of the snow melting time, etc., occur secondarily. – Especially in the shady parts, there are problems of the scattering of snow melting agents, shortening of the farm cultivation period, the occurrence of snow rot disease, etc. – The occurrence of wind snowdrifts on roads where they are installed and a lowering of temperature.
land use related items	– limits land use along the road – limits entry to cultivated land – the possibility of fire spreading	– The planning of joint freight loading and unloading facilities is restricted. The development of residences and shops cannot progress. – It is necessary to find subsitute entry roads to cultivated areas. The entry and exit of large machinery is restricted. – With large-scale fires that overcome the tree's ability to withstand fire it becomes, instead, a cause of the spread of fire.
tree related items	– root penetration – falling leaves - falling branches – sprouting of seeds – occurrence of insect damage – bird and animal activity	– Roots which penetrate into cultivated areas compete with the crops for moisture and nutrients. There are also times when they hinder the starting of cultivation. – Leaves and branches falling on the cultivated land, besides hindering the work, exert an influence on the crops and soil. There are also times when things falling on residences create obstacles. – It is necessary to remove the tree seeds that have fallen on cultivated land and sprouted. – Insect damage occurs in highway snowbreak forests and there are times when it damages the surrounding area. – Breeding of field mice and from feeding birds causes damage to crops.

Table 3-3-20 Negative effects of highway snowbreak forests

Most of the negative effects follow.

1. Shade

Ordinarily, shade changes correspond to the sun's height. Since the height of the sun varies depending on the time and the season, the relationship of the shadow's direction, length, and scale within the highway snowbreak forest means there are parts that are in the shade only during certain time periods and other parts that are continuously in the shade.
See Diagram 3-3-21.

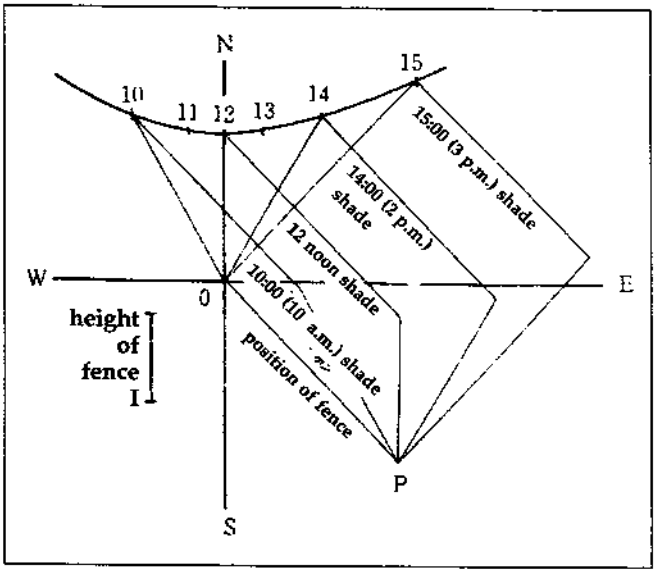


Diagram 3-3-21 Shade cast from a fence according to the shade curve[28]

The evaluation of shade influence differs depending upon the land use. In residential areas, a lowering of temperatures traces to the obstruction of sunshine and insufficient solar radiation. In relation to crop, because material production depends on photosynthesis, a reduction in the quality and amount of harvest usually occurs. Due to the lateness of the snow melting period during spring, the farming schedule might be delayed, especially if snow hills form in the shade.

Measures to counteract the occurrence of shade include a. ensure a wider site for the highway snowbreak forest, b. plant middle- and low-height trees on the side of cultivated land and c. cut the tops of tall trees on the side where there is cultivated land (ordinarily, there is no problem with trees reaching a height of about 10 m).

2. Lateness of the Snow Melting Period

Because the lateness of the snow melt is caused from an insufficiency in solar radiation that delays cultivation and the initial growth period of crops, the subsequent harvest also occurs later. For instance, autumn sown wheat, which is widely planted in Hokkaido can experience conditions of low temperature and humidity under accumulated snow leading to disease damage, such as snow rot disease. Melting snow water can also cause damage. To cope with late snow melting periods, snow melting agents are used.

3. The Creation of Strong Wind Through Gaps (intervals)

The speed of the wind where the highway snowbreak forest intersects with a road causing wind convergence is shown in Diagram 3-3-22. The effect is sometimes

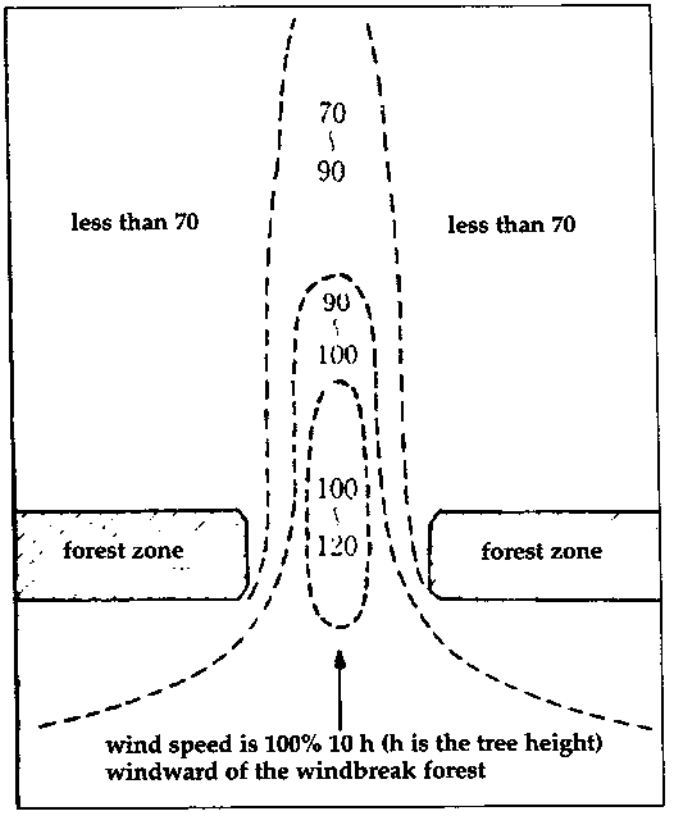


Diagram 3-3-22 Example of the increase in wind speed at a gap in the forest zone[9]

stronger than that over flat land, and snow-drifts and wind damage can take a toll in the vicinity. To make the forest gaps as small as possible, the construction of intersecting roads is best avoided, if possible, during an early planning stage. Depending on the location of the connecting roads, the cuts in the highway snowbreak forest increase so the snowbreak effect is reduced. To reduce the number of cuts in the forest zone, it is desirable to set up side roads and connect them to the main road all at once. In Diagram 3-3-23 the establishment of fences at the cuts creates wind relief.

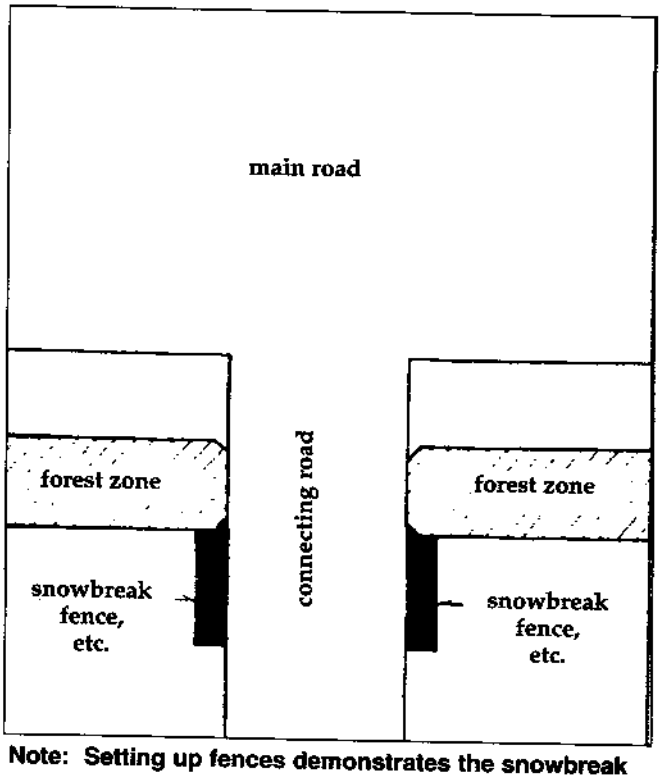
4. The Possibility of the Spread of Fire

The fire endurance of fresh leaves varies depending on the hydration rate of the tree. The relationship of thick-leafed deciduous trees is greater than other deciduous trees is greater than needle-leafed trees. Leaves

have the fire prevention function of providing heat intercepting surfaces at temperatures below that required for combustion, but if the tree is exposed to flame temperatures for a long time, the tree itself becomes a cause of spreading fire.

5. Root Invasion

It is known that the tree's root systems invade cultivated land and compete with the crops for moisture and nutrients. Close to the forest zone a reduction in the harvest, depending upon the type of crops, occurs. The process of absorption through the root system is mainly performed from the numerous small roots that are dispersed in the comparatively shallow A-level, ground layer divisions where the root system horizontally exceeds the tree crown. See Diagram 3-3-24.



Note: Setting up fences demonstrates the snowbreak effect of the highway snowbreak forest. (See black box area)

Diagram 3-3-23 Relationship between a highway snowbreak forest and connecting roads

To prevent these roots from invading a neighboring field, dig a ditch and bury a concrete board, which forms a protective wall.

6. The Occurrence of Insect Damage

Insect damage occurs in highway snowbreak forests, and there are cases of it spreading into the surrounding agricultural land and forest area. Because cases of parasitism insect damage have occurred in highway snowbreak forests, it may be necessary to exterminate with pesticide.

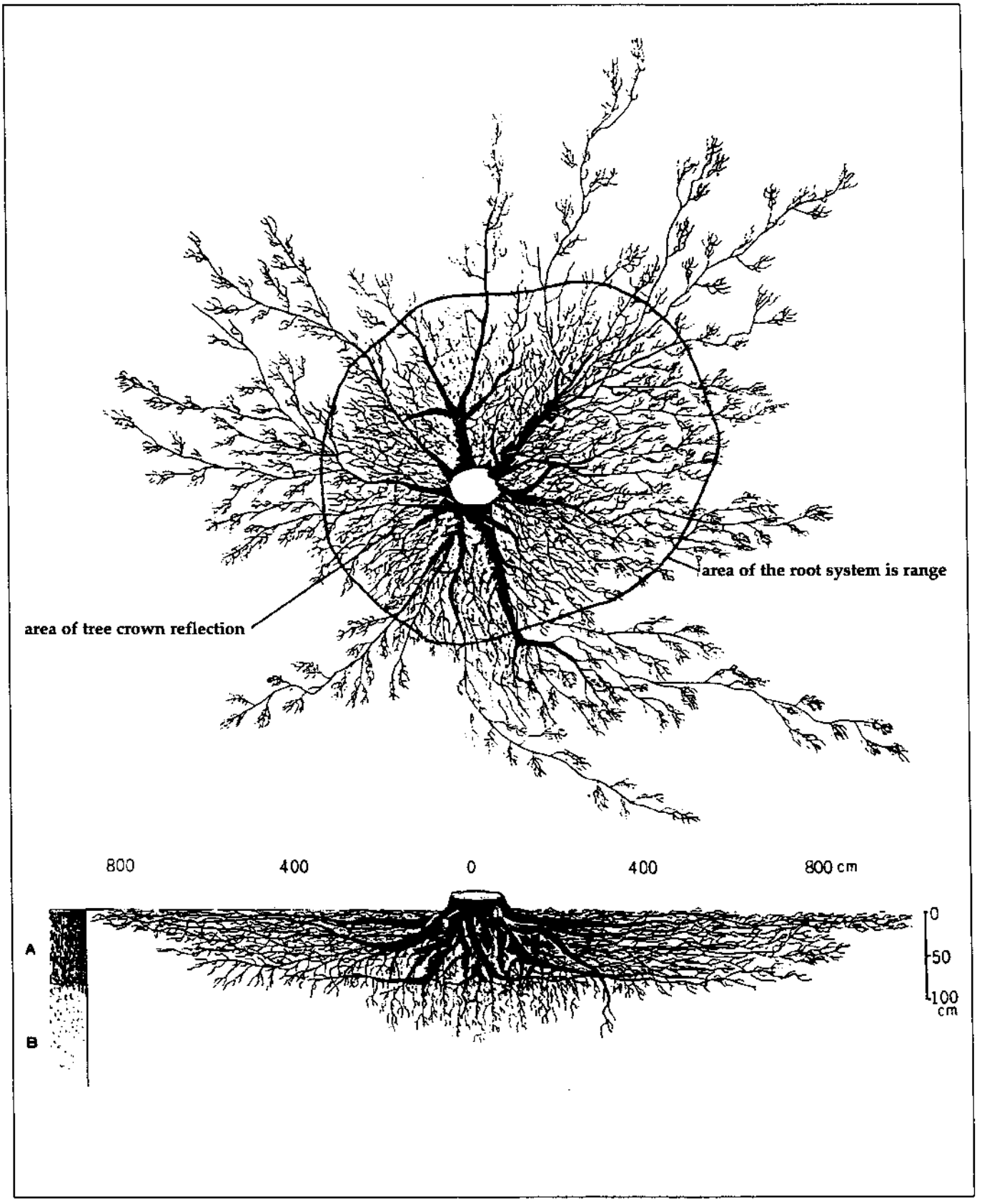
In Hokkaido, for example, it is possible to mention the median green area of the Obihiro Airport where there is occasional damage from the aphids that live there in the winter, providing a medium for a virus that affects the Tanebareisho field vicinity where roes and beans are planted.

7. Activities of Birds and Animals

In the forests of Hokkaido there is a problem with damage from rodents who mainly eat vegetation. To prevent rodent damage, it is necessary to properly cut the weeds beneath the trees in the snowbreak forest before they harm the neighboring crops on cultivated land.

3-3-3 Execution Design

Execution design of the snowbreak forest creation construction is composed of the creation plan, the earthwork plan, the land allotment plan, the planting pattern plan, a plan of the constructed items, a quantity record, and a statement covering the specific details. First execute a trial planting, conduct follow-up surveys, and revise the basic plan.



Note: The range of the root system indicates the absorption range.

Diagram 3-3-24 Typical diagram of root dispersion demonstrated in a sawara cypress in the Meguro Experimental Forest (Kanto loam)[10]

Commentary

Create a construction plan based on the content drawn up during the basic design that includes tree type, planting density, arrangement, tree zone width, and growth foundation and encompassed facility and maintenance-management plans. The execution design links the basic design with the execution of the work and calls or a high degree of practicality. In places with special conditions such as an inferior environment, execute a trial planting and follow-up surveys before revising the basic design and incorporating those results.

Chapter 4 Carrying Out the Planting of a Highway Snowbreak Forest

4-1 Planting Procedure

Commentary

When creating a highway snowbreak forest, the tree planting procedure and method differ depending on whether the trees are seedlings, not yet full-grown trees, or full-grown trees. See Diagram 4-1-1. The focus in this section is seedlings. If the need arises, refer to the 1986 *Hokkaido Highway Afforestation Manual (draft)* from the Hokkaido Development Department, Chapters Four and Five on Executing Planting, which concerns the supplemental use of trees that are not full-grown and full-grown trees.

The planting procedures and methods are similar to those of the economic forest and disaster protection forest of the forest industry, but there are many cases when a highway snowbreak forest is established in a place where the conditions are poor, and the speedy exhibition of the snowbreak function is expected of the planted trees. The initial forest creation requires special care so that the seedlings will grow healthily.

(1) Creation of the Growth Foundation

The creation of the growth foundation is ground preparation work that makes the planting of seedlings easier and improves the seedlings' growth after planting. For the specific details, refer to the previous section.

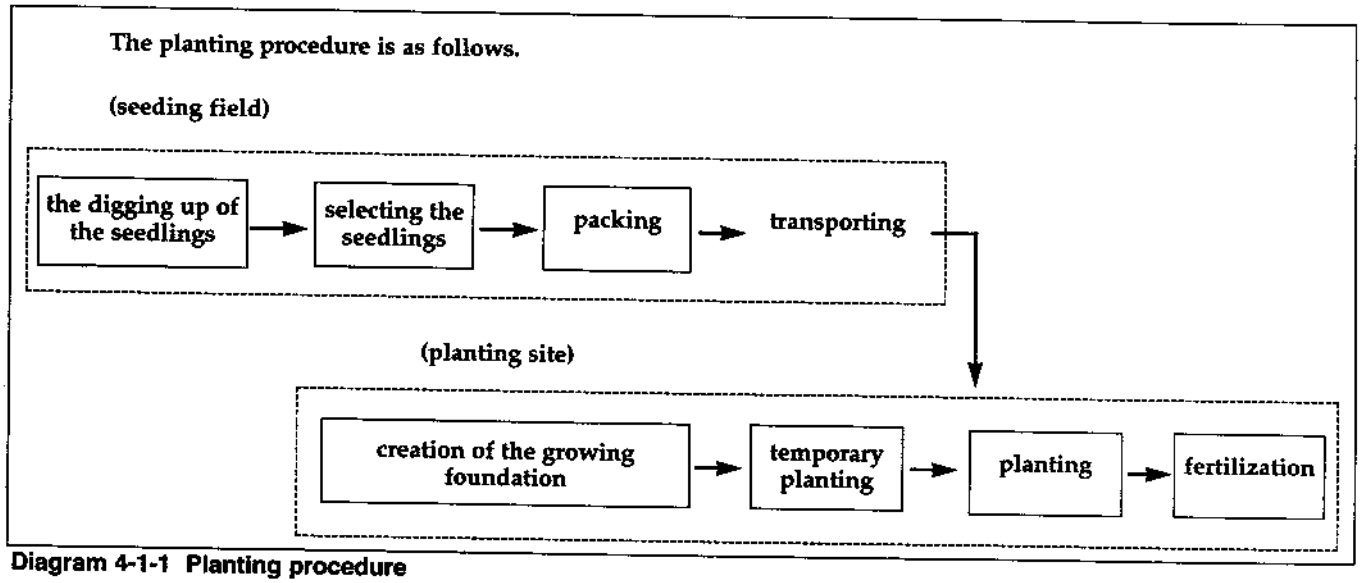


Diagram 4-1-1 Planting procedure

(2) Provisional Planting

Provisional planting is the temporary planting and conserving in the vicinity that protects the newly arrived seedlings from drying and withering at the creation site. It is necessary to quickly untie the wrapping on the roots of the seedlings, select a shady area, and before planting them in one row, press the seedlings' roots and soil closely together, and recover them with the wrapping material. If the provisional planting lasts too long, the seedlings produce white roots and their future ability to take root is diminished. At the longest, delay only three days or less.

(3) Planting

The handling of the seedlings relates to their growth following planting so special care is required. Workers carry the seedlings from the provisional planting area in small groups so that they do not dry out. Containers of waterproof canvas and thick straw mats make it difficult for plants to receive effects from the outside air. For planting that occurs where a growth foundation does not exist, dig the planting hole after removing fallen leaves and small branches, grasses, etc., from the planting site. The size of the planting hole is about 30 cm in diameter and 25 cm deep for needle-leafed trees. For deciduous trees the hole diameter and depth are both about 30 cm. A summary of planting is shown in Diagram 4 -1-2. First, shake the seedling to knock off the dirt, and after stamping on the ground near the roots, lightly apply dirt, not creating a hollow space.

For planting in a place where a growth foundation exists, dig a planting hole 40 cm in diameter and 25 cm deep. Plant the seedling where the soil is already well cultivated. Finally, after stamping at the base of the roots, once again lightly apply surface dirt.

(4) Fertilization

Fertilization occurs where a growth foundation was not prepared. If an excessive amount of fertilizer is used, the plants

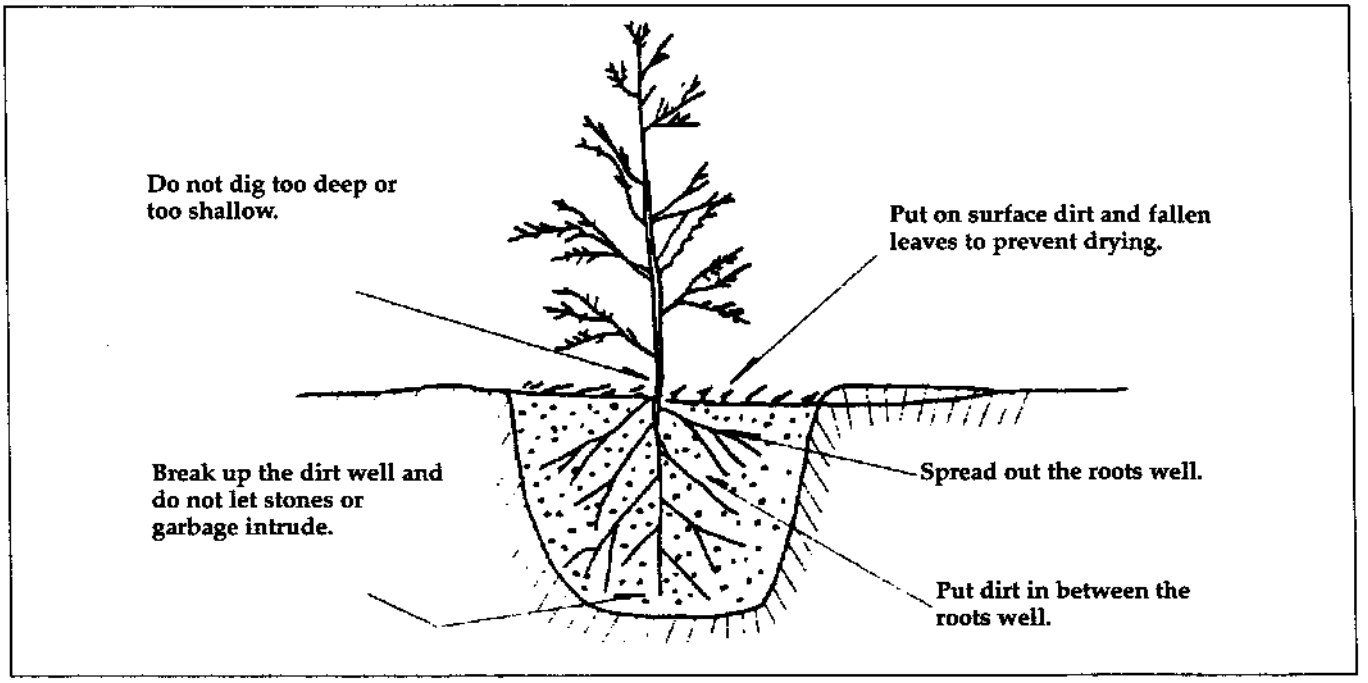


Diagram 4-1-2 Summary of seedling planting[34]

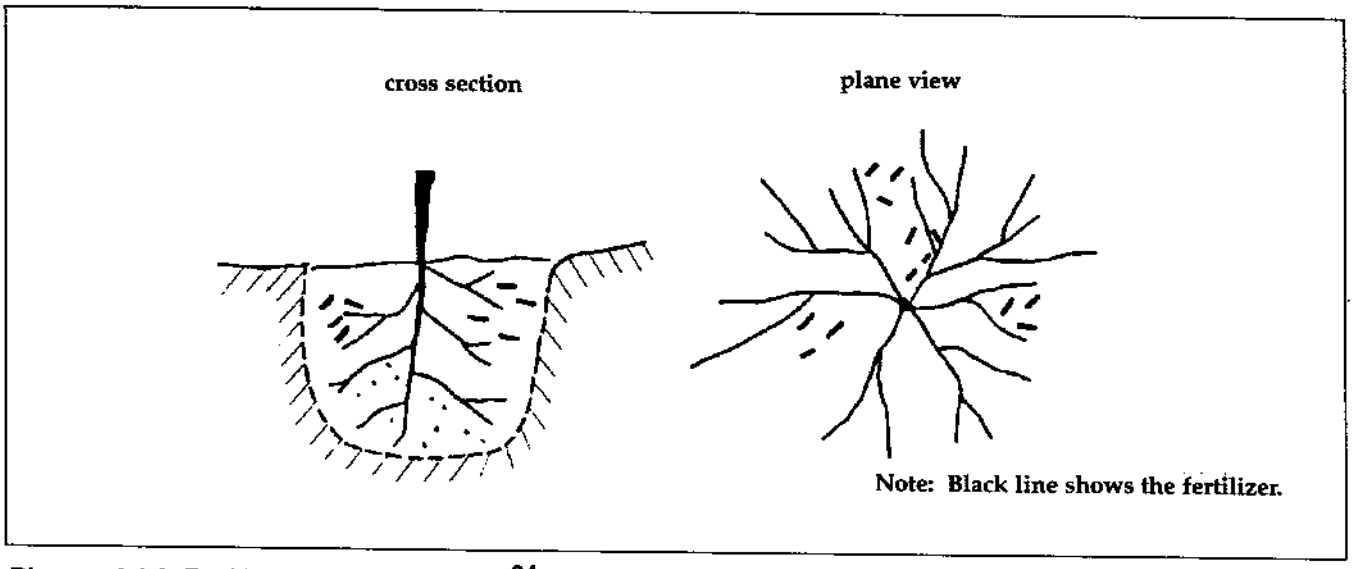


Diagram 4-1-3 Fertilizer application method[34]

become easily susceptible to weather and insect damage, so carefully apply the proper amount. Refer to "Growth Management" for the ratio of fertilizer. Premixed fertilizer for forest creation is also available on the market. Apply nutrients as shown in Diagram 4-1-3. Divide the fertilizer in three places or more around the perimeter of the roots and bury at a depth of about 10 cm. It is necessary to avoid absorption from the surrounding weeds.

4-2 Planting Period

The period for planting trees differs according to the region and tree type, but considering wheather conditions, it is desirable to plant at the most suitable time after sufficiently studying the methods and health maintenance.

Commentary

Ordinarily, the most suitable time for planting deciduous trees is during the spring just before the opening of the leaves, but in places where there is an enduring snow melting period that overlaps with the opening of the leaves, the suitable period is extremely short. For needle-leafed evergreen trees, the ideal time is rather late in spring when the sprouts are out and the root activity is lively.

During fall planting trees can suffer snow damage or snow rot before the roots take hold. For the white birch, elm, and maple varieties, types which quickly absorb water, it is best to plant in the fall. If planting at the suitable period is impossible, the following points are helpful. Always avoid planting during the summer.

a. Swiftly carry out the entire process from digging up to planting.

b. If possible, use potted seedlings.

c. Investigate mulching at the roots, which prevents winter frost and freeze damage and evaporation dispersion due to dry, cold wind.

d. To prevent roots rising and slanting in response to cold and frost, stamp hard at the

base of the roots, and repeat the stamping after the snow melts.

Note: Pot seedlings: A seedling that has grown in a vinyl chloride container (pot). The advantages include: cultivation and shipping are simple, seedlings with full, high-quality root systems are obtained, they can be planted in a period unsuitable for planting, damage from planting is minimal, the roots take hold at a successful rate, and growth after planting is smooth.

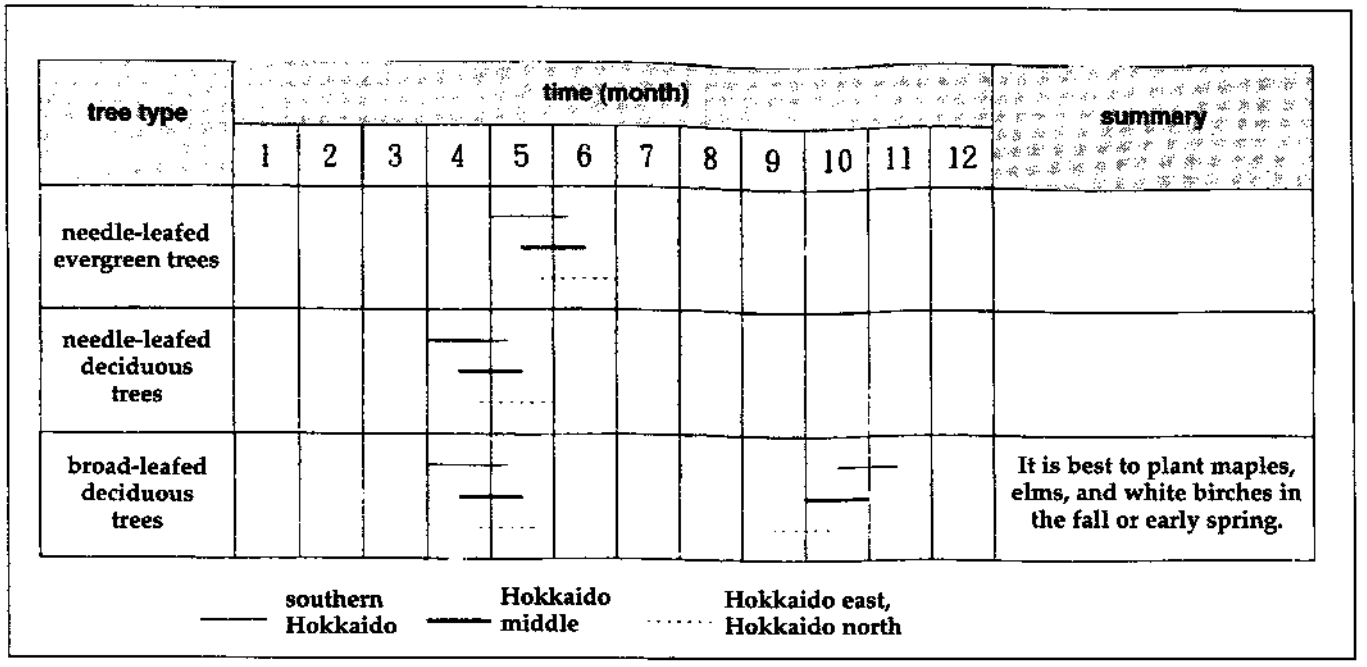


Table 4-2-1 Suitable period for planting

Chapter 5 Managing the Growth of a Highway Snowbreak Forest

5-1 Fundamental Aim

Growth management is an important work that protects trees from all damage, plans their healthy growth, accomplishes the objective of the creation, and controls the success or failure of the highway snowbreak forest project. Because trees, as opposed to constructed items, grow, the maintenance-management depends on the growth stage. Growth management is divided into three divisions–the early stage of creation, the middle stage of creation, and the stable period–and strives for ecological balance, stable trees, and conservation. Growth management addresses protective measures and establishes structure to discover damage early and deal with it rapidly. The creation of a highway snowbreak forest is a "living thing construction method" that is different from other civil and construction engineering methods. The end of the creation of a forest is not its completion. It is necessary to continue its original purpose through sufficient growth management after its creation.

Commentary

(1) Growth Management Is Not Uniform or Mechanical

It is necessary to continuously observe and respond to take the situation of the trees. The physiological function of the trees must be understood according to the various characteristics to avoid contradicting the life cycle of the trees. See Tables 5-1-1 and 5-1-2.

(2) Trees Are Always Affected By Their Surrounding Environment

If growth is suppressed, trees wither and die. The environmental factors include weather, soil, living things, and human acts, as in Diagram 5-1-1 and Table 5-1-3. There are many cases when tree damage is the result of a combination of these factors and times when one factor causes several types of damage. The damage that occurs and its influence change. Ordinarily, during the early period of creation, damage is easily incurred.

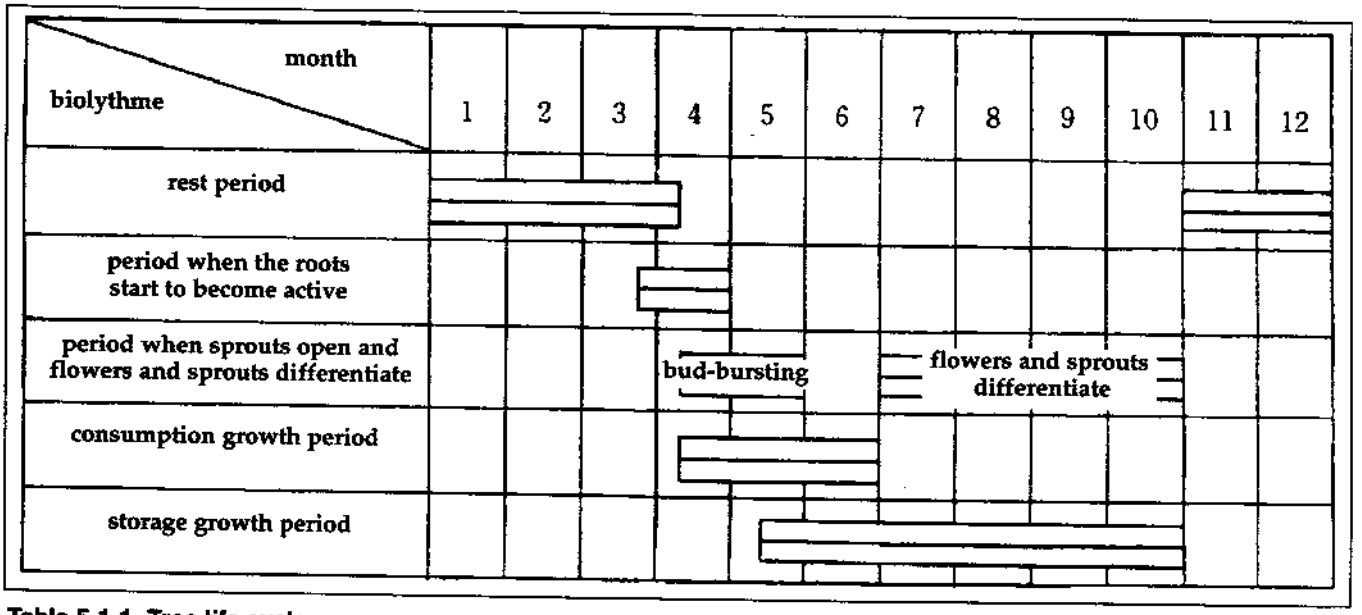


Table 5-1-1 Tree life cycle

symptom	cause	
incomplete growth	insufficient nutrients	insufficient soil base displacement capacity, incompatible soil pH, insufficient fertilizer
leaves fall early	dearth of moisture	soil lacks ability to hold water and egress for rainwater runoff, planting standard is narrow, lowering of ground water level, cold, dry wind
leaves turning yellow, turning black	root acid deficiency	soil's permeability to water, soil's concretion, increase in level of ground water
occurrence of withering and dying	harmful ingredients	gas leak
withering, wilting	natural conditions	too much or too little sunshine, unusual weather, wind damage, snow damage, salty air damage, air pollution, agglutination of oil, old age
unusual occurrence of dragonfly nymph, torso blowing sprouts	injury	human or natural damage to the trunk, branches
opening of flowers, fruit bearing is poor	mistaken management	branches cut, re-digging of the planting site, too much fertilizer, chemical damage
	weed damage	weeds overgrown, mistake in their removal
	insect damage	disease damage, insect pests
	mistake in execution of the design	mistake in tree selection, dense planting, sparse planting, deep planting, unsuitable material, unsuitable creation techniques and unsuitable creation construction methods

Table 5-1-2 The debilitating conditions and causes of tree damage

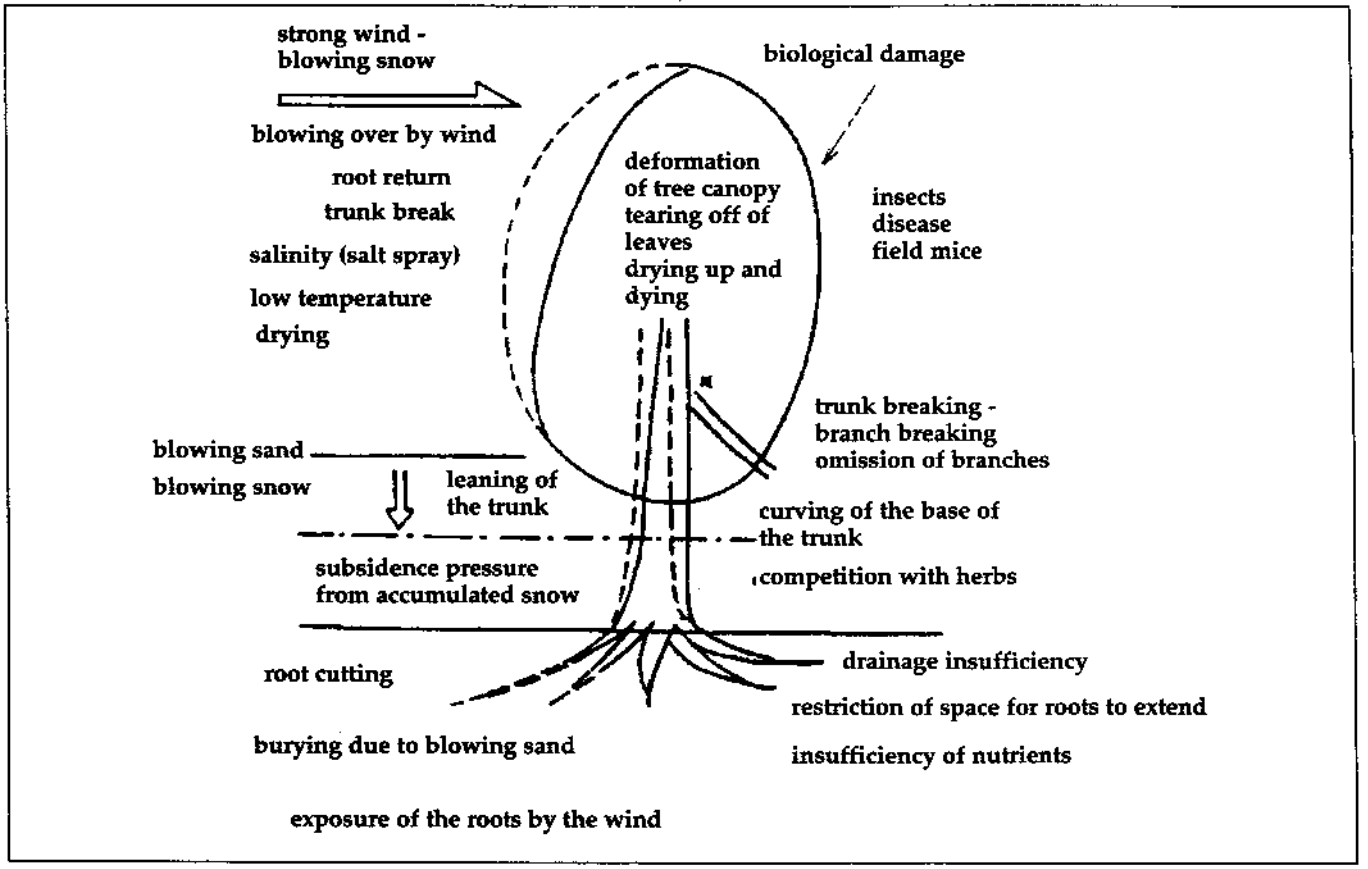


Diagram 5-1-1 Growth hindering factors related to the trees of a creation site[16]

division				period of occurrence	cause	main damage condition	countermeasure	management stage		
								initial period	middle period	stable period
weather	cold damage	freeze damage	late frost	just before the leaves open - open leaf period, April - July	frost and freezing	sprouts of fir die from freezing	–smoking – cover with straw –raise roots (cut roots) –use chemicals –stamp on roots –irrigate –cover and enclose –sunshade, windbreak fence	◎	○	○
			early frost	just after growth stops September - October		The current year's growth of branches of young Japanese larch die from freezing				
			ground freezing	early winter before snow accumulates, October early spring just after snow melts, March-April	unusually low temperature	The part of the trunk near the ground of young fir and Japanese larch suffer freezing damage. Roots rise.		◎	○	○
			blight type freeze damage	late winter - early spring end of February - early April		The part of the fir near the surface of the snow suffers freezing damage				
		dehydration damage	cold wind damage	very cold season, when part of the soil or trunk is always frozen	dry winter wind	withering of the branches, leaves or entire trunk of fir, akaezomatsu (in Japanese spruce family), and pine types in areas that recieve the brunt of the wind	–shielding from sunlight –reducing wind speed –maintaining relative temperatures –sunshade, windbreak fence	○	○	○
			cold drying damage	when the soil is frozen and clear days continue	drying from the solar radiation and open air	withering of fir, akaezomatsu (in Japanese spruce family) on southern slopes where there is little accumulated snow				
	drying damage		bad growth	when clear days continue and the soil dries	insufficient rainfall solar radiatrion - wind	bad growth	–plant ground cover –increase the soils ability to hold water through cultivation and applying organic substances –irrigate –sunshade, windbreak fence, cover with straw	○	○	○
			drying of the ends of twigs, sprouts on the ends of branches, leaves			sprouts and leaves on the ends of twigs and branches withering				
			withering			withering and dying				
	snow damage		crown snow and sticking snow	when the snow falls or accumulates	falling snow	change of tree shape, fall down.	–block strong wind, weaken it –snowbreak fence –snow hanging, support, snow enclosure –knock down branches, thin the branches –proper management of standing timber density	◎	○	○
			subsidence pressure and vine pressure		accumulated snow	breaking, splitting. bending, etc. of trunk, twigs, branches.				
			overhanging snow and snowdrifts		accumulated snow and wind					
			blowing snow							
	wind damage		blown over	especially dangerous when typhoons attack	strong wind	fall down, trunk break, branch break, change in tree shape	–windbreak fence –proper management of standing timber density –wind avoidance, support	◎	○	○
			trunk break, branch break							

Table 5-1-3 Tree protection countermeasures[17, 36, 50]

division		period of occurrence	cause	main damage condition	countermeasure	management stage		
						initial period	middle period	stable period
soil	excessive moisture	when rainfall continues	bad drainage	Trees that cannot endure wet ground die.	–establish drainage ditch	○	○	○
	surface erosion	when rainfall continues	sliding of surface soil	fall down, growth hindrance or dying	–plant ground cover plants	◎	○	○
living creature	disease	differs depending on the name of disease	pathogen and immediate cause (weather, soil, seedling-tree growing conditions	growth hindrance or dying, dark color snow rot disease, standing withering disease, blights, spider web disease, gray mold disease; invite disease; etc.	–remove sources of infection –mix tree types –spread chemicals –exterminate the insects –improve environment	○	○	○
	insect damage	constantly occurring type suddenly occurring type uniquely occurring type	root eating damage, sap absorption, leaf eating damage, new twig pith eating damage, under the bark - wood eating damage, etc.	hindrance to growth or death Cutworm, himekogane, fir leaf,mite, big aphid types, etc.	–discover forest damaging insects at an early period –mix tree types –spread chemicals –improve environment –catch and kill, kill with stabbing, lure and kill –remove interim parasites –remove weak and damaged trees –use natural enemies	○	○	○
	bird, animal damage (field mice)	damage occurs underneath accumulated snow	eating damage	Among field mice types, ezoyachinezumi causes damage to the bark of young planted trees near the roots. Withering and dying or destroys tree shape	–ground preparation-mow grass at base of tree –trap-ditch to prevent breeding and to exterminate –spread chemicals-use natural enemies	◎	◎	○
human acts	fire	especially dangerous when the humidity is low and there is wind	They are mostly caused from human acts: arson, bonfire, cigarettes, lighting a furnace, spreading fire, etc.	danger of losing the forest due to fire and fire spreading to residential areas	–fire protection line –fire protection tree zone –early discovery –public relations activity –fire prevention education –refusal of entry	○	○	○
	garbage	n/a	throwing away garbage	generates flies, fire and bad smell not desirable from the view standpoint.	–public relations activity –sentiment education –collection	○	○	○
	stamping pressure	n/a	hardening the ground by stamping on it	bad growth of planted trees.	–refusal of entry –cultivation	○	○	○

Table 5-1-3 (cont.) Tree protection countermeasures[17, 36, 50]

5-2 Content of Growth Management

In growth management, mowing the weeds around the bases of the trees and density management are especially important. As the need arises, carry out supplemental planting, trim the trees, fertilize, set fallen trees upright, and irrigate or replace them, carry out harmful insect and animal countermeasures. see Table 5-2-1.

Commentary

(1) Supplemental Planting

If some of the planted trees die within one or two years, the tree density is lowered. As soon as possible carry out supplemental planting to achieve the proper tree density even if one tree dies and the number of tree is low. When the number of planted trees is large and the trees stop dying, the gaps increase, which is harmful to the growth of the surrounding trees. Supplemental planting during the middle and stable management periods requires studying the local conditions and planting a different type of tree compared to the one that died.

Moreover, if a large number of trees die over a large area, some creation method was unsuitable to the creation plan's environmental conditions, and beginning anew from the basic stage may have to follow.

item	management stage		
	initial period	middle period	stable period
1 supplemental planting	◎	○	○
2 mowing around the trees	◎	○	○
3 tree (young tree) care	○	○	○
4 set fallen trees upright	◎		
5 fertilize	◎	○	
6 repair windbreak fences	◎	○	
7 density management	◎	○	
8 harmful insect and animal countermeasures	◎	○	○
9 irrigate	○		
10 renew			◎

Note: ◎ The 00 marks the important period.
○ The 0 mark, when necessary, depends on the conditions.
Concerning management stages, refer to "5-4 long-term plan."

Table 5-2-1 Growth management items and their management stages

(2) Mowing Around the Trees

Mowing around the trees is important, especially during the initial management stage after creation. The luxuriant growth of weeds oppresses planted trees and hinders their growth, but mowing removes the weed tree varieties. Usually, the growth of the weed tree varieties occurs faster than that of the seedlings, and the creation of a snowbreak forest is terminated from the tree type weeds. Insufficient light retards photosynthesis, and it becomes difficult for trees to continue growing. Moreover, if there is competition for water and fertilizer between the trees and the weeds, trees are at the disadvantage.

Mowing around the trees, until they escape from the oppression of the tree type weeds

helps assume future stability. For trees that grow well in the sun, continue mowing until they are 1.5 times the height of the tree type weeds. For trees that grow well in the shade, mow the surrounding area until they are the height of the tree type weeds or taller. Because the reproductive process of the tree type weeds reaches a growth maximum during the early summer when the stored up nourishment is depleted and the flowers and fruit are yet to appear (ordinarily, June to July), mowing is particularly effective.

The work of mowing around the base of the trees is performed with a sickle and cutting tool, but it is necessary to be careful not to cut or mistakenly damage the planted trees. Avoid removing the cut tree type weeds. Instead spread them over the forest floor to restrain the growth of future weeds, but also to prevent the drying and sliding of the soil and return organic matter to the environment.

(3) Young Tree Care

In the initial period of planting the extension of the roots is insufficient because they have not become completely attached to the soil. As a result they rise during the course of the winter, the roots are injured, and their adhesion to the soil diminishes, which hinders growth. Until the roots have become sufficiently extended, generally after the snow melts in the spring, or as early as possible, straighten the trees that have fallen or lean and stamp down the base of the roots. It is desirable to stamp at the roots of all the planted trees in the spring; even continue the practice in the next year, if rising roots are seen again. If root stamping is begun at a time other than during the spring, repeat it at the same time that the roots of the seedlings were covered. Because the same kind of root rising traces to strong winds, it is advisable to stamp on the roots following a vigorous wind.

(4) Fertilization

In the preparation of the creation foundation for a highway snowbreak forest, carry out soil improvement that is both sufficient and necessary for the growth of the planted trees. To promote the growth of a robust, healthy highway snowbreak forest, especially when a creation foundation is missing where the soil is poor, fertilization provides an indispensable item. After analyzing the soil and studying the growth conditions, etc., of the planted trees, conduct the appropriate fertilization in the initial management period after the creation.

The two primary periods for fertilization are the spring (May and June) and fall (September and October). To promote growth in the spring apply fertilizer that is rich in nitrogen. In the fall, apply fertilizer that is rich in phosphoric acid and potassium, which imparts the ability to endure cold. The amount of fertilizer differs according to the size of the trees. Because damage occurs if too much is applied, pay attention to the proper amount as indicated in Table 5-2-2.

Whichever method of applying the fertilizer is used, apply it at a shallow position compared to the initial fertilization and never directly touch the roots.

1. Types of Fertilization

• Part fertilization (apply at appropriate places) - method of applying the fertilizer by lightly cultivating intermittently below the tree crown (ordinarily, often used).

(grams per tree)

tree type	seedling			young tree			grown tree		
	nitrogen N	phosphoric acid P_2O_5	potassium K_2O	nitrogen N	phosphoric acid P_2O_5	potassium K_2O	nitrogen N	phosphoric acid P_2O_5	potassium K_2O
needle-leafed tree type	8～10	5～8	4～8	10～15	10～12	8～10	15～20	10～15	8～10
broad-leafed tree type	8～10	5～10	5～10	10～25	10～15	10～15	15～20	15～20	10～15
rhizobium tree type	8～10	10～15	5～10	10～15	20～25	20～25	15～20	25～30	20～25
flower tree type	8～10	10～15	5～10	10～15	20～25	15～20	15～20	25～30	15～20

Table 5-2-2 Standard fertilizer amount for planted trees[52]

•Circle fertilization (circle fertilization) - method of applying fertilizer by digging a circular hole beneath the tree crown and mixing the fertilizer well with the dirt.

•Total surface fertilization - method of applying fertilizer by lightly cultivating the entire surface under the tree crown. When there is an insufficiency of fertilizer in the growth foundation, the leaves of the trees turn yellow, change color, wither in size, and the general growth dissipates because the tree's energy is lost. On the other hand, if excessive nitrogen fertilizer is used, the leaves become oversized. Furthermore, the opening of the flowers and the leaf stems become weak, and they are easily affected by cold damage.
Among the types of fertilizer are the slow-effect organic substance fertilizer and the immediate-effect chemical fertilizer. On soil that holds fertilizer poorly, even if only chemical fertilizer is used, the fertilizing effect does not increase. It is necessary to primarily use organic substance fertilizer simultaneously with chemical fertilizer. For general purposes, use the slow-effect organic substance fertilizer. Nitrogen (N) increases the speed of growth. Phosphoric acid (P_2O_5) causes root growth or increases he ability to take root. Potassium (K_2O) restricts dispersion from evaporation, endures drying during transporting, and takes root well. It also increases resistance to damage.

2. Soil Types

•Sandy soil--maintains fertilizer poorly because nutrients do not wander. Use organic substance fertilizer rather than water soluble chemical fertilizer. Solid fertilizer has a vigorous effect as does melted phosphoric acid.

•Volcanic ash soil--very acidic soil. Phosphoric acid absorption ability is extremely strong, but phosphoric acid is difficult for plants to absorb. Correct the acidity through applying organic compost and melted phosphoric acid.

•Severe clay soil--both drainage and ventilation are poor, if a large amount of chemical fertilizer is applied and density damage occurs. After carrying out covered culvert drainage and soil improvement techniques, apply organic substance fertilizer.

Soils that are 10 cm or less thick and include humus, even though they are physically good, can receive root injury from fertilizer, so it is good to use organic substance fertilizer and sold fertilizer.

(5) Setting Up Fallen Trees

Setting up fallen trees that have drooped under snow pressure after the snow melts involves holding them fast connected with supports and ropes to neighboring trees. When stretching a rope, stability is high if it is stretched horizontally at a place about one third of the tree's height on a slope. The pivotal period for setting up fallen trees is as soon as possible after the snow melts.

The snow damage condition is not derived simply from the falling over of trees. It is divided into three general divisions.

•Snow pressure damage--This is damage suffered from the pressure of accumulated snow on buried trees that causes deformations called either subsidence pressure or creep.

•Crown snow damage--attached snow damage---The is the breaking and bending of branches from the weight of fallen snow that sticks to the branches and leaves.

•Avalanche damage--This is damage suffered following avalanche and its subsequent wind pressure and snowdrifts that pummel trees along the route of an avalanche and snowdrift region.

(6) Tree Types and the Ability to Endure Snow

The life histories of the main tree types in Hokkaido have not yet received sufficient clarification. For this reason, standards for the ability to withstand snow for the tree types are yet to be established; however, the general divisions are shown below.

1. Trees That Cannot Easily Withstand Accumulated Snow Pressure.

Trees such as varieties of pine bend easily and break and their recovery is late. Broad-leafed trees like the elm family have roots that are easily broken when planted. Mizunara is one whose roots and trunk bend remarkably. Yachidamo (in sweet osmanthus family), harigiki (in deciduous Araliaceae family), etc., have branches that break easily. When the replacement of deciduous trees is planned in areas of heavy snow, the method of replacement requires a careful procedure.

2. Trees Partly Affected From Accumulated Snow Pressure.

The Japanese larch is a type of tree that grows quickly in a comparatively wide range of areas but it is easily susceptible to crown snow damage and the trunk easily bends. In areas where there is a lot of snow, until the tree reaches about one meter in height, it can fall over from the pressure of accumulated snow the same as other trees. But when it reaches two to three meters, the roots will bend and the trunk grow into a deformed condition like the fir trees. The deciduous pine family hybrids and the (karamatsu) or Japanese larch Fl are better able to withstand accumulated snow than the (karamatsu) Japanese larch. Even in the vicinity of Otoineppu, where the larch reaches a tree height of four to five m after about 10 years, the growth of the tree is good, the trunk bending is minimal, and growth is steady.

3. Trees That Endure Accumulated Snow Pressure Comparatively Well.

The Norway spruce has grown well in

Hokkaido for a long time and it provides a good example as a performing railroad snowbreak forest. However, in places where the deepest accumulated snow exceeds two meters, the broken trunk damage is striking. At a height of about 0.8 to 1.5 m, many break, grow twigs, and in the broken places develop unusual hypertrophy. Furthermore, they are very susceptible to crown and sticking snow damage. The Todo fir trees are usually planted at the creation site as seedlings fresh from the mountains at the age of five to seven years and a height of about 0.3 to 0.6 m. To achieve a height of 1.5 m and over, the period for mowing around the base of the trees differs according to the planting site and nurturing conditions. About 5 to 10 years is required. Fir trees during this period have comparatively flexible trunks so when the snow accumulates they bend into complicated S shapes called "chouchin tatami" or collapsed paper lantern. Yet the percentage of bent and broken trees and broken roots and centers of trees (pith) is relatively few. Bent trunks rapidly recover in four to five days after the snow melts and return to an upright position. The bent trees recover extremely slowly if they have suffered large injuries such as breaks and large bends at the roots; these bends recover over the life of the tree.

When planted fir trees reach about two meters tall, their trunks harden and they cope with accumulated snow differently than when they were about one meter tall. When the snow first starts to fall they are buried, the same as when they were small, but if the deformation of the accumulated snow weighs heavily, depending on its movement, the roots are ruined, the part near the roots breaks, and the trunk along with branches break. The recovery of the bent trunks is not as swift as when the tree is young. It may recover in part, but damage is now fixed in place and the result is deformed trees.

At present in Hokkaido among the most widely planted trees are red yezo-spruce because this type can endure the pressure of snow, yet in heavy snow areas bent trunks and broken trunks still occur. However, their percentage, even when compared to the Todo fir is small. Even when the spruce tree is about one m tall, the trunk bends well, and it quickly recovers from the bends once the snow melts. Natural recovery from a broken trunk is also fast compared to the Todo fir.

4. Fruit and Garden Tree Methods

Each region applies extremely diverse methods of snow damage countermeasures that respond to a combination of issues: accumulated snow, tree type, and method of planting.

It is impossible to control the amount of falling snow, but if the accumulated snow was completely removed, the ground would freeze from the severe cold in Hokkaido. This would definitely not help the trees thrive. It is possible to protect trees from snow pressure damage using "winter enclosing," the same as in gardening, but this is unsuitable for a large number of trees in a highway snowbreak forest.

Since there is a big difference in the countermeasures used, it is possible to reduce snow pressure damage through the selection of tree type. For highway snowbreak forests, seedlings fresh from the mountains are used. It takes several years, 20 or more, before the planted trees reach a size where they are not harmed from accumulated snow. The fluctuation in the annual amount of snow is great and even one year of heavy snow causes trees to suffer great damage. Because

growth in the initial period of planting is important and the probability of snow damage decreases, the adequate execution of planting-nurturing that includes the selection of good seedlings, ground preparation, and mowing around the base of the trees is a key snow pressure damage countermeasure.

Branch hitting and strength will be discussed later. At present there are no specific guidelines, but in Hokkaido, the branches are hit until the snow gets deep. The trunks of a rather large percentage of young planted trees also break each year; many are one to three years old. If these are left alone, the closest verticillated branch beneath the place where the break occurred becomes unusually elongated taking a reverse umbrella shape that is easily snow damaged. See Diagram 5-2-1. Either the tree should be felled or it is necessary to raise the broken trunk and make other provisions.

Fujiwara and others have said the following about the Todo fir and red yezo spruce that were the experimental subjects at the Hokkaido University practice forest in the Nakagawa area in 1985.

In the cases of trunks breaking and the twig parts breaking and falling, as shown in Diagram 5-2-1, several of the verticillated branches closest to the broken place show unusual growth as if attempting to start a new trunk. If all the verticillated branches remain, they form upside down umbrellas and snow accumulates here, and the rate of verticillated branches that break is high. In this instance, it is better to select a verticillated branch as the growth candidate and cut off the others. If the trunk remains broken and bent, attach a brace to it and fix it upright as in Diagram 5-2-2. Do this as soon as possible after the snow melts, but before growth starts. It is necessary to remove it after the snow melts the next spring. Since the broken part grows larger before the normal part, if the splint is left on after the next year, the rope used to tie it will dig into the growing trunk and contribute to snow breakage.

(7) Windbreak Fence Repair

When a windbreak fence is damaged, the wind concentrates on that part, and effects are suffered locally. Since damage occurs during the periods when snow accumulates and there are strong winds, go on inspection patrols once the snow thaws and after strong winds to make repairs at an early stage. There is a risk of damage immediately after

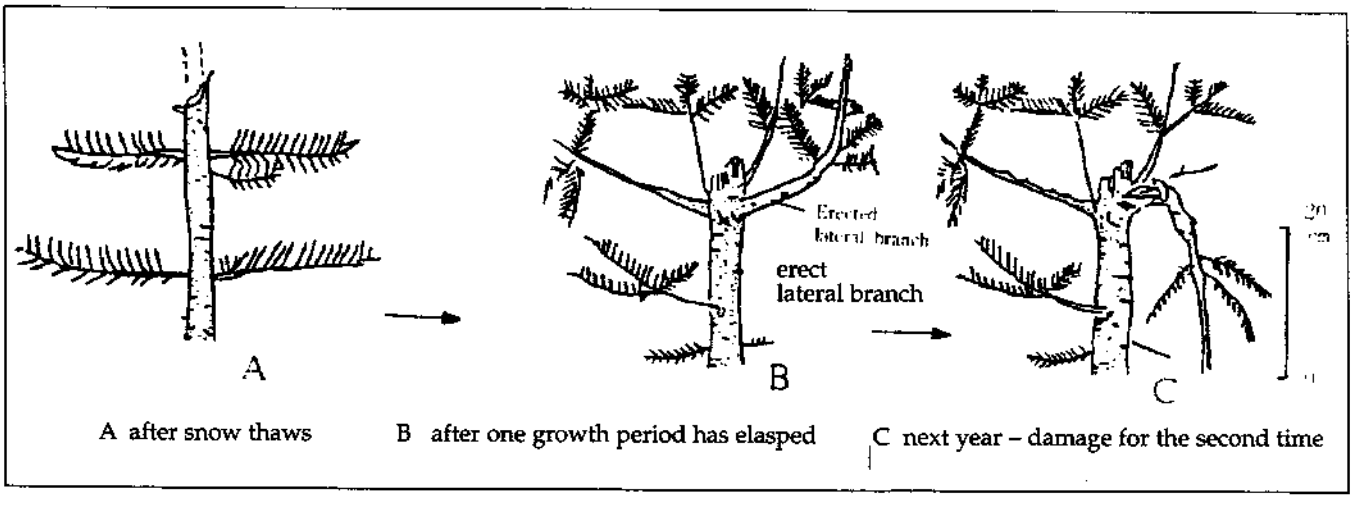


Diagram 5-2-1 Example of trunk breaking and branch base falling[45]

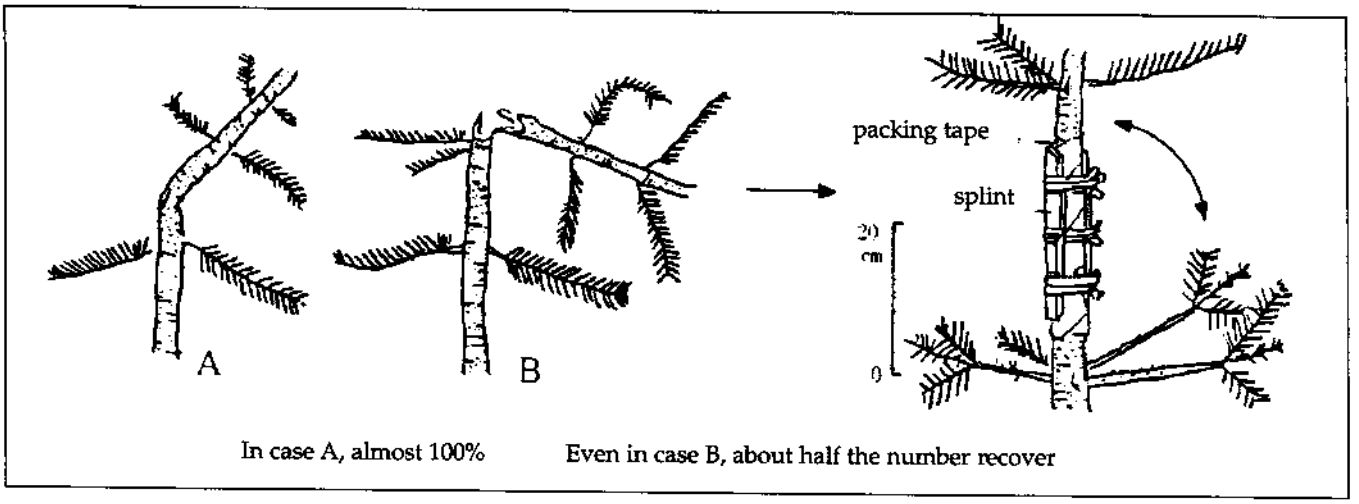


Diagram 5-2-2 Method of caring for a broken trunk[45]

a windbreak fence is set up, and it increases as the years pass.

Plan to remove a windbreak fence about 10 to 15 years after planting. Since the trees will grow rather densely, in addition to weakening the effectiveness of an interior windbreak fence, the work will become more difficult, but do not replace it. Only replace an exterior perimeter windbreak fence.

(8) Density Management

To grow a healthy highway snowbreak forest and maintain its effectiveness, it is necessary to carry out felling - periodic thinning to properly manage its density.

Trees that are subject to felling - periodic thinning are: dead and damaged trees, trees damaged by disease and harmful insects, fallen trees, and weak trees in very dense parts.

Aim to start felling - periodic thinning three to five years after finishing mowing around the bases of the trees. Felling differs depending on the planting density and location conditions and is decided in response to the growing circumstances.

If the canopies of the planted trees grow into each other and the density becomes excessive, so that trees are oppressed, carry out felling-periodic thinning. The method applied depends on the extent to which the tree canopies of a snowbreak forest overlap. Density is defined as the percentage of total tree canopy area per unit of area in the various overlap conditions. The various types of tree canopies are shown in Diagram 5-2-3.

Diagram 5-2-3 indicates that the density of the tree canopy when one part is touching is 79 percent and that when the entire tree canopies are touching, the tree canopy density is 157 percent. In commercial forests or the ordinary forest industry where the production of useful material is aimed for, a high tree canopy density is maintained and the tree canopies are always touching. The result is the promotion of dying branches.

In highway snowbreak forests, when the tree canopy density exceeds 157 percent and the entire tree canopies are touching, the distance of the lowest branches from the ground rapidly increases and the ground blowing snow passes through under the tree canopies. In a snowbreak forest that has a narrow forest zone, like a highway

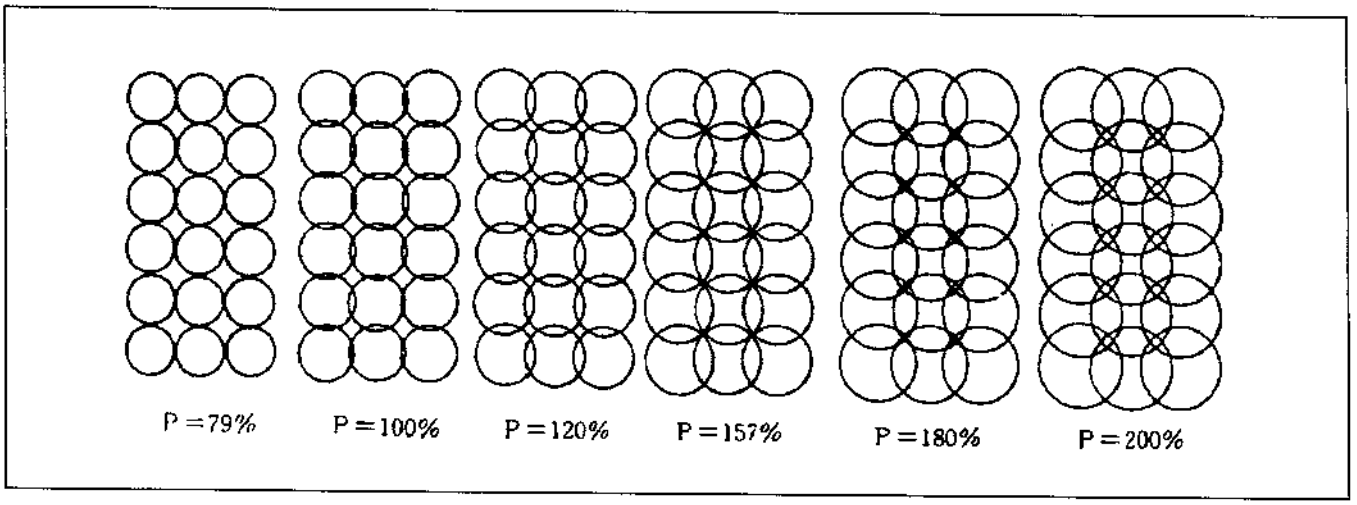


Diagram 5-2-3 Various types of tree canopy density[38]

snowbreak forest, make the tree canopy density 79 percent or less. If the tree canopies do not touch at all, there is a greater danger that the ground blowing snow will pass through among the trees. For this reason, in a highway snowbreak forest always make part of the tree canopies touch, and do not make the tree canopy density high so that the distance of the lowest branches from the ground increases.

In an artificially created disaster prevention forest like a highway snowbreak forest, if the periodic thinning percentage is about 30 percent or less, canopy density should be maintained within a range of about 40 percent between the upper and the lower limits.

For the previously mentioned reasons, in the case of the comparatively narrow highway snowbreak forest, it is suitable to make the lower limit of the tree canopies about 80 percent and the upper limit 40 percent to achieve a total of 120 percent. Before the density of the tree canopies reaches the upper limit of 120 percent, cut them back * to the lower limit of 80 percent.

(9) Harmful Insect and Animal Countermeasures

The healthy nurturing of the highway snowbreak forests aims to keep their blowing snow prevention function in top condition and sufficient care protects against harmful insects and harmful animals.

Insecticides for harmful insects are not very developed so to maintain the growth environment in a performing condition, it is important that the snowbreak forest grow healthily. Strive for early detection of harmful insects and suitable early extermination. For (ezoyachinezumi) mice, try to predict where they will occur, and along with the suitable measure of scattering poison in places where there is a danger of them residing, especially during the young period, carry out appropriate extermination countermeasures.

* Periodic thinning: Cutting that properly adjusts the tree crown to the targeted tree density. Requires maintenance until tree crowns in the entire forest area have grown over and reached the stable period.

1. Harmful Insect Countermeasures

When tree types are selected for highway afforestation, most are ones which withstand harmful insects comparatively well. Since the occurrences of harmful insects in Hokkaido are few compared to Honshu, the issue for highway afforestation is insignificant. However, because advanced damage is difficult to exterminate, there are cases when it causes trouble for the people living alongside the highway; therefore, early detection requires investigative patrols.

For extermination, learn the habits of the harmful insects and carry out measures in a manner that reflects their ecology in the early period of their occurrence. If it is necessary to use insecticide, handle it carefully and strive to use it at the advantageous, timely period. In residential and commercial areas or places where there is automobile and people traffic, select a windless day and a time when they will not be present to conduct the work.

The main harmful insects in Hokkaido are shown in Table 5-2-3.

2. Mice (Ezo swamp rats) Countermeasures

In the forest creation areas of Hokkaido damage to young trees occurs from mice eating them during the winter. Because there is the strong possibility of periodic large outbreaks, the system that predicts their occurrence and the responding control efforts is advanced.

The mowing of the weeds beneath the trees in the initial stage of creation has the effect of making the environment difficult for the mice to live in. Carrying the cut weeds out of the forest so that the mice cannot use them, or piling them up in one place to destroy them are also effective measures. Based on the results of a survey, it is ideal to exterminate with chemicals the number that subsist. If it is not possible to conduct the survey in the snowbreak forest, refer to the results of the mice occurrence prediction in the survey of the Hokkaido Forest Protection Project Promotion Council (Ministry of Agriculture, Forestry and Fisheries, Forest Industry Experimental Station, Hokkaido Branch, in the Protection Department).

The standard for spreading rat poison is shown in Table 5-2-4. According to the Hokkaido Forest Protection Project Promotion Council, there is no worry about secondary damage from rat poison if other animals eat it.

division	number of mice captured per hectare			
	less than 10	11-20	21-40	41 or more
age class to control	I ～ II	I ～ II	I ～ III	I ～ IV
times to control	1	1	1	2

Table 5-2-4 Mice (swamp rats) Ezo control standard

It is best to apply the poison before the snow accumulates. If it is applied twice, spread it at two to three week intervals before the snow accumulates. For a control chemical use phosphorous lead that is evenly spread 2,500 grains per hectare. If the grains are spread one by one (broadcast), put them at an interval of one grain every two meters. If the bag holds five grains, generally, disperse them at intervals of one bag every 4.5 meters.

Tree Type	Harmful Insect Damage	Condition of Occurrence	Control Method
Todo fir Yezo spruce (types of touhil) spruces in Japan	cancer	Bumps appear on branches, trunk. When the affected part encircles a branch or trunk, the part above it withers and dies.	Remove and incinerate the damaged part.
	blight	Turns reddish brown and when the affected part encircles a branch or trunk, the part above it withers and dies.	Remove and incinerate the damaged part.
	Tengusu (Tengu nest) disease	Part of the branches, trunk swell up, many small branches come out like a broom.	Remove and incinerate the damaged part.
	(Todomatsu) fir large aphid	A	
	(todmatsunohadani) fir leaf tick	F	
	(ezomatsu) Japanese spruce kasaabura	A	
	(ezomatsu) Japanese spruce sawfly	I	
	kosujiobi (hamaki = a leaf folder)	G	
	tsugakareha (tsuga = Japanese hemlock kareha - flag, withered leaf)	G	
	oosujikogane (kogane = gold beetle)	D	
	matsunoshinmadarameiga	G	
	nagachakogane	D	
	(karamatsu) Japanese larch kokikui	H	
	(todomatsu) fir kikui	H	
	yatsubakikui	H	
(kuromatsu) Japanese black pine (akamatsu) Japanese red pine	matsukareha (matsu = pine; kareh = flag, withered leaf)	G	
(karamatsu) Japanese larch	senkobyo (early withering disease)	The branches that grow in the current year are affected If they are damaged each year, a brook-like condition occurs.	Remove and incinerate the damaged part. Scatter. cyclohexymide.

Table 5-2-3 The main harmful insects in Hokkaido, the conditions of their occurrence, and methods of control

3. Irrigation

There are key times for watering: the nurturing irrigation after planting and the irrigation during a drought. Hokkaido does not have a rainy season unlike Honshu. From spring to summer, clear days continue. Because there is little rain, it is often necessary to water trees planted in the spring. Roadside trees are, generally, irrigated individually with a watering truck, but, since the area of highway snowbreak forests is large, it is necessary to devise an irrigation method. In addition the method of increasing the ability of the soil to hold water requires spreading straw on the forest floor when planting and later when spreading the weed cuttings around the trees.

Avoid irrigating during the day and do it either early in the morning or in the evening. Give plenty of water so that it will sufficiently penetrate to the roots of the trees and do it every few days until sufficient rainfall occurs. It is only necessary to irrigate during occasions of the above conditions: in the first year of creation (in the case of fall planting, the next year), other than this, except for special cases, it is not necessary. While the trees are young, irrigation has a strong influence on the healthiness of the forest so water as occasion demands.

4. Replacement

After a stable forest has formed and its function gradually decreases, create a forest zone that will continue the original purpose.

When a forest is in a stable condition, it is very dense, and there are few young trees on the forest floor, so the possibility of natural replacement is low. Plan to replace trees through positive action. It is necessary to plan for replacement because often it is not possible to secure another foundation site, therefore felling rows is considered a useful method. Fell rows usually parallel the highway and have the protection of the present forest, which opens the possibility of planting more diverse types of trees. Introducing a more complicated mixture to the forest zone lets the trees that naturally invaded the forest floor remain.

During the management of a highway snowbreak forest in its stable period, execute two types of growth management simultaneously. While carrying out the second generation of growth management synthesize the three maintenance points: 1. speed of tree growth, 2. highway traffic safety, and 3. the blowing snow snowbreak function. When the tall trees reach ten meters, fell about half of the forest and plant new seedlings on the land, which will ensure that the snowbreak function remains from approximately half of the original stand of trees.

The work flow of the important items of the highway snowbreak forest replacement work is shown in Diagram 5-2-4 and the following paragraphs.

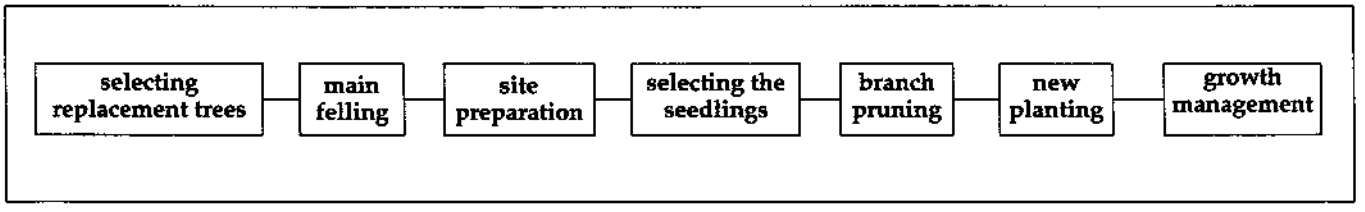


Diagram 5-2-4 Work flow for highway snowbreak forest replacement

(1) Selecting Replacement Trees
Selecting trees for replacement in a highway snowbreak forest that has reached the stable period is a process that ascribes to the previously cited density management. Ordinarily pick the rows of trees located on the downwind side of the highway first then proceed with the main felling of the highway snowbreak forest mechanically by row number. When making the tree selections, avoid creating a gap in the forest floor.

(2) Main Felling
When felling the trees that are in the rows selected for replacement, the tree tops are suspended from cranes and felled in order with chainsaws. Avoid letting a fallen tree obstruct highway traffic or injuring the remaining trees.

(3) Ground Preparation
To plant the seedlings of the next generation on the land where the main felling has occurred, ground work is in order to improve the growth of the seedlings. Remove the root systems of the weed trees, but not the main tree roots, on the ground surface, and depending on the growth conditions of this part of the forest, conduct drainage work or cultivate and provide soil improvement. The management of this second period becomes the simultaneous management of trees of two different ages.

(4) Selecting the Seedlings
Newly planted seedlings, in principle, continue the tree type that was present before the replacement, but change types as necessary. For the growth of an artificial forest, the quality of the seedlings greatly controls the subsequent adult forest. For this reason, it is important to pay sufficient attention to the selection of the seedlings. For details refer to the tree quality standards section.

(5) Branch Cutting
Replacing either narrow or the edges of snowbreak forests requires that new planting is carried out under the trees on the same forest land where the twigs, branches, and leaves of the newly planted seedlings contact or are obstructed with the branches and leaves of the upper layer trees. Cut the branches and leaves of the upper layer trees to reduce obstructions to the growth of the seedlings and promote sunlight.

(6) New Planting
In principle, plant the type of trees that were present before the replacement and at the same interval followed in the original design of the snowbreak forest on the prepared ground where the main felling took place. There are times when the present snowbreak forest growth data is studied resulting in modifications to increase the snowbreak effect.

(7) Growth Management
The main operations of the stable period are the replacement of about half of the main forest zone, the subsequent nurturing of the newly planted seedlings (initial stage of creation), and the management of the main snowbreak forest.

5-3 Annual Plan

In the making of a highway snowbreak forest, it is necessary to plan and execute a rational rearing and cultivating plan in order to raise healthy trees and cause the snowbreak to function correctly. The rearing and cultivating management is divided into an annual plan and a long-term plan. Since the one-year cycle annual plan following the creation of a highway snowbreak forest is particularly important, execute management in compliance with the schedule of the nurturing management annual plan.

Commentary

The highway snowbreak forest nurturing management is divided into the scheduled (periodic) management, which is a patrol inspection carried out yearly in order to grasp all the conditions, and the unscheduled management that accompanies incidentally occurring disasters.

A patrol inspection is carried out in the manner of the afforestation patrol to check snow, melted snow, and mice damage, view the condition of weed growth under the trees or insect outbreaks, observe tree growth conditions including damage from mowing under the trees, determine the necessity for irrigation, to confirm the effectiveness of harmful insect and animal controls, to check the windbreak effectiveness, to perform follow-up surveys at fixed points, and to detect the existence of human damage. See Table 5-3-1. These observations are made in scheduled and unscheduled management patrols.

1. Scheduled Management

Recurring seasonal work includes weeding, fertilizing, cleaning, etc. It is best to clarify the amount of work for each route and make a comprehensive annual contract. Because the various forms of work are related, separate, classify, and organize it from the standpoint of efficiency and forest protection.

2. Unscheduled Management

Unscheduled management is unexpected management work. Some years it is not necessary. It includes dealing with withered and dangerous trees, supplemental planting, repair of windbreak fences, irrigation, extermination of insect pests, root stabilizing, etc. If the growth of a tree has diminished, the factors hindering growth shown in Diagram 5-1-1 on the tree life cycle are helpful.
In the initial period of creation, most of the growth management work takes place over the course of a year (except for the period of accumulated snow), and it is necessary to carry out the annual schedule as shown in Table 5-3-2.

In making the annual plan, it is important to consider the past course of management. For this purpose it is desirable to create a management register following a sample form like that in Table 5-3-3.

5-4 Long-Term Plan

For highway snowbreak forest creation, it is necessary to carry out growth management with a long-term view so that the creation purpose and methods are clearly understood. After the creation of a highway snowbreak forest, compose a long-term plan that includes the initial period, the middle period, and the stable period.

Commentary

(1) Model

A model of the forest condition at each growth management stage (initial period of creation, middle period of creation, and stable period), is shown in Diagram 5-4-1.

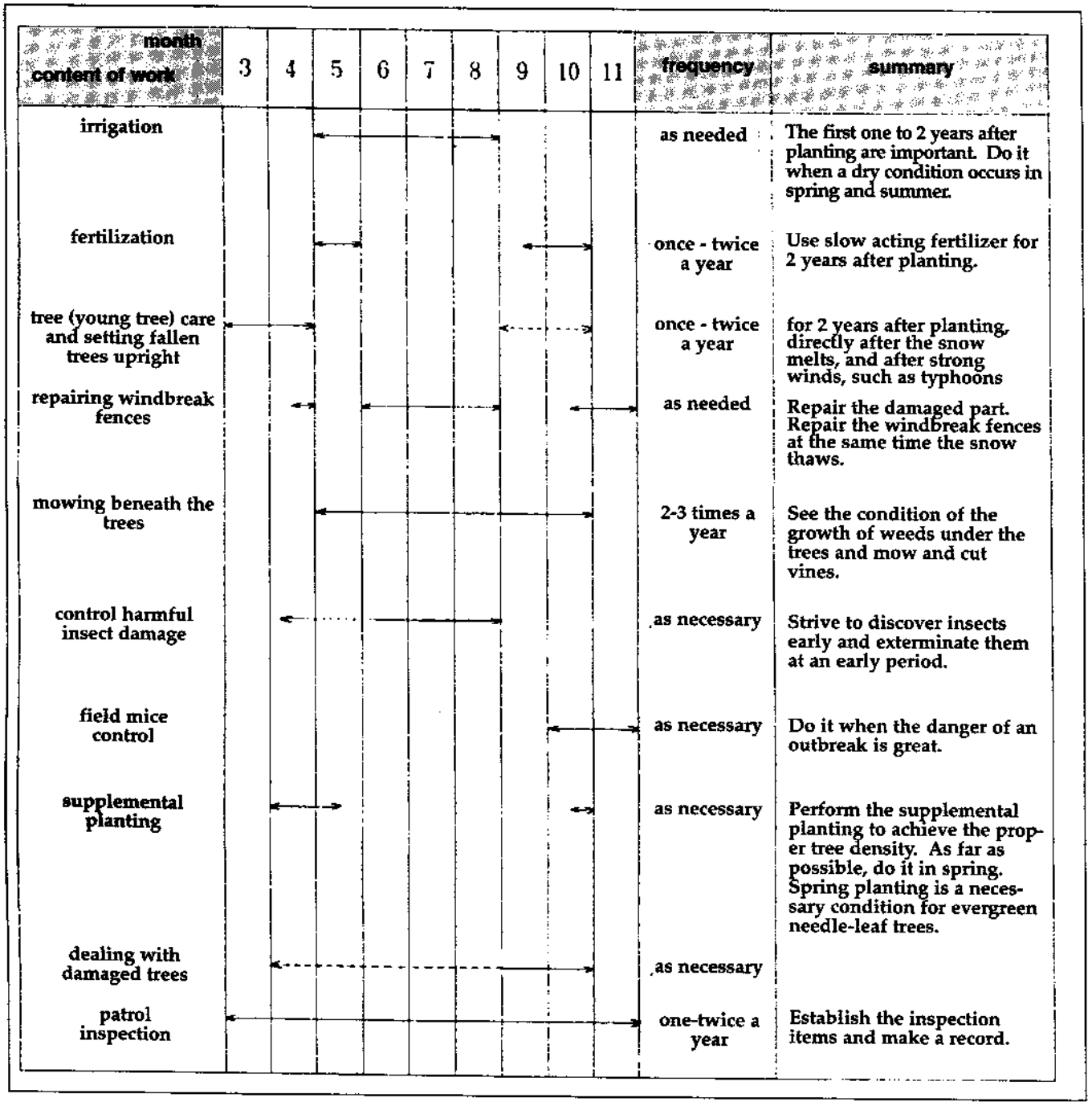
(2) Growth Management in the Initial Period of Creation (One to Three Years)

The period that begins from creation until the roots first take hold and growth is shown is an important stage that determines the success of the adult forest; therefore, intensive growth management is necessary.

At the initial stage of growth management drainage, fertilization, repair of windbreak fences, mowing and vine cutting, harmful

inspection item	spring	summer	fall	winter	remarks
condition of snow damage	○				to determine the necessity of supplemental planting, supplemental works, such as pile driving
drainage, stagnant water condition of the forest ground after the snow melts	○				remove and deal with stagnant water and spring water. to collect data on bad growth
condition of mice damage	○		○		to grasp the existence and scale of the condition of eating damage to the trees, nest building, and movement routes Carry out prediction surveys in the fall and make control plans based on their results; determine the amount of rat poison to spread
condition of growth of weeds under the trees	○	○			to determine the time for mowing
existence of an outbreak of insect damage	○	○			places of outbreaks; scale; type of harmful insects, animals; chemicals to use and number of times to spread them; time period.
tree growth conditions	○	○	○		in the initial period of creation, to check the necessity for the supplemental planting of withered trees and replacement of weak trees to determine the necessity for more fertilization based on an evaluation of the vitality of the trees; to decide the year for felling
injury to trees from mowing	○	○			do not cut within 10 cm of the trunks, or cut by hand to reduce damage.
necessity for irrigation because of dryness		○			to check the tree weakness condition due to dryness and determine whether irrigation is necessary
confirm the effectiveness of harmful insect and animal control			○		to grasp the result of measures to control harmful insects and animals
check windbreak effectiveness				○	go along the highway and inspect the windbreak effectiveness Since wind can blow around bridges, culverts, boxes, surfaces and borders of cut and filled slopes, etc., check and create countermeasures.
fixed-point, follow-up surveys			○		because there is almost no fundamental data concerning the growth of the young trees that will become the basic forest, it is necessary to accumulate unique data at established places in the highway snowbreak forest and carry out follow-up surveys each year.

Table 5-3-1 Highway snowbreak forest patrol inspection list[38]



month / content of work	3	4	5	6	7	8	9	10	11	frequency	summary
irrigation			←	—	—	→				as needed	The first one to 2 years after planting are important. Do it when a dry condition occurs in spring and summer.
fertilization			←	—	—		←	—	→	once - twice a year	Use slow acting fertilizer for 2 years after planting.
tree (young tree) care and setting fallen trees upright	←	—	→				←	—	→	once - twice a year	for 2 years after planting, directly after the snow melts, and after strong winds, such as typhoons
repairing windbreak fences		←	→							as needed	Repair the damaged part. Repair the windbreak fences at the same time the snow thaws.
mowing beneath the trees			←	—	—	—	—	—	→	2-3 times a year	See the condition of the growth of weeds under the trees and mow and cut vines.
control harmful insect damage		←	···	—	—	→				as necessary	Strive to discover insects early and exterminate them at an early period.
field mice control								←	→	as necessary	Do it when the danger of an outbreak is great.
supplemental planting		←	→					←	→	as necessary	Perform the supplemental planting to achieve the proper tree density. As far as possible, do it in spring. Spring planting is a necessary condition for evergreen needle-leaf trees.
dealing with damaged trees		←	···	···	···	···	···	···	→	as necessary	
patrol inspection	←	—	—	—	—	—	—	—	→	one-twice a year	Establish the inspection items and make a record.

Table 5-3-2 Annual growth management work schedule of the initial period of creation[24]

name of road		place or section	Kp- Kp road going towards a main city road going away from a main city
name of maintenance work		year, month, day of work	
content of the work executed and photographs before and after doing the work			

Table 5-3-3 Snowbreak forest management register (sample form)

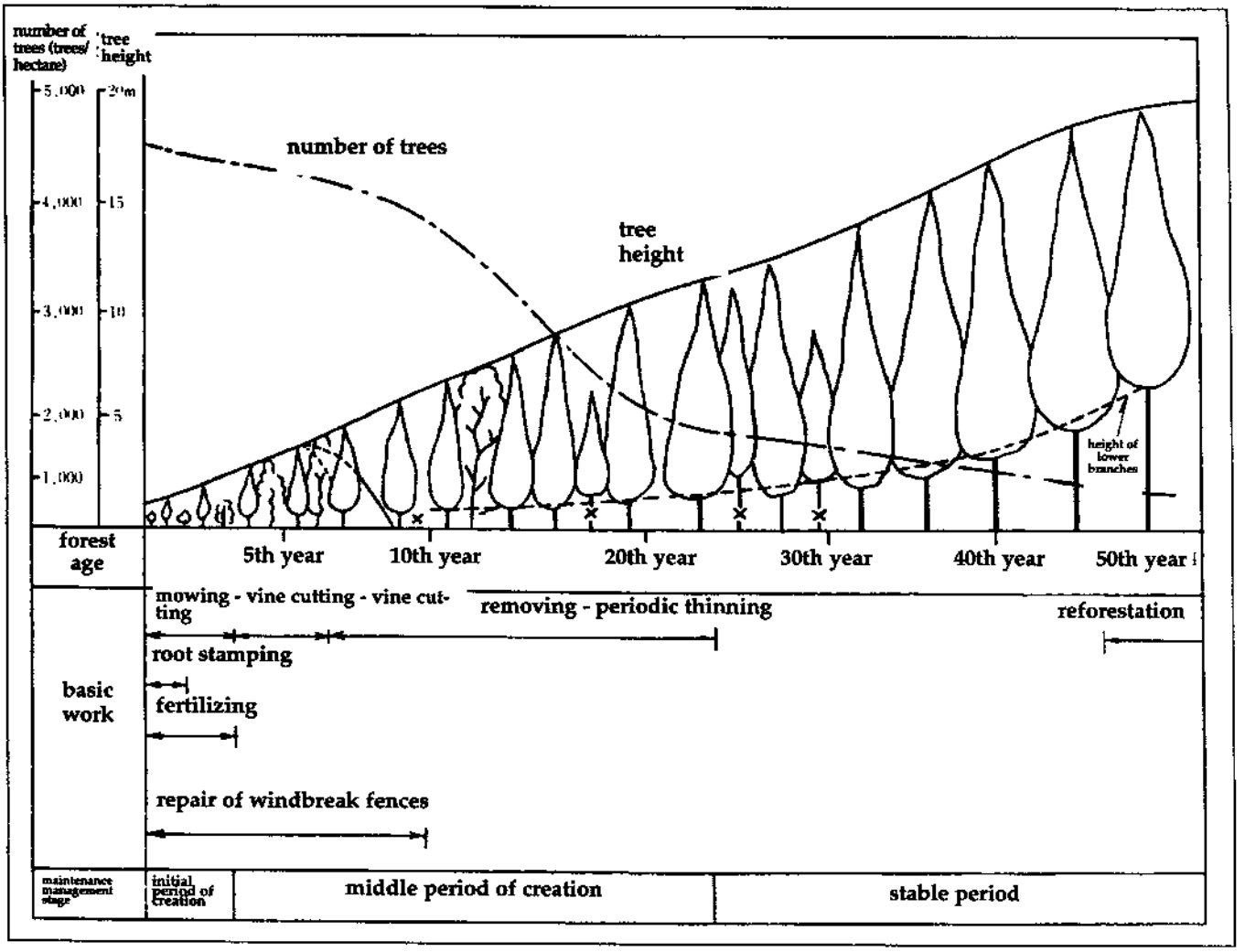


Diagram 5-4-1 Stages of forest growth management and forest condition model (example)[36]

insect control, mice control, and supplemental planting are extremely important requiring the initiation of an annual detailed schedule.

This stage generally lasts until the third year after creation, but if the planned creation site is located in a coastal area, it lasts until the fifth year.

(3) Growth Management in the Middle Period of Creation (Four Years and Beyond)

The middle period of creation begins when the planted trees first take root and show growth and lasts until they begin to form a dense forest The purpose of the maintenance-management of this period is to cause the trees to become quickly ecologically stable or to strengthen their ability to resist damage, which requires the protection of nurturing and transition management. Growth management during this period includes fertilization, repair of windbreak fences, vine cutting, control of harmful insects, supplemental planting, tree removal, and periodic thinning.

(4) Growth Management in the Stable Period

In the stable period, after the ecologically stable forest has been formed, vine cutting, control of harmful insects, supplemental

planting, etc., can be mentioned as growth management items which are suitably carried out while observing the forest condition.

In this period, since the forest trees gradually lose strength, its effectiveness decreases. Replacement work and tree growth management restore vitality and purpose.

5-5 Making Use of the Forest Management Plan

In applying forest growth management based on a long-term plan and an annual plan, it is necessary to establish a system to execute the maintenance-management work and the patrol inspections.

Commentary

(1) Maintenance-Management Work

The classifications of the types of maintenance-management work and their content are shown in Table 5-5-1.

(2) Patrol Inspection

The patrol inspection is the physical entering of the highway snowbreak forest to examine the forest ground and trees and determine the present condition, discover changed conditions, and to predict future changes all with a purpose of preventing a reduction in the snowbreak performance.

The inspection work entails scheduled and unscheduled patrols, the maintenance of inspection records, and the recordings in highway snowbreak forest registers.

The scheduled inspections determine whether or not there is something wrong with the trees and supplemental works, if they received damage before and after the occurrence of large changes within the year, and the general growth conditions of the trees. The results of patrols are reflected in emergency restoration work, surveys, and the annual plan for the next year. The scheduled inspection, as shown in Table 5-5-2, is carried out when the accumulated snow melts in spring, during summer and fall, and in winter when the snow is blowing.

Conduct special inspections for sudden disasters and phenomena and as necessary execute (special) surveys for planning countermeasure purposes.

(3) Surveys

1. Forest Condition Surveys

Conduct surveys on the trees when they reach a height of three to five meters as they begin to exhibit the snowbreak function. Survey items cover the important factors in tree zone composition: tree height, tree diameter, height of the lowest branches from the ground, tree stand density, wind speed changes in front of and behind the forest zone, snow hill formation, amount of snowdrift, and visibility.

2. Tree Stand Survey

The management of the forest zone density includes removal and felling, periodic thinning, main felling, and the decisions determining when the trees will be felled. Tree removal, periodic thinning and replacement require the judgment of an expert. Survey items are tree weakness, the position of oppressed trees, and trees with insect and animal damage whose vitality has dissipated and reduced tree crown density.

Work Classification	Work Content
general management	Grasp the entire maintenance-management of a highway snowbreak forest and carry out the work that is necessary to make all projects proceed smoothly. The specific content includes grasping the snowbreak function, understanding the forest condition, executing a budget, making additions, conducting production management, permit approval, data management, etc.
plan creation	Consider a course of growth management work and carry out the creation and revision of a long-term plan and an annual plan. In the year before it is implemented, outline the work plan for the next year.
survey	Carry out forest condition surveys to observe the snowbreak function and tree surveys to manage the density. Carry out other surveys, as necessary, and inquire into the causes of unusual weather or conditions.
inspection	Enter the forest and directly patrol and inspect such things as unusual conditions of the forest ground and trees and the degree of growth. Do the patrol inspection in the spring (snow melt period), summer, fall, and winter (when the wind blows) and reflect these results in the growth management work. Carry out suitable incidental inspections with respect to sudden disasters and phenomena.
operation management	Carry out maintenance management work; quality management in construction; process management, etc.
work - construction	Execute the work and construction to preserve the tree growth and forest ground, etc., of the highway snowbreak forest, based on the annual plan.

Table 5-5-1 Maintenance-management work of highway snowbreak forests

Comprehensive judgments regarding the trees to be felled are reached once all the factors are weighed.

3. Special Survey

Special surveys are those carried out to plan countermeasures when a highway snowbreak forest is damaged during sudden weather disasters (concentrated heavy rain, wind, drought, snow, etc.) and other phenomenon, such as harmful insect or harmful animal damage, fire, or collision. Survey items cover cause, place, and scale of damage, prospects for recovery, etc., and emergency and rehabilitation countermeasures that will return the forest to its original function.

inspection item	spring	summer	fall	winter	remarks
snow damage condition	○				observe broken trunk, broken branch, fallen tree on other damage and determine the necessity for supplemental planting, snow damage repairs, or other countermeasures
drainage, stagnant water condition of the forest ground after the snow melts	○				grasp the places, etc., where there is stagnant water and take countermeasures
condition of mice damage	○				grasp the condition of eating damage to the tree trunks, nest building, whether or not movement routes exist, and their scale
condition of growth of weeds beneath the trees	○	○			determine when to mow
whether or not there is an outbreak of harmful insects	○	○			decide the place of the outbreak, scale, type, and the number of times to spread chemicals, and when to use them
tree growth conditions	○	○	○		decide the need for supplementary fertilization of young trees in the spring, supplemental planting, the year for thinning, etc.
damage to trees from mowing		○			the damaged part and degree of damage and protection measures
necessity for irrigation due to dryness		○			condition of weakness due to dryness
confirm effect of harmful disease from insects and animals and determine how to control			○		grasp the effect of control measures
determine the necessity for wintering measures			○		
check snowbreak effectiveness				○	travel on main road and inspect snowbreak effectiveness
fixed-point, follow-up survey			○		number sample trees and track tree height, tree crowns, height of lowest branches from ground, withering damage, etc. Do it every year in the initial stage of creation and subsequently as needed.

Table 5-5-2 Scheduled inspection items and process

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