CHAPTER 6

FOREST FIRE SURVEY

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6.1 Outline

The forest and grassland fire which occurred in April through June, 1996 spread over Mongolia's entire forest land with damage extending to Selenge Aimak (i.e. the Study Area of some 4.28 million ha), the Intensive Area (some 160,000 ha) and the Model Areas (total of some 30,000 ha). According to the estimate of the Ministry of Nature and the Environment, the damaged forest area totalled 2.36 million ha in the entire Mongolia.

During the field survey conducted in June, 1996, the outline of the fire damaged areas was established based on the field investigation and interviews at the Forestry Office of Selenge Aimak (see Fig. 40). The findings suggest that some 60% of the Intensive Area which is directly related to the forest resources management plan was affected and that damage was caused to standing trees in some 25% of the Intensive Area. It was often observed that the roads worked as firebreaks.

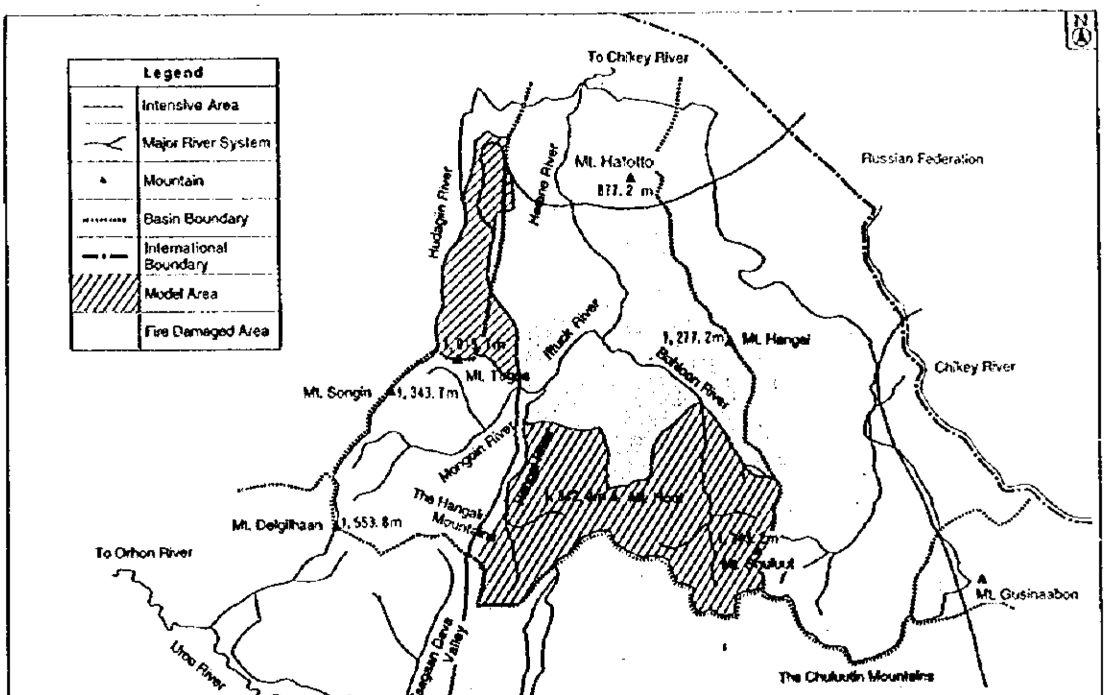


Fig. 40 Outline of Damage in Intensive Area

As it was judged that the effects of the forest and grassland fire should be incorporated in the formulation process of the Forest Resources Management Plan, related organizations in Japan and Mongolia held a consultation meeting in July, 1996 and agreed to conduct an additional survey for the forest fire survey (see Appendix 16: Minutes on Extension of Forest Fire Survey).

This additional survey would succeed the present forest fire survey which was due to be completed in fiscal 1996 and the extended forest fire survey would feature the following activities regarding the post-fire state of forests in the Intensive Area and Model Areas.

- Aerial photography of the fire damaged areas in 1996
- Preparation of post-fire land use and vegetation map
- Preparation of post-fire forest type map
- Preparation of post-fire forest inventory book

6.2 Survey on Intensive Area

6.2.1 Aerial Photography of Fire Damaged Areas in 1996

In order to establish an accurate picture of the fire damaged areas in 1996, aerial photography covering the said areas in the Intensive Study Area was conducted between June 1st and July 5th, 1997.

(1) Aircraft

The AN-30 used for the aerial photography in 1994 was not in service and the situation was compounded by the fact that no aircraft with similar capability was available for lease in Mongolia and neighbouring countries. An AN-2, the only aircraft available for aerial photography in Mongolia was, therefore, used even though it was not ideal for high altitude, high precision aerial photography.

(2) Camera

A Zeiss Jena MRB camera with a focal length of 8.8 cm which was available in Mongolia was used.

(3) Film : panchromatic black and white

(4) Photo scale : approximately 1:20,000

(5) Flight altitude : average of 2,950 m above sea level

(6) Subject area : 1,100 km²

(7) Flight courses : 19 courses (see Fig. 41)

(8) Overlap and Sidelap

The target overlap and sidelap for the aerial photographs were 60% and 50% respectively. The slow speed and vulnerable body structure of the AN-2, a biplane with canvas wings, to wind, coupled with the improper functioning of the camera made it necessary to give the priority of the photography to covering the entire subject area rather than keeping the target overlaps and sidelaps. Consequently, no overlap was produced in the case of some photographs.

(9) Airfield

It was initially assumed that the airfield would be at Sukhbaatar. However, due to security concerns at the Sukhbaatar airfield, it was decided to change to the Darhan airfield which offered better facilities. Darhan airfield was used for a while following the completed preparation of fuel supply and repair of the aerial camera which was found troublesome at the beginning. In addition to the subsequent inconsistent performance of the camera (improper functioning of the shutter and film magazine and non-exposure of instrumental data due to unstable voltage), there was also concern in regard to the safety of the aircraft itself. While emergency repairs were made to keep the aircraft flying from the Darhan airfield, it was very clear that these repairs were simply stop-gap measures. It was finally necessary to relocate the aircraft to Ulaanbaatar for better repairs and the aerial photography flying missions were conducted from Ulaanbaatar thereafter.

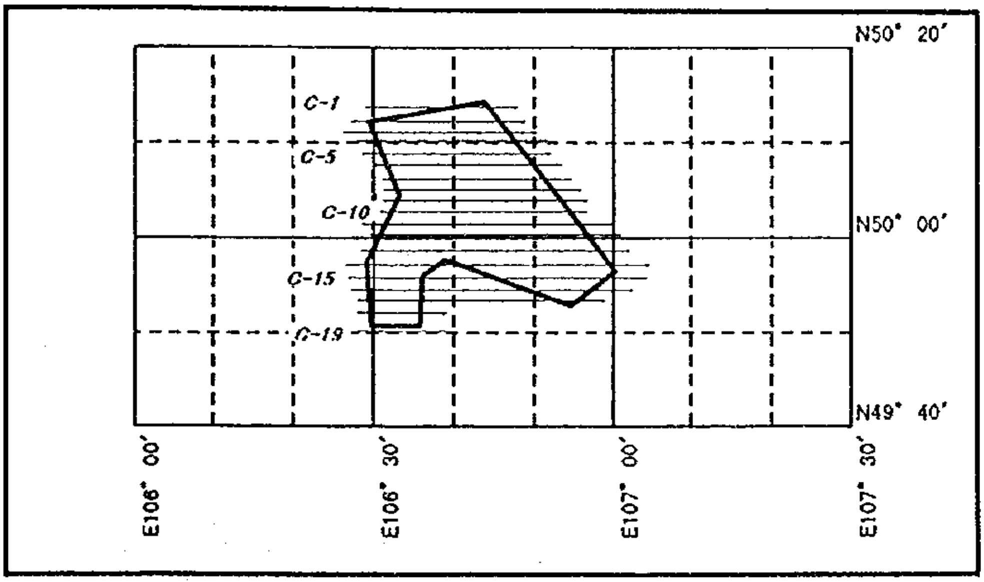


Fig. 41 Results of 1997 Aerial Photography

6.2.2 Land Use and Vegetation Survey

The survey was conducted on the fire damaged areas in 1996 in the Intensive Area by means of interpreting the aerial photographs taken in 1997 and verifying the interpretation results through ground investigation and land use and vegetation maps after 1996's fire (scale: 1/50,000) were prepared.

(1) Interpretation Categories

For the preparation of the post-fire land use and vegetation maps, the newly taken aerial photographs were interpreted to identify those areas where the upper-story trees were damaged by the fire in 1996 as fire damaged forests in 1996 and the pre-fire land use and vegetation maps were accordingly modified.

Damaged trees which had lost leaves or which were dead due to the fire showed up as white or whitish on the aerial photographs and the survival ratio was determined as the ratio of surviving trees, which excluded the above-mentioned damaged trees, in the total stand area. Those stands with a survival ratio of 30% or less were classified as fire damaged areas.

The classification (interpretation) categories used for the post-fire land use and vegetation map are listed in Table 77. The symbol "UN" is used here to indicate the new fire-damaged forests in 1996.

Table 77 Classification Categories and Symbols Used for Post-Fire Land Use and Vegetation Map

Primary Category	Secondary Category	Symbol
Forest	Pine Forest	NP
	Larch Forest	NL
	Pine/Larch Forest	N
	Planted Area	P
	Broad-Leaved Forest	L
	Mixed Forest	M
	Unstocked Land	U
	Fire Damaged Area	UF
	Logged-Over Land	UL
	Shrub Land	S
	New Fire-Damaged Forest in 1996	UN
Non-Forest	Grassland	G
	Farmland	F
	Settlement	ST
	Rocky Land	R

(2) Comparison of Pre- and Post-Fire Conditions

The changes of the land use and vegetation in terms of area before and after the fire in 1996 are shown in Table 78. In the Intensive Area, pine forests are believed to have been the main victims of the fire in 1996. The current state of damage is clearly worse than the situation in 1996 when the interview survey found that upper-story trees damaged by previous fires were found in 25% of the Intensive Area.

Table 78 Changes in Pre- and Post-Fire Area Composition on Land Use and Vegetation Map

Primary Category	Secondary Category	Area Before Fire (A) (ha)	Area After Fire (B) (ha)	Decrease (A)-(B) (ha)	Decrease Rate {(A)-(B)} /(A) (%)
Forest	Pine Forest	33,159	19,143	14,016	42%
	Larch Forest	3,199	2,536	663	21%
	Pine/Larch Forest	2,766	2,724	42	2%
	Planted Forest	837	1,212	-375	-45%
	Broad-Leaved Forest	30,149	23,931	6,218	21%
	Mixed Forest	23,700	19,361	4,339	18%
	Unstocked Land	8,817	2,841	5,976	68%
	Fire-Damaged Forest	5,143	431	4,712	92%
	Logged-Over Land	3,588	906	2,682	75%
	Shrub Land	8,791	8,039	752	9%
	New Fire-Damaged Forest Suffered in 1996	0	39,025	-39,025	
	Subtotal of Forest Area	120,149	120,149	0	0%
Non-Forest	Grassland	31,048	31,048	0	0%
	Farm Land	4,844	4,844	0	0%
	Settlement	115	115	0	0%
	Rocky Land	4,146	4,146	0	0%
	Subtotal of Non-Forest Area	40,153	40,153	0	0%
	Total	160,302	160,302	0	0%

6.2.3 Meteorological Survey

Meteorological data for the period from the initial outbreak of the forest fire to it being extinguished in 1996 was collected and the relationship between the forest fire and the weather was analysed.

Firstly, monthly rainfall and snow depth data was analysed to compare the 1996 weather conditions with those in the past. In addition, daily data on humidity, wind velocity and fire likelihood index, etc. from 10 days before the outbreak was analysed to establish the chain of meteorological events leading to and during the forest fire. This data was obtained from the Sukhbaatar Aimak Meteorological Research Center which is the nearest meteorological observation station to the Intensive Area as well as the Model Areas.

(1) Comparison of Monthly Rainfall Data for 1996

The monthly rainfall data from 1989 to 1996 suggests that the months with much rainfall are June through September (see Fig. 42). The actual rainfall level in April and May, 1996 appear to be slightly lower than expected when compared with the performance of other months in 1996.

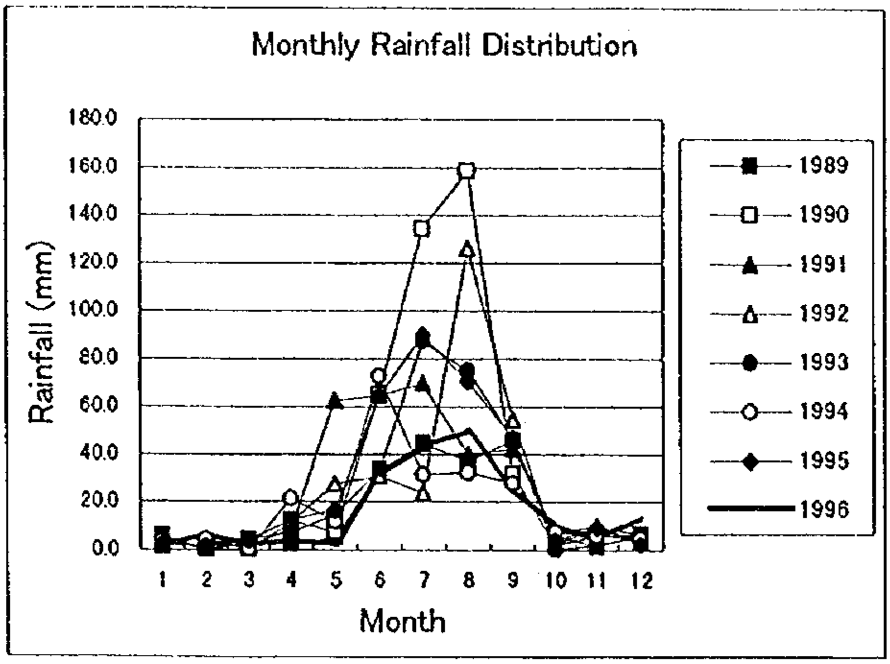
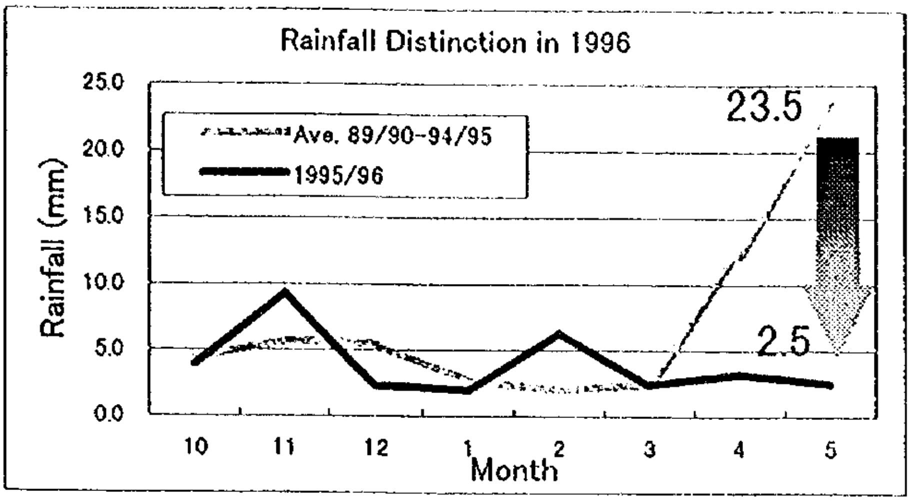


Fig. 42 Comparison of Monthly Rainfall in Sukhbaatar (1989 - 1996)

The forest fire hazard periods in Mongolia are generally considered to be March through June and September through November. The fire which began in May, 1996 was in the former period.

Rain and snow are environmental factors which act to suppress forest fires. As the effect of rain on a fire is said to last for only 2 - 3 days, the timing of rain is crucial for the fire suppression function. Following the outbreak of a forest fire, rain can be considered to be an environmental factor which directly contributes to extinguishing the fire. In the case of snow, in addition to its fire suppression effect as in the case of rain, laying snow has the additional advantage of water storage. Compared to rain, the amount of snowfall prior to a fire may well have a greater effect on the outbreak of a forest fire. Fig. 43 compares the monthly average snowfall values between 1989 and 1995 and those in 1995/96 for the period from October when it usually starts to snow to May, a likely month for the outbreak of forest fires.



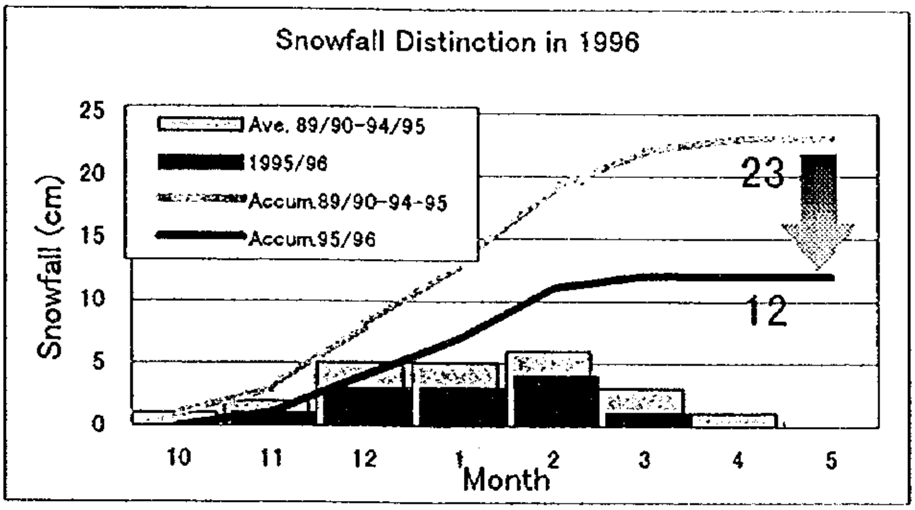


Fig. 43 Monthly Rainfall and Snow Depth Changes in the Forest Fire Hazardous Period at Sukhbaatar

According to Fig. 43, the level of rainfall in April and May, 1996 of approximately 2.5 mm, almost one-tenth of an average year, was drastically low.

The average temperature at Sukhbaatar is below 0℃ from November to March, during which time snow replaces rain and accumulates. Comparison of the simply accumulated snowfall figure after October shows that the figure for March, 1996 was some 60% of an average year (12 mm compared to 23 mm), implying less snowfall than usual in the winter of 1995/96. It is, therefore, inferred that the low snowfall level followed by an exceptionally low rainfall level in April and May, 1996 made the ground surface, including the humus layer, extremely dry in and around the Intensive Area.

Although the Sukhbaatar Aimak Meteorological Research Center and other organizations should have been aware of this low snowfall level upto May, 1996 by March, 1996, there is no record of their evaluating the monthly precipitation figures and issuing a forest fire warning. The same is true in regard to the exceptionally low rainfall in April and May.

(2) Comparison of Humidity and Wind Velocity Data Before and After Outbreak of Forest Fire in 1996

Among the meteorological factors possibly affecting the outbreak and duration of a forest fire, humidity and wind are particularly important short-term factors. Humidity and fire hazard are generally considered to have the relationship shown in Table 79 (Araki, "Forest Meteorology", 1995).

Table 79 Humidity and Fire Hazard

Humidity Level	Fire Hazard
Less than 60%	Fire is likely to occur
60% - 50%	Only easily combustible objects are likely to burn and a fire is slow to spread
50% - 40%	A fire sometimes becomes fast to spread
40% - 30%	A fire is fast to spread, causing a dangerous situation
Less than 30%	It is difficult to extinguish a fire

The fire hazard index used in Mongolia and effective humidity can be used as indices to indicate the relationship between humidity and fire hazard.

The effective humidity is a kind of average humidity, combining long-term and short-term humidity levels. When the effective humidity is 60% or less, the prospect of the occurrence of a fire increases. When the effective humidity drops below the 50% level, there is a real danger of a conflagration (Araki, "Forest Meteorology", 1995). The effective humidity can be calculated by the equation below and official fire warnings informing the public of the fire hazard level are based on the respective effective humidities calculated from the relative humidities of the previous two days.

$$H_e = (1 - r) \cdot (H_0 + rH_1 + r^2H_2 + r^3H_3)$$

Where, He : effective humidity (%)

r : factor (normally 0.7)

H : average daily humidity (H_0: day in question, H_1: one day before, H_2: two days before)

Most fires in the Study Area are surface fires fuelled by dry grass and their heat occasionally causes a crown fire. As the ground fire hazard is believed to be significantly affected by the short-term humidity level, the use of factor r of 0.7 appears more appropriate for a ground fire than for other types of fires. In the case of Hokkaido in Japan for example, a fire warning is issued by the Sapporo District Meteorological Observatory based on the following conditions.

- Effective humidity : 60% or lower
- Minimum humidity : 30% or lower
- Ground wind velocity : 12 m/s or more

The forest fire hazard in Mongolia is judged based on the fire hazard index, calculated by the temperature and dew-point temperature. This fire hazard index is calculated using the following equation established by W. G. Nestirov of the former Soviet Union.

$$\gamma = \Sigma (t - \tau) \cdot t$$

Where, γ : fire hazard index

t : temperature at 14:00 (°C)

τ : dew-point temperature (°C)

This fire hazard index is the cumulative value for the period in which daily rainfall of not more than 2 mm continues and the rainfall observed the previous day. In other words, it is presupposed that an accumulated fire hazard is rendered nil when daily rainfall exceeding 2 mm is observed.

The observed value is classified as a specific fire hazard class depending on its numerical value. In the case of Class III and Class IV, the Sukhbaatar Aimak Meteorological Research Center issues a fire warning to the Selenge Aimak Disaster Committee and other related organizations.

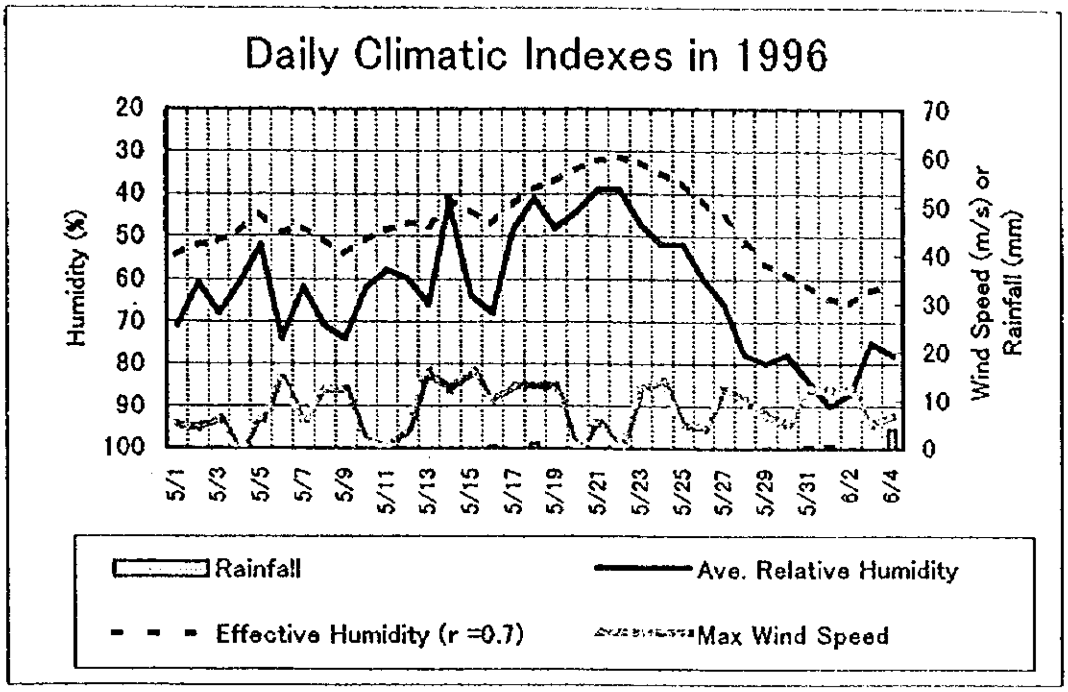
Table 80 Fire Hazard Index Ranges

Fire Hazard Class	Observation Period and Fire Hazard Index Range	
	Spring/Summer (March - June)	Summer/Autumn (September - November)
I	0 ~ 150	0 ~ 400
II	151 ~ 1,250	401 ~ 1,500
III	1,251 ~ 3,000	1,501 ~ 8,000
IV	3,001 ~	8,001 ~

An increased wind velocity due to a decline of the humidity after the initial outbreak of a fire can cause spot fires and an increase of the fire spreading speed, accelerating the expansion of the overall damage. The spreading speed of fire is some 4 - 7 km/hr in the case of a ground fire. The speed of a forest fire involving a crown fire is generally slower than the speed of a ground fire and is often 2 - 4 km/hr. The increase of the fire spreading speed is in proportion to the square of the wind velocity and the reference speed at a wind velocity of 10 m/s is believed to be 3 - 5 km/hr (Araki, "Forest Meteorology", 1995).

An updraft appears in the place where a fire breaks out due to the heat of the fire. This upward movement of air causes a convergence of the air current from the surrounding area on the ground and a descending of strong wind high in the sky, both of which result in an intensification of wind on the ground to further flare the fire. Moreover, the sparks of a fire travel a long distance on the updraft, causing spot fires. A conflagration can produce cumuli, cumulonimbi and a strong wind called a fire whirlwind (Asakura, et. al., "Weather Handbook", 1995). The fire records for 1996 do not mention these meteorological phenomena caused by the force of the fire.

A further comparison was conducted on the above-mentioned daily data and indices for the period around May 14th, the day when the fire broke out. Data for the period from May 1st to June 4th in 1996 and 1997 is given in Fig. 44 and Fig. 45 respectively (see Appendix 17 for the original data).



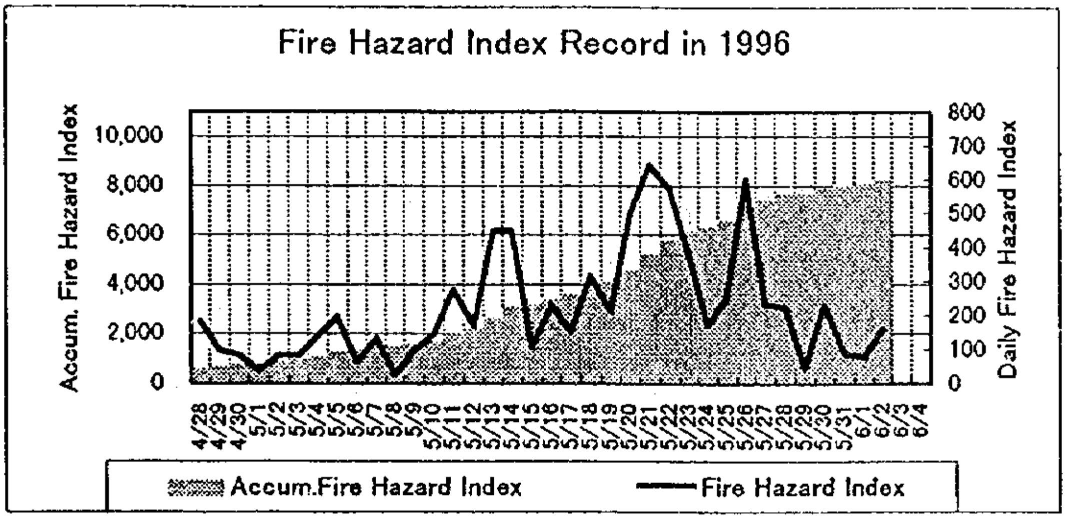
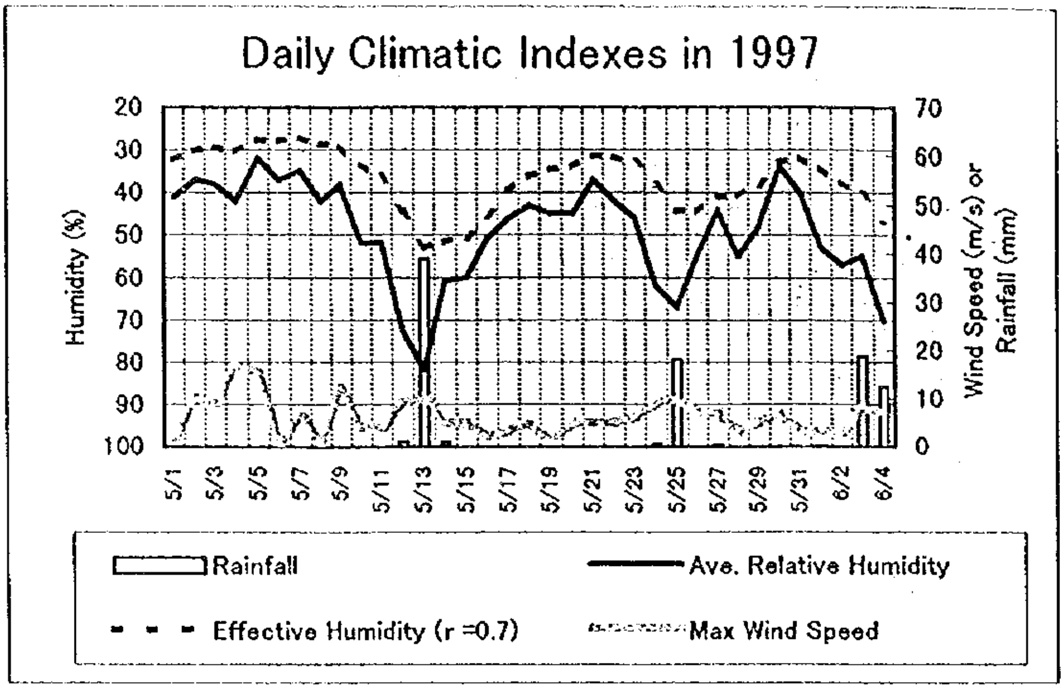


Fig. 44 State of Meteorological Factors and Fire Hazard Index Before and After the Forest Fire in 1996



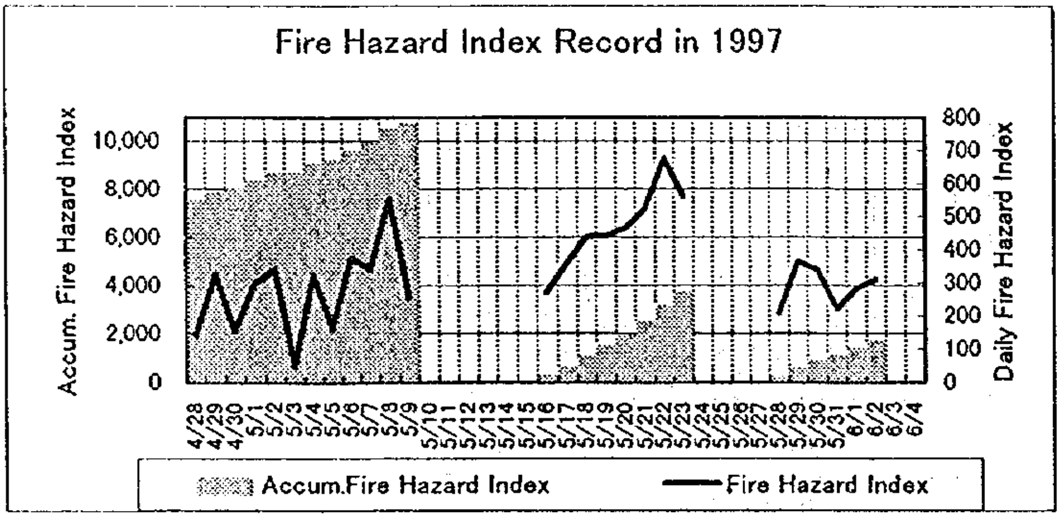


Fig. 45 State of Meteorological Factors and Fire Hazard Index for Same Period in 1997 and Period Around the Fire in 1997

The comparison results for each factor are summarised in Table 81.

Table 81 Summary of Daily Data Comparison Between May, 1996 and May, 1997

Factor for Comparison	Characteristics of 1996	Characteristics of 1997
Rainfall	• No daily rainfall exceeding 2 mm was recorded for more than 30 days	• Daily rainfall of more than 2 mm was recorded with an interval of approximately 10 days
Humidity	• While the number of days with relative humidity of 50% or lower was only eight days, this dry condition lasted for seven consecutive days with a lowest level of 39% • Effective humidity of 50% or lower continuously lasted for 17 days from May 11th with a lowest level of 25% being recorded	• There was a total of 23 days when the relative humidity was 50% or lower. Although interrupted by rain, each dry spell lasted for at least seven days with a lowest level of 32%. The rain increased the relative humidity each time • There was a total of 32 days when the effective humidity was 50% or lower and the longest spell was 19 days. The lowest recorded level was 16%
Wind	• From May 13th to 19th, the maximum wind velocity consecutively exceeded 10 m/s • The wind direction was mainly N to WNW	• Maximum wind velocity exceeding 10 m/s did not last for more than two days • The wind direction was mainly NW to N
Fire Hazard Index	• The Class III and Class IV fire hazard indices were reached on May 5th and May 14th respectively with a maximum index value of nearly 8,000	• Class IV was reached before April 28th with a maximum index value of more than 10,000

(3) Relationship Between Meteorological Conditions and Fire

Analysis of the rainfall and humidity changes before and after the outbreak of the forest fire using monthly and daily meteorological data reveals that the exceptionally dry conditions in 1996 led to the large-scale forest fire.

Noticeable falls of the monthly rainfall and snow cover thickness data are considered to be important indicators for evaluation of the data for preceding months in the long-term forecasting of forest fire. To be more precise, the exceptional fall of the snow cover thickness in March, followed by an exceptionally low rainfall level, indicates an alarmingly high hazard for a large-scale forest fire.

Comparison of the daily data between 1996 and 1997 finds that while a low humidity level was more frequently observed in 1997 than in 1996, the intermittent rain in 1997 is assumed to have suppressed the outbreak and spread of fire. In addition to the dry conditions in 1996, the most prominent characteristic in 1996 was the continuance of a strong wind of more than 10 m/s for one week. This strong wind appears to have been decisive in the expansion of the forest fire in 1996.

The forest fire hazard in Mongolia is judged on the basis of the fire hazard index of which humidity is a paramount factor. When considering the scale of a forest fire, however, the wind velocity and wind direction should be effectively used as vital information to examine desirable measures to combat the forest fire.

6.2.4 Survey on Administrative Response

(1) Administrative Response to Fires

1) Central Government

The response of the Government of Mongolia to a major natural disaster is organized through the establishment of disaster committees at the central as well as aimak levels. These central committees maintain close linkage and prepare measures to combat the disaster while the aimak level committees instruct concrete measures to the district offices. These committees deal not only with fires but also with flooding, earthquakes and the dropping of a nuclear bomb.

The central government decides the necessary measures based on information from the district and aimak offices.

As the forest fire in 1996 was nationwide, it was classified as a natural disaster. Consequently, the Law on Measures to Deal with Forest and Grassland Fires [No. 116 (1334), enforced on May 28th, 1996] was enacted as part of the relief measures. This Law consists of the following items.

① Authority of the central government
② Authority of central government organizations
③ Authority of local administrative organizations
④ Obligations of individual persons, companies and organizations
⑤ Causes of fire, investigation of persons responsible for fires and estimation of damage

2) Selenge Aimak

The administrative response to forest fires by the government of Selenge Aimak, i.e. the Study Area, is described in this section. The government of Selenge Aimak established a disaster committee for the first time in 1992. In fiscal 1996, a disaster committee was established in March with 18 members. This committee is chaired by the governor and its members include representatives of the military and administrative organizations, owners of large private companies and the chief customs officer. Although the disaster committee discusses measures to combat fires, the gathering of information and decisions on actual measures are left to the fire committee of the aimak government.

In Selenge Aimak, a fire committee was first established in 1992 and, in fiscal 1996, the committee was established on October 25th, 1995 with 10 members. It is chaired by a forestry officer of the Department of Agriculture, Stock Raising and Natural Protection and its members consist of the head of the Forestry Office, representatives of the military and the Meteorological Research Center and both administrative and legal experts. The primary responsibilities of this fire committee are to obtain information on fires and to issue instructions on fire-fighting measures.

Information is obtained through communication with the district offices and ground surveys using vehicles. An aircraft is also dispatched from Ulaanbaatar for aerial observation and is operated during the forest fire hazard periods, i.e. from March 15th to June 15th and from September 15th to November 15th, with a view to preventing the outbreak of fire and observing the fire situation after an outbreak. At the time of an actual fire, a parachute team may board the aircraft for fire-fighting activities.

Instructions on fire-fighting measures are issued by the aimak fire committee to the district level fire committees. The contents of such instructions include information on the fire, evacuation orders and/or personnel assignment for fire-fighting activities. These contents are examined and finalised by the aimak fire committee disregarding district boundaries. For the fire in 1996, the Forestry Office of Selenge Aimak acted as the secretariat to coordinate the fire-fighting activities.

3) Altanbulag District

The following administrative response to forest fires is generally made in the Altanbulag District which accounts for some 80% of the Intensive Area.

In principle, the district office follows the instructions of the aimak fire committee and is engaged in its own fire-fighting activities using information provided by the military. The funding for these activities is appropriated by the aimak government. In this sense, the district office acts as an executing agency for fire-fighting activities. The main expenditure items of this funding are ① cost of food provided for people engaged in fire-fighting activities, ② fuel cost of equipment and ③ communication cost.

Damage due to the forest fire in 1996 occurred in the following two locations in the Altanbulag District.

- Around Shamalfundi (fire broke out on May 12th)
- Near the Russian border at the northern end of the Altanbulag District (fire broke out on May 14th in Russia and extended into Mongolia)

A forest fire first broke out on May 12th at Shamalfundi (some 20 km south of central Sukhbaatar City along the national road). Because of its proximity to the Altanbulag District, fire-fighting assistance was provided in the form of fire beating and control fires for two days from May 12th.

On May 14th, a new forest fire broke out near the Russian border at the northern end of the Altanbulag District. A total of some 340 people, including 270 local residents and members of the district office, the military and the police, were mobilised to fight the fire for 20 days. On the night of May 13th, the military issued a warning on the possible spread of the fire from the Russian side of the border. The fire-fighting team was divided into two groups with a view to containing and extinguishing the fire from its western and eastern ends where the fire was spreading. At the beginning, nature protection officers of the district office led the fire-fighting activities. Around May 24th when the fire was extinguished at on its eastern side, the two groups were unified which then continued their activities under the leadership of the Selenge Aimak fire committee. Military assistance played an important part in the establishment of a base, medical care, communication and transportation. The fire finally covered several tens of thousand hectares and was eventually extinguished on May 30th. With the end of the fire-fighting activities, however, the monitoring work continued as soil fires were observed at those sites where animal dung had accumulated. This monitoring finally came to an end when it rained on June 3rd.

The actual fire-fighting activities consisted of ① fire beating, ② setting up of firebreaks and ③control fires. Firebreaks totalling some 10 km in length were created using tractors. Thirty cars, seven trucks and 28 horses were mobilised for fire-fighting purposes and no water was used.

(2) Survey Activities on Scale of Fire Damage

1) Nationwide Activities

The Ministry of Nature and the Environment conducted an urgent survey on the massive forest fire in 1996 and prepared the 1996 Forest Fire Survey Report. There were five survey areas, i.e. Hangai Mountains, Hentii Mountains, Selenge Aimak, Hovsgol Aimak and Bulgan Aimak. The survey involved interviews with related people and a field investigation using the forest type maps (scale: 1/50,000) of the subject maps and took place from August to September, 1996. NOAA satellite data and various existing data was also used.

The damage caused by the forest fire was classified into three categories using the ratio of damaged trees in existing stands as the yardstick. The size of the damaged area, representing the extent of ecological damage, and the total value of damage, representing the extent of economic damage, were then calculated as shown in Table 82.

Table 82 Size of Damaged Area and Estimated Total Value of Damage Due to Forest Fire in 1996

Damage Category	Corresponding Ratio of Damage Volume (%)	No. of Years Required to Restore Forests Through Natural Regeneration (years)	Size of Damaged Area Surveyed (ha)	Estimated Value of Damage Surveyed (million Tg)
Large	60 - 80	(difficult to assess)	252,238	24,218.37
Medium	30 - 40	7 - 10	331,339	5,140.29
Small	5	2 - 3	1,870,208	3,215.92
Total			2,453,785	32,574.58

The size of the damaged area and the total value of damage were, in fact, estimated for each species and the most severely damaged species was larch, accounting for 75% of all damaged areas. In terms of the value, larch accounted for some 40% of the total damage. The report made recommendations on the following issues while pointing out the prospect of secondary damage due to harmful insects and the desirable cutting and use of trees for general timber production.

- Utilisation and rehabilitation of damaged forests
- Employment of either artificial regeneration or natural regeneration depending on the degree of damage
- Strengthening of the forest fire prevention system in regard to the legal framework, fire-fighting activities and information gathering activities
- Cooperation with foreign aid organizations

Meanwhile, in the face of the frequent illegal cutting of those stands damaged by the fire, the Ministry of Nature and the Environment issues new regulations designed to halt the illegal cutting as described later.

2) Selenge Aimak

According to the 1996 Forest Fire Survey Report published by the Ministry of Nature and the Environment, the damage due to forest fire in Selenge Aimak extended to 13 districts in the period from March 24th to June 5th with 65 separate fires being observed. The estimated fire damage in Selenge Aimak is shown in Table 83. The Report put forward the following recommendations to deal with the damaged areas.

① Artificial regeneration should be planned for those areas of major damage.

② Both artificial regeneration and natural regeneration should be planned for those areas of medium damage. Natural regeneration is expected to take place in the case of *Larix sibirica* (larch) forests, the extent of damage of which is relatively minor.

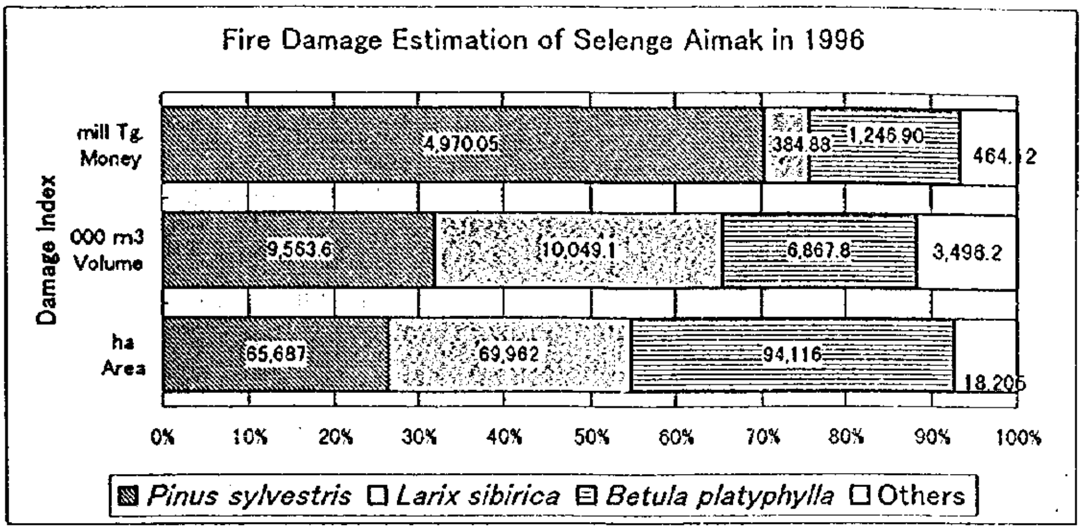
③ Prior to the implementation of artificial regeneration, nurseries should be created.

④ In order to avoid loss of the use value of damaged trees due to secondary damage, such as damage due to harmful insects, the damaged trees should be cut by 1997. Strip clear cutting or selective cutting (at a rate of 30%) should be employed for areas totally fire damaged.

The damage in the Tojiin Nars area where the Model Areas are located is estimated to be 26,096 ha in area and 3,826,900 m^3 in volume.

In Fig. 46, the top three species in terms of damage are compared with other species using the figures shown in Table 83.

Some 90% of the damage in Selenge Aimak in terms of the area, volume and value is accounted for by three species, i.e. *Larix sibirica*, *Pinus sylvestris* and *Pinus sibirica*. In terms of the area and volume, the extent of the damage to these three species is similar. However, in terms of value, the damage to *Pinus sylvestris* accounts for some 70% of the total value of damage, indicating major economic damage to this particular species compared to others.



Note: Others are *Pinus sibirica, Populus tremula, Picea obovata, Populus suaveolens, Populus laurifolia* and *Abies sibirica*.

Fig. 46 Composition of 1996 Forest Fire Damage by Species in Terms of Area, Volume and Value in Selenge Aimak

Table 83 Estimated Damaged Area, Volume and Total Value by Forest Fire in 1996 in Selenge Aimak

Species	Degree of Damage									Total		
	Minor			Medium			Major					
	Area (ha)	Volume (000 m^3)	Value (mill.Tg)	Area (ha)	Volume (000 m^3)	Value (mill.Tg)	Area (ha)	Volume (000 m^3)	Value (mill.Tg)	Area (ha)	Volume (000 m^3)	Value (mill.Tg)
Larix sibirica	62,966	9,044.2	11.76	4,897	703.4	96.47	2,099	301.5	276.65	69,962	10,049.1	384.88
Pinus sylvestris	24,430	3,537.5	5.31	12,462	1,817.2	302.83	28,795	4,208.9	4,661.91	65,687	9,563.6	4,970.05
Pinus sibirica	14,941	2,808.0	10.67	2,066	412.0	122.52	824	158.4	325.81	17,831	3,378.4	459.00
Picea obovata	1,061	155.1	0.29	98	14.2	2.99	60	8.9	12.24	1,219	178.2	15.52
Betula platyphylla	69,077	4,975.5	3.48	9,411	689.5	102.58	15,628	1,202.8	1,140.84	94,116	6,867.8	1,246.90
Populus tremula	1,248	102.2	0.06	250	20.4	2.48	167	13.6	11.07	1,665	136.2	13.61
Populus suaveolens/ laurifolia	554	38.8	0.03	61	4.3	0.60				615	43.1	0.63
Abies sibirica	179	28.5	0.05	16	2.6	0.49	10	1.6	2.04	205	32.7	2.58
Total	174,456	20,689.8	31.65	29,261	3,663.6	630.96	47,583	5,895.7	6,430.56	251,300	30,249.1	7,093.17

Note : The indicated volume is the whole volume at the damaged site including fire damaged trees.
Source : 1996 Forest Fire Survey Report (Ministry of Nature and the Environment, 1996)

6.2.5 Survey on Utilisation of Damaged Trees

(1) Administrative Response

At first, the government of Selenge Aimak planned to cut the damaged trees, accompanied by the planting of new trees, in the period of one year after the fire and to follow the policy of the central government from the second year onwards. Accordingly, the same procedure and contractual contents as normal cutting were adopted for the cutting of damaged trees. The Forest Law gives the authority to permit cutting for timber production to district heads. While permits were issued on the grounds that damaged trees would be cut, the illegal cutting of trees other than damaged trees was frequently conducted.

Note : Many cases of malpractice which are difficult to believe could have been conducted by responsible organizations with reasonable technical capability were found at logged-over land. These include the cutting of only large diameter trees, the use of only high price sections (leaving tree ends of less than some 30 cm in diameter in the stand) and the non-clearance of the tree ends of the cutting and logging of damaged trees, such dangerous cutting as combined cutting and the illegal cutting of standing trees in the neighbourhood of undamaged trees.

In order to prevent activities violating the Forest Law and to promote the appropriate use of forest resources, the Ministry of Nature and the Environment issued a notification in March, 1997 (Decree of the Minister of Nature and the Environment No. 34, "Measures to be Taken for Forest Protection", issued on March 13th, 1997) affording the aimak government and the Council of Representatives the authority to monitor the cutting permit issuing process while restricting the eligible persons for such permits to logging contractors with past records. At the aimak level, the Forestry Office acts as the competent agency for the monitoring of the cutting and logging work of such contractors. While these strict control measures introduced by the Ministry of Nature and the Environment did work to prevent illegal cutting, more positive measures regarding the use and storage of damaged trees before their commercial value is lost due to damage by harmful insects and the recycling of revenue to fund rehabilitation planting, improvement cutting and forest management to rehabilitate forest resources were not implemented.

Cutting is conducted in Mongolia within permitted cutting volumes set by government organizations. In the case of Selenge Aimak, its allocation by the central government was 134,300 m^3 in 1996 and 95,000 m^3 in 1997. Meanwhile, the Altanbulag District was allocated 58,250 m^3 in 1996 and 42,200 m^3 in 1997 by the Selenge Aimak government. According to a report compiled by the Altanbulag District Office, the actual cutting volume in 1996 was 40,826 m^3, conforming to the allocation. The permitted cutting volume figure is issued in January, i.e. the beginning of the fiscal year. Following the forest fire in 1996, the special cutting of damaged trees has been conduced.

Compared to the damaged volume of 4,510,400 m^3 of the most severely damaged *Larix sibirica* and *Pinus silvestris* in Selenge Aimak indicated by the 1996 Forest Fire Survey Report, the permitted cutting volume of 95,000 m^3 in 1997 for Selenge Aimak represents only a tiny proportion. Based on these figures, almost all of the damaged trees will be left standing, providing hotbeds of secondary damage with the prospect of a major loss of the trees' use value.

(2) Use of Damaged Trees by Forest Products Industry

A survey was conducted on activities relating to damaged trees of the following major cutting and sawing companies operating in and around the Intensive Area.

Table 84 Main Sawing Companies In and Around Intensive Area

Name	Business Activities	No. of Employees	Annual Sawing Capacity (m^3)	Sawing Volume in 1996 (m^3)	Main Market
ALFUFUCHU	Sawing	200	110,000	8,200	China
BUTEEL	Cutting and Sawing	80	60,000	1,600 *1	China
DULAANKHAAN	Cutting and Sawing	240	150,000	6,100	China

*1: The figure is upto July, 1996.

The new Forest Law enforced in 1995 bans clear cutting, reducing the cutting allocation nationwide. As a result, the actual sawing volume of all of these companies has declined.

It can be seen that damaged trees are not actively used by these companies, the production level of which using damaged trees is similar to the conventional production level using live trees. Trees damaged by harmful insects are not used at all as it is difficult to process trees which have dried as well as hardened due to insect damage. In addition, those trees damaged by borers have little market value as they cannot be sold to China.

As the Ministry of Nature and the Environment has reduced the overall cutting volume, the sawing volume has accordingly declined. At present, the use of damaged trees which have passed more than one year since the forest fire is hardly considered.

6.2.6 Survey on Rehabilitation Measures and Fire Prevention

(1) Central Government

Rehabilitation plans to deal with such huge forest damage as that seen in 1996 are generally led by the Ministry of Nature and the Environment. It is currently planned to reforest 30,000 ha in the four year period from 1996 to 1999 at various damaged sites throughout Mongolia. In addition, a programme to reforest 260,000 ha in Arhangay Aimak and Selenge Aimak in the two years from 1997 to 1998 is in progress. This programme also involves the provision of education on forest fire prevention and other subjects.

(2) Selenge Aimak

The reforestation activities of the Forestry Office of Selenge Aimak in 1997 are a mixture of those based on programmes which commenced prior to the forest fire in 1996 and those designed to rehabilitate the fire damaged forests. The planned reforestation area for 1997 is 519 ha which includes areas to be planted by companies conducting cutting and sawing. A total of 294 ha of planting will be conducted in the Tojin Nars area. At present, the Forestry Office is planning annual planting of 250 ha in the period from 1997 to 2000 to rehabilitate the fire damaged forests.

Other activities include the Forest Fire Prevention Seminar held by the Forestry Office, inviting district-level protection officers to improve their awareness of and knowledge on forest fire prevention and extinguishing measures.

(3) Altanbulag District

No special measures have been taken in the Altanbulag District in the Intensive Area in regard to the 1997 forest fire damage. The on-site monitoring of officially permitted cutting at forests of some 200,000 ha in size is conducted by three district nature protection officers who are mounted on a horse. However, the lack of manpower and mobility together with the absence of proper maps and radio equipment makes it difficult for these officers to strictly control illegal cutting.

6.3 Survey on Model Areas

6.3.1 Forest Physiognomy Survey

A forest physiognomy survey consisting of field survey and the interpretation of aerial photographs was conducted to establish an accurate picture of the forest fire damage in the Model Areas. The established damage situation was then classified using interpretation categories and the findings were shown on the forest type map after 1996's fire. The damage level categories and judgement criteria were established through consultations with the Mongolian side.

(1) Damage Level Categories for Ground Survey

The damage level categories shown in Table 85 were used for the ground survey to classify single trees, taking the accuracy of the aerial photograph interpretation into consideration.

The damage level category of "Large" applies to those single trees which are considered to be dead or certain to die as the leaves of the crown are burned out or dead. The details of the damage level categories and judgement criteria for single trees are given in Table 85.

Table 85 Damage Level Categories and Single Tree Interpretation Criteria for Ground Survey

Damage Level Category	Single Tree Interpretation Criteria	Symbol Used for Ground Survey
Large	• The inside of the trunk is burned • The leaves of the crown are burned out (Main fire impact: crown fire, stem fire)	1
	• The outside of the stem is burned and the formative layer is lignified • Many traces of insect damage are observed on the stem • The crown does not have new shoots at the top or is dead • The surviving leaves of the crown do not form a cone • The surviving leaves rate at the top of the crown is less than 25% when the DBH is 20 cm or more • The surviving leaves rate at the top of the crown is less than 20% when the DBH is less than 20 cm (Main fire impact: loss of crown due to heat of stem fire and ground fire)	
Medium	• The crown partially survives with dead leaves (Main fire impact: partial loss of crown due to heat of ground fire)	2
Small	• The crown survives as before (Main fire impact: heat of ground fire)	

The single tree judgement criteria were decided taking the empirical judgement rules used by the staff of the Forest Management Center into consideration and were used to conduct an inventory.

(2) Damage Level Interpretation Criteria for Aerial Photographs

Based on the results of the ground survey, the interpretation criteria shown in Table 86 were established to interprete the aerial photographs. The interpretation results were entered in the forest inventory book using the symbols shown in Table 85.

Table 86 Damage Level Categories and Forest Interpretation Criteria

Damage Level Category	Forest Interpretation Criteria	Symbol Used for Forest Inventory Book
Large	In the case of a forest dominated by *Pinus sylvestris*, a mass of trees which have lost all leaves is found. The typical photographic image shows a pattern of wavy strips. The colour tone is black. In the case of a broad-leaved forest, the colour of the same damaged trees shows pale white. Such trees account for 70% or more of the forest stand.	3
Medium	Trees which have lost their leaves or which have dead leaves show in white or pale white. The ratio of such trees in the forest is 30% or more and less than 70%.	2
Small	Trees which have lost their leaves or which have dead leaves show in white or pale white. Such trees are dotted in the forest.	1
Nil	Forests which escaped fire damage only exist in the southwestern part of Model Area 1	0

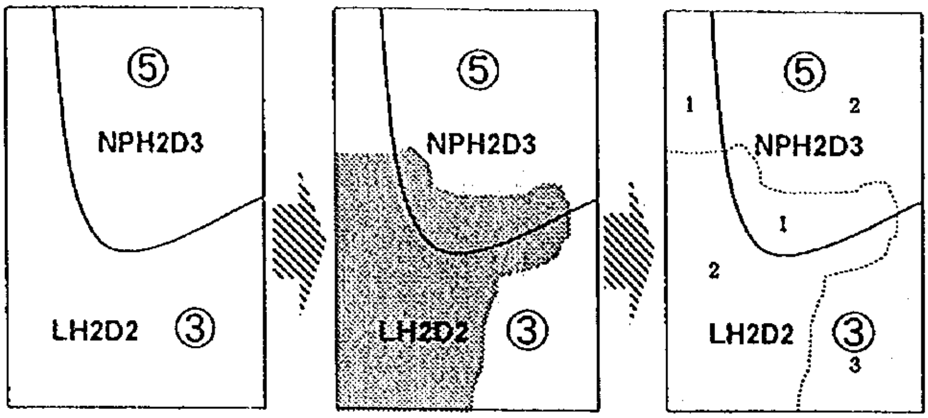
(3) Preparation of Forest Type Map

The entries on the pre-fire forest maps (scale: 1/25,000) are those categories used for the land use and vegetation map in addition to the height class and crown density.

The existing category symbols remain unchanged and a fire damaged area is indicated by the "section number after the 1996's fire" in the sub-compartment on the forest type map. These arrangements are intended to avoid confusion on the map and also to make pre and post-fire comparison easier. The fire damage level at each section is also entered in the forest inventory book.

When an entire sub-compartment suffers from the same damage level, the post-fire forest type symbol is given on the map. In the case of a sub-compartment which is totally burned out, this is classified as a fire damaged area in 1996 and is shown by the symbol UN on the land use and vegetation map after 1996's fire.

The actual work process was firstly classification of the fire damaged areas in 1996, followed by mapping of the classification results on the pre-fire forest type map. Finally, section numbers after the 1996's fire were given to each sub-compartment as illustrated in Fig. 47.



Part of Forest Type Map prepared in 1996

Range of Fire-Damaged Forests which belong to Damage Level 2 or 3

Part of forest Type Map prepared in 1997

Index			
NPH2D3	Forest Type		Range of Fire-Damaged Forests which belong to Damage Level 2 or 3
⑤	Sub-Compartment No.	——	Boundary of Sub-Compartment
2	Section No. after the 1996's Fire	....	Boundary of Section No. after the 1996's Fire

Fig. 47 Examples of Post-1996 Fire Section Numbers

Only Damage Levels 2 and 3 can be interpreted on the aerial photographs.

The surveys conducted by various organizations in 1996 and the field survey in 1997 found the distribution of Damage Level 1 in Compartments 1 through 4 in Model Area 1 and also throughout Model Area 2 and Damage Level 0 in only Compartments 5 through 10 in Model Area 1.

6.3.2 Volume Survey

A volume survey was conducted to estimate the stand volume following the fire in 1996.

(1) Sample Plot Survey

Sample plots were established for those *Pinus sylvestris* stands which were the most severely damaged. A sample plot was given a rectangular shape with an area of 0.1 ha (20 m × 50 m) and a total of 20 sample plots were established for the inventory. The total stand volume of each sample plot is shown in Table 87.

Table 87 Results of Sample Plot Survey

Sample Plot No.	Model Area No.	Forest Physiognomy			No. of Trees/ha	Average DBH (cm)	Average Tree Height (m)	Volume/ha (m^3/ha)
		Vegetation Category	Height Class	Crown Density				
1	2	NP	3	3	220	25	12	98
					170	25	12	78
2	1	NP	3	2	370	25	15	150
					160	31	16	92
3	1	NP	2	2	1,000	17	14	125
					320	30	15	85
4	1	NP	2	2	490	27	18	263
					320	30	19	209
5	1	NP	3	2	410	19	13	104
					70	31	16	42
6	1	NP	2	2	400	21	13	114
					400	21	13	114
7	1	NP	2	2	330	19	12	70
					80	20	14	19
8	1	NP	2	3	340	20	14	82
					50	22	15	15
9	1	NP	2	3	410	29	18	267
					170	36	20	160
10	1	NP	2	2	740	20	14	190
					100	19	14	24
11	1	NP	2	3	620	16	12	89
					80	23	14	24
12	1	NP	2	2	330	20	15	85
					90	26	16	36
13	1	NP	2	3	190	22	16	62
					100	25	17	41
14	2	NP	2	4	320	27	15	150
					120	32	16	76
15	2	NP	2	2	410	23	13	137
					310	25	14	115
16	2	NP	2	2	280	31	17	182
					60	37	20	61
17	2	NP	3	3	200	26	13	68
					140	26	14	52
18	2	NP	2	3	290	26	13	104
					210	28	14	87
19	2	NP	2	2	470	22	14	142
					230	26	16	98
20	2	NP	3	1	790	16	9	108
					90	22	12	26

Note: The figures in the lower column correspond to Damage Category 2 in Table 85, indicating the respective data for live standing trees.

The results of the sample plot survey indicate the following characteristics of post-fire forests.

1) Standing Trees With DBH of 10 cm or More

The relationship between the tree height distribution and survival rate is shown in Fig. 48. Trees with a DBH of 10 cm or more and the damage level categories of "Medium" and "Small" constitute the data as shown in Table 85.

There is a significant tendency for the survival rate to decrease in accordance with a lower tree height. Trees with height of less than 12 m which comprise the middle storey of a forest have a survival rate of approximately 20%. Such low trees were mainly burned upto the crown and many carbonised stems can be seen.

While trees with a tree height of 20 m or more show evidence of burned stems, trees with burned crowns are rarely found. This tendency is more obvious in the case of taller trees.

The above findings generally reflect the complex conditions of the volume of humus on the ground, soil humidity at the onset of the fire and the spatial composition of standing trees. They cannot, therefore, be directly applied to forests other than *Pinus sylvestris* forests.

In regard to the spatial composition of standing trees, it very often appears to be the case that the occurrence of a crown fire at those stands with a high density of small diameter trees is the result of the high density of combustible dead branches, etc.

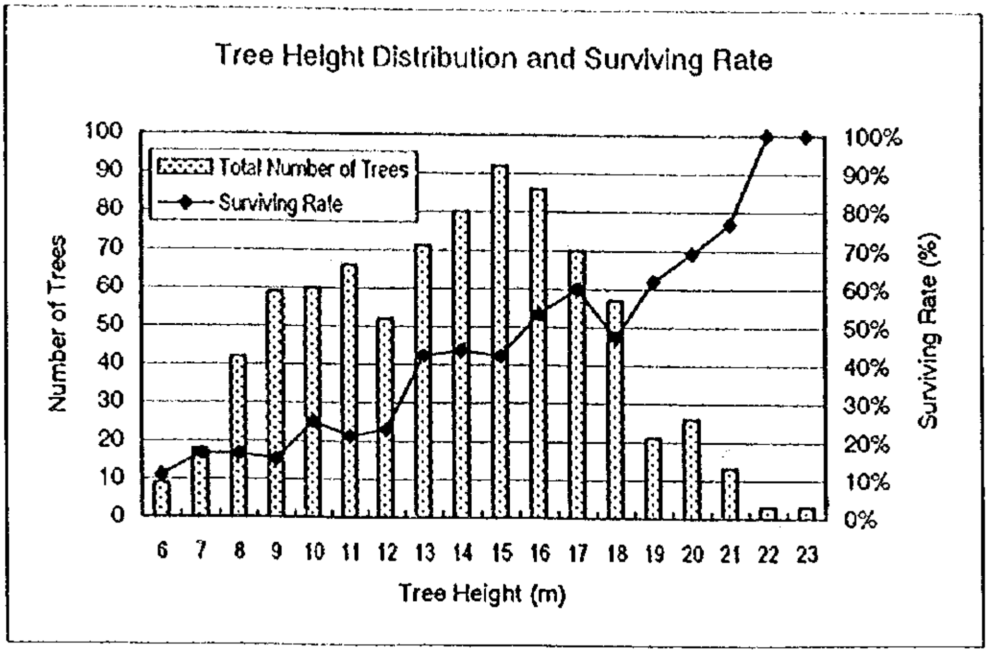


Fig. 48 Tree Height Distribution and Survival Rate

2) Standing Trees With DBH or 10 cm or Less

Trees forming the lower storeys of forests show burned stems and branches and lost leaves. Only *Rhododendron dahuricum* can be seen to be vigourously sprouting from the stumps. The tree species forming the high storeys of forests are described in detail in 6.3.4.

3) Herbacious Species

Even before the fire in 1996, the grass coverage was not very high where the forest floor was dark with a high crown density and high shrub coverage. The vital regeneration of seeds carried by the wind is not observed among herbacious species. The regeneration of herbacious species is rarely found at those sites where the species grew poorly before the fire even though the forest floor has become brighter due to the gaps which appeared after the fire.

In contrast, herbacious species show rich growth at sites where they are believed to have originally grown before the fire despite the fact that the ground vegetation was completely burned.

In short, species with rhizomes, tubers and corms are believed to have become dominant while regeneration by seeds carried by the wind is relatively rare.

The main regenerating species are *Iris ruthenica, Calamagrostis obtusata* and *Carex pediformis* which typically grow in the Model Areas. These are believed to have sustained very little damage in terms of regeneration because of the presence of dormant buds under the ground.

Chamaenerion angustifolium, a species peculiar to former fire sites, is observed at fire damaged grassland in the form of gregarious habit.

(2) Estimation of Surviving Volume

The surviving volume after the fire in 1996 was estimated for each site given a section number after the 1996's fire which was used as the fire damage interpretation unit for the forest type maps after 1996's fire using the tree survival ratio interpreted on the aerial photographs. In regard to the correlation between the survival ratio and post-fire surviving volume, the value obtained by multiplying the "pre-fire volume" by the "survival ratio based on aerial photograph interpretation" was used as an explanatory variable and the volume of "live standing trees" established by the ground survey (sample plot survey) was used as the target variable for the regression analysis. The results are shown in Table 88.

Table 88 Correlation Between Survival Ratio and Post-Fire Volume

Sample Plot No.	Pre-Fire Volume (A)	Survival Ratio of Aerial Photograph Interpretation (B)	Explanatory Variable Volume (v): (A) × (B)	Target Variable Volume of Live Trees of Sample Plot Survey (V)
1	40	80%	32	78
2	100	80%	80	92
3	170	70%	119	85
4	170	100%	170	209
5	100	40%	40	42
6	170	100%	170	114
7	170	40%	68	19
8	150	40%	60	15
9	270	70%	189	160
10	210	50%	105	24
11	130	30%	39	24
12	170	60%	102	36
13	170	60%	102	41
14	70	50%	35	76
15	210	80%	168	115
16	210	20%	42	61
17	40	70%	28	52
18	170	60%	102	87
19	150	60%	90	98
20	140	30%	42	26

Results of Regression Calculation

Regression coefficient	:	0.69
Correlation coefficient	:	0.71
Number of samples	:	20
t value	:	4.31

The t verification of the two variables subject to the regressive calculation found a significance at a significance level of 5%, indicating a positive correlation. Consequently, it was decided to estimate the post-fire surviving volume using the following equation.

$$V = 0.69 \times vr$$

Where, V : post-fire surviving volume (m^3)

vr : pre-fire volume (m^3) $\times$ survival ratio based on aerial photograph interpretation

(3) Compilation Results

The pre and post-fire areas and volumes by land use and vegetation type in the Model Areas are shown in Table 89.

Table 89 Areas and Log Volumes of Pre and Post-Fire in Model Areas

Model Area	Land Use & Vegetation Type	Before Fire (A) Area (ha)	Before Fire (A) Volume (m³) N	L	計	After Fire (B) Area (ha)	After Fire (B) Volume (m³) N	L	計	Fire-Damaged Amount (A−B) Area (ha)	Fire-Damaged Amount (A−B) Volume (m³) N	L	計	Damaged Rate Area	Damaged Rate Volume
1	Pine Forest	3,965	634,003	46,137	680,140	2,770	386,356	43,114	429,470	1,195	247,647	3,023	250,670	30.1%	36.9%
	Larch Forest														
	Pine/Larch Forest														
	Planted Forest	97				97									
	Broad-Leaved Forest	1,235	8,403	139,077	147,480	1,235	8,403	139,077	147,480						
	Mixed Forest	1,066	121,132	91,858	212,990	923	109,000	83,010	192,010	133	12,132	8,848	20,980	12.6%	9.9%
	Unstocked Land	90				18				72				80.0%	
	Fire-Damaged Forest	199				1,394				-1,195				600.5%	
	Logged-Over Land	42	320		320	247	320		320	-205				488.1%	
	Shrub Land														
	Grassland	222				222									
	Farm Land	24				24									
	Rocky Land	4				4									
	Total	6,934	763,658	277,072	1,040,930	6,934	504,079	265,201	769,280		259,779	11,871	271,650		26.1%
2	Pine Forest	1,571	281,819	26,351	308,170	1,115	141,979	16,761	158,740	456	139,840	9,590	149,430	29.0%	48.5%
	Larch Forest	1,123	283,609	51,871	335,480	1,101	255,483	46,447	301,930	22	28,126	5,424	33,560	2.0%	10.0%
	Pine/Larch Forest	1,218	310,381	45,639	356,020	1,205	275,027	39,033	314,060	13	35,354	6,606	41,960	1.1%	11.8%
	Planted Forest														
	Broad-Leaved Forest	7,376	70,414	727,766	798,180	6,563	57,957	604,643	662,600	813	12,457	123,123	135,580	11.0%	17.0%
	Mixed Forest	5,755	736,987	574,943	1,311,930	5,379	614,685	480,045	1,094,730	376	122,302	94,898	217,200	6.5%	16.6%
	Unstocked Land	1,579								1,579				100.0%	
	Fire-Damaged Forest	18				4,075				-4,057				22538.9%	
	Logged-Over Land	776	4,690	4,760	9,450					776	4,690	4,760	9,450	100.0%	100.0%
	Shrub Land	22								22				100.0%	
	Grassland	2,365				2,365									
	Farm Land														
	Rocky Land	914				914									
	Total	22,717	1,687,900	1,431,330	3,119,230	22,717	1,345,131	1,186,929	2,532,060		342,769	244,401	587,170		18.8%
1 & 2	Pine Forest	5,536	915,822	72,488	988,310	3,885	528,335	59,875	588,210	1,651	387,487	12,613	400,100	29.8%	40.5%
	Larch Forest	1,123	283,609	51,871	335,480	1,101	255,483	46,447	301,930	22	28,126	5,424	33,550	2.0%	10.0%
	Pine/Larch Forest	1,218	310,381	45,639	356,020	1,205	275,027	39,033	314,060	13	35,354	6,606	41,960	1.1%	11.8%
	Planted Forest	97				97									
	Broad-Leaved Forest	8,611	78,817	866,843	945,660	7,798	66,360	743,720	810,080	813	12,457	123,123	135,580	9.4%	14.3%
	Mixed Forest	6,811	858,119	666,801	1,524,920	6,302	723,685	563,055	1,286,740	509	134,434	103,746	238,180	7.5%	15.6%
	Unstocked Land	1,669				18				1,651				98.9%	
	Fire-Damaged Forest	217				5,469				-5,252				2420.3%	
	Logged-Over Land	818	5,010	4,760	9,770	247	320		320	571	4,690	4,760	9,450	69.8%	96.7%
	Shrub Land	22								22				100.0%	
	Grassland	2,587				2,587									
	Farm Land	24				24									
	Rocky Land	918				918									
	Grand Total	29,651	2,451,758	1,708,402	4,160,160	29,651	1,849,210	1,452,130	3,301,340		602,548	256,272	858,820		20.6%

6.3.3 Modifications of Forest Inventory Book

The purpose of the post-fire forest inventory book is to provide forest data for June, 1996 when the fire was extinguished. The data contained in the pre-fire forest inventory book is based on the results of the sample plot survey conducted in July, 1995, describing the volume as of July, 1995. In contrast, the post-fire forest inventory book tries to establish the surviving volume of live standing trees in stands one year after the end of the fire using the results of the follow-up survey conducted in July, 1997.

Table 90 Timing of Forest Inventory Book Preparation and Subject Period of Data Gathering

Timing of Forest Inventory Book Preparation	Period of Aerial Photography	Period of Sample Plot Survey
Pre-Fire	June/July, 1994	July, 1995
Forest Fire	From May to June, 1996	
Post-Fire	June, 1997	July, 1997

As the forests subject to the survey mainly grow from May to July, the increment for the period from July, 1995 when the sample plot survey ended to May, 1996 when the forest fire broke out is assumed to be small. Accordingly, no increment is considered for those stands in the damage level category of 0 or 1.

The surviving volume for those stands in the damage level category of 2 or 3 is the result of the regression analysis using the results of the sample surveys conducted in July, 1995 and July, 1997 and the level of damage based on the aerial photograph interpretation. These regression analysis results include the surviving volume of secondary damage following the initial damage by the forest fire in 1996.

The stands subject to the aerial photograph interpretation, in fact, suffered extensive damage far exceeding the net increment over the two year period, affected by the forest fire as well as the quantity of secondary damage, and it can be reasonably assumed that the quantity of secondary damage will continue to increase. It is difficult to accurately determine the net increment and quantity of secondary damage at present as the latest field survey results cannot be reliably used for this purpose. Accordingly, it has been decided to use the results of the additional sample plot survey as the remaining volume at the time at which the forest fire in 1996 was extinguished.

In the preparation of the post-fire forest inventory book, special attention was paid to allowing easy comparison between the pre and post-fire states of forest resources. The items used for the post-fire forest inventory book shown in Table 91 include new items (marked●) and certain items in the pre-fire forest inventory book are given the prefix "pre-fire" and marked △.

Table 91 Items Used for Post-Fire Forest Inventory Book

No.	Item	Unit	Remarks	No.	Item	Unit	Remarks
1	Administrative Location			18	Crown Density Class After Fire		
2	Model Area			19	Stand Density Ratio	%	
3	Compartment Number			20	Stand Age	10 yrs	
4	Sub-Compartment Number			21	Mean Tree Height	m	
5	Section Number After the 1996's Fire		●	22	Mean DBH	cm	
6	Forest Area	ha		23	Species		
7	Non-Forest Area	ha		24	Volume Composition by Species	%	
8	Legal Designation			25	Volume Before Fire	m^3	△
9	Management Category			26	Volume/ha Before Fire	m^3/ha	△
10	Stand Quality			27	Annual Increment Before Fire	m^3/yr	△
11	Slope Class			28	Fire Damage Level		●
12	Soil			29	Surviving Rate After Fire	%	●
13	Forest Management Type			30	Surviving Volume After Fire	m^3	●
14	Land Use and Vegetation Type Before Fire			31	Surviving Volume/ha After Fire	m^3/ha	●
15	Land Use and Vegetation Type After Fire			32	Annual Increment After Fire	m^3/yr	●
16	Height Class			33	Forest Floor Vegetation		
17	Crown Density Class Before Fire			34	Remarks		

6.3.4 Natural Regeneration Survey

(1) Damage Survey on Young Stands

1) Damage to Naturally Regenerated Young Trees

a) Natural Stands

The state of forest fire damage to young needle-leaved trees in natural forests was surveyed, featuring natural *Pinus sylvestris* forests. The survey method used to establish the fire damage volume was the establishment of two survey plots of 10 m × 10 m each at both ends of a sample plot and the counting of the number of surviving and dead seedlings (30 cm to 1.3 m in height) and saplings (tree height of 1.3 m or more with a diameter of less than 9 cm). The trees killed by the forest fire account for some 12 - 100% in terms of volume in the surveyed stands.

Of the 40 survey plots, 3 of the 23 plots in Model Area 1 and 15 of the 16 plots in Model Area 2 did not have any young trees. Many young trees may have been burned without trace and, therefore, cannot be counted. As Table 92 shows, the mean death rate of young trees due to the fire in the survey plots was 100% for seedlings and 96% for saplings. Some saplings survived the fire, presumably because of weak fire or relatively high elevation. In short, however, almost all young trees were burned or killed by the fire together with such shrubs as *Rhododendron dahuricum* and others.

Table 92 Death Rate of Young Trees in Natural Stands in Intensive Area

(Unit: number of trees/ha)

	Model Area 1			Model Area 2			Total		
	Seedlings	Saplings	Sub-Total	Seedlings	Saplings	Sub-Total	Seedlings	Saplings	Total
Surviving Trees	0	19	19	0	41	41	0	28	28
Dead Trees	169	1,027	1,196	0	63	63	101	641	742
Total	. 169	1,046	1,215	0	104	104	101	669	770
Death Rate (%)	100	98	97	-	61	61	100	96	196

Note: Death rate (%) = number of dead trees ÷ total number of trees × 100

b) Naturally Regenerated Sites

A further damage survey on naturally regenerated trees was conducted at those sites in Model Area 1 where the forest fire in 1996 damaged young stands of *Pinus sylvestris* which had naturally regenerated at almost tree-less sites after the cutting and logging of trees damaged by the fire in 1985. The survey method used was the establishment of six survey plots of 10 m × 1 m each and the counting of the number of surviving and dead *Pinus sylvestris* trees with a tree height of not less than 30 cm.

The mean death rate of naturally regenerated, young *Pinus sylvestris* seedlings and saplings due to the fire was 79% as shown in Table 93. These trees grew in groups and are assumed to have been killed collectively depending on the strength of the fire. This explains the widely varying death rate, ranging from 50 - 97%.

Even though the natural regeneration of *Pinus sylvestris* through seed shedding from the side at these naturally regenerated sites damaged by the fire is hoped for in the coming years, planting will be required in some areas because of the worsened environmental conditions, such as the dense growth of grass and exposure to direct sunlight.

Table 93 Death Rate of Naturally Regenerated, Young *Pinus sylvestris* Trees by Forest Fire

(unit: seedlings/ha)

Species	Surviving Trees		Dead Trees		Total No. of Trees
	No. of Trees	Mean Tree Height (cm)	No. of Trees	Death Rate (%)	
Pinus sylvestris	2,475	160 (30 - 290)	9,467	79.3	11,942

Note: Death rate(%) = number of dead trees ÷ total number of trees × 100

2) Damage to Man-Made *Pinus sylvestris* Stands

The state of damage to man-made *Pinus sylvestris* stands by the fire was surveyed by firstly establishing three survey sites of 40 m (in the planting direction) × 50 m in the relevant stands in Model Area 1 and then counting the number of surviving and dead *Pinus sylvestris* trees (both planted and naturally regenerated) with a tree height of not less than 30 cm.

The mean death rate due to the fire among planted and naturally regenerated trees was 67% as shown in Table 94. The death rate of planted trees was 56% and that of naturally regenerated trees was 70%. The mean value is largely determined by naturally regenerated trees because of their numerical superiority to planted trees. In general, a ground fire is significantly affected by combustible matter on the ground and by wind at a reforestation site without upper-storey trees. In the case of the man-made stands in question, naturally regenerated trees growing in groups were collectively killed while line planted trees were less affected by the fire, resulting in a lower death rate than that of naturally regenerated trees.

Man-made *Pinus sylvestris* stands in Model Area 1 are assumed to be capable of growing together with naturally regenerated trees despite the small number of planted trees. However, their collective death due to the fire and the dense as well as relatively high growth of grass imply less likelihood of natural regeneration in the coming years. Accordingly, it is believed that replanting will be necessary for some 30% of the total area.

Table 94 Death Rate Due to Forest Fire of Man-Made *Pinus sylvestris* Stands

(unit: seedlings/ha)

Species	Surviving Trees		Dead Trees		Total No. of Trees
	No. of Trees	Mean Tree Height (cm)	No. of Trees	Death Rate (%)	
Planted Trees	307	77 (30 - 160)	385	56	692
Naturally Regenerated Trees	818	148 (30 - 400)	1,907	70	2,725
Total	1,125	129	2,292	67	3,417

Note: Death rate (%) = number of dead trees ÷ total number of trees × 100

(2) Natural Regeneration Survey

The state of post-fire natural regeneration was surveyed at needle-leaved and broad-leaved forests damaged by the fire.

1) Needle-Leaved Forests

In order to identify the state of natural regeneration of *Pinus sylvestris* forests one year after the forest fire, four survey plots of 1 m × 1 m were established at both ends of each of the sample plots used for the fire damage volume survey and the number of current year seedlings and one year old seedlings (from the previous year) were counted in July, 1997.

The density of the seedlings grew in *Pinus sylvestris* stands in the post-fire period ranges from 0 to 150,000 seedlings/ha in the case of current year seedlings and 0 to 290,000 seedlings/ha in the case of one year old seedlings. The mean figure for the survey plots of 24,000/ha is modest as shown in Table 95 (some areas other than the survey plots showed as many as some 400,000 seedlings/ha). Survey plots where no seedlings are observed account for 41% of the total (40% in Model Area 1 and 43% in Model Area 2), showing no difference in the death rate due to the fire of upper-storey trees. The size of the seedlings is approximately 1.5 cm for current seedlings and 4 - 5 cm for one year old seedlings. The forest floor where seedlings are observed can be seen at those sites with low or high grass coverage in Model Area 1. As seedlings are observed at those sites with a high coverage of tall grass of 50 - 100 cm, there is no noticeable difference in regard to the state of seedling generation due to the different degree of grass coverage. However, as the coverage by grass and upper-storey trees will determine the future survival and growth of these seedlings, the clearing of grass and shrubs and the improvement cutting of low quality broad-leaved trees which suppress the growth of seedlings and saplings should prove highly effective to facilitate the growth of these young trees.

Table 95 Naturally Regenerated *Pinus sylvestris* Seedlings After Fire

(Unit: 1,000 seedlings/ha)

Seedling Category	Death Rate of Upper-Storey *Pinus sylvestris* (Volume)				Remarks
	Upto 30%	31 - 70%	71% or More	Total	
Current Year	5.0	12.5	6.0	8.4	
One Year Old	11.5	23.9	9.0	15.9	
Total	16.5	36.4	15.0	24.3	

Meanwhile, seedlings of *Larix sibirica* were not found in those stands damaged by ground fire as well as crown fire. In general, the upper and middle storeys of *Larix sibirica* stands are dominated by *Larix sibirica* while the medium to lower storeys are dominated by *Betula platyphylla*. As such broad-leaved trees as *Betula platyphylla* and *Rhododendron dahuricum* quickly regenerate by sprouting after being burned by fire to occupy the forest floor, the regeneration of needle-leaved tall species tends to be suppressed. Underlining this tendency, seedlings of *Larix sibirica* (2 cm tall current year seedlings and 7 - 12 cm tall one year old seedlings) can be observed together with seedlings of *Betula platyphylla* at former logging road sites where there is currently no suppression by broad-leaved trees.

2) Broad-Leaved Forests

The *Betula platyphylla* and *Populus tremula* growing in the Intensive Area are easily killed by forest fire but can regenerate themselves by sprouting. In the forest areas damaged by the fire in 1996, this regeneration by sprouting was already observed one month after the fire. One year old seedlings of *Betula platyphylla* sprouting from stumps and those of *Populus tremula* sprouting from roots and seeds were seen to have reached a height of 1 - 2 m.

As described above, broad-leaved trees tend to quickly reproduce through natural regeneration after being killed by a forest fire, making it virtually unnecessary to adopt special regeneration measures for the fire damaged areas of broad-leaved forests. Nevertheless, tending will be necessary in the course of their growth, including the improvement cutting of poor quality trees in the regenerated population.

6.3.5 Secondary Damage Survey

(1) Damage Due to Diseases and Harmful Insects

Forests damaged by fire or wind are vulnerable to secondary damage due to harmful insects, the threat of which can last for several years. Fig. 49 shows the relationship between the fire damaged forest area and the area damaged by harmful insects in the past, indicating that a major forest fire tends to be followed by an outbreak of insect damage lasting for several years.

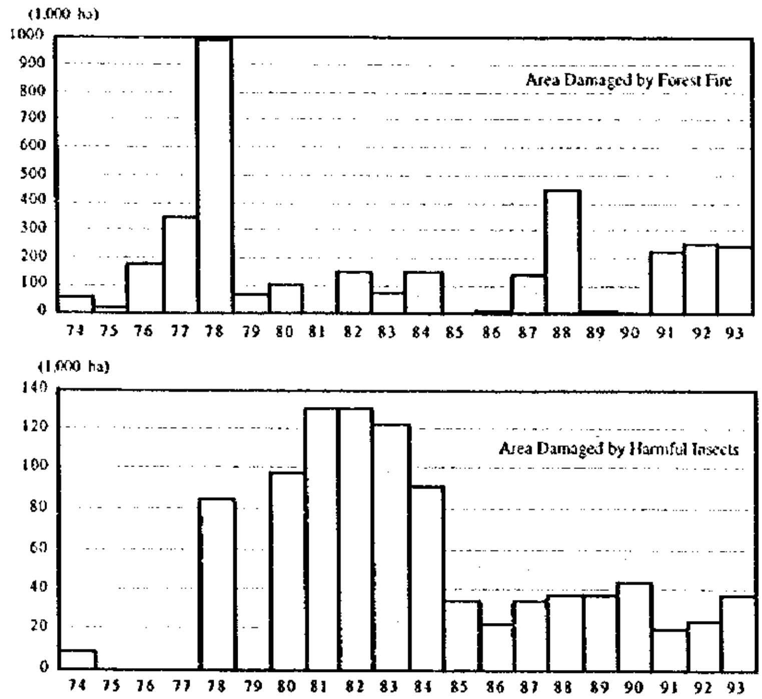


Fig. 49 Area Damaged by Forest Fire and Area Damaged by Harmful Insects
(Based on Ministry of Naturde and the Environment Data)

In mid-July, 1997, 14 months after the end of the forest fire in 1996, a survey was conducted to check the state of damage to *Pinus sylvestris* forests by diseases and harmful insects. The survey method used was the establishment of sample plots of 0.1 ha in size (0.05 ha for young stands) in Model Area 1 and the determination of the survey routes. The types of harmful insects were examined by cutting trees damaged by the fire. The number of such insects was determined using the G. Dinseman's formula given below.

$$X = \frac{N}{2RL}$$

Where, X : number of harmful insects per m^2

N : number of harmful insects caught in 100 netting operations

L : distance from first site of netting to second site of netting

R : number of netting operations

As shown in Table 96, many harmful insects were found to be attacking different parts of the damaged trees. In particular, a high density of borers (⑦ to ⑨) which are secondary harmful insects were found below the bark (many larvae were found inside the bark). Their existence was also externally confirmed as streaks of white fat on bark blacked by fire and the exfoliation of the bark around the holes created by woodpeckers were observed.

Table 96 Harmful Insects to Fire Damaged *Pinus sylvestris* Forests

Species		Population Density	Tree Species Subject to Damage	Damaged Tree Section(s)
①	*Evetria resinella*	+++	*Pinus sylvestris*	buds
②	*Hylobius abietis*	+	"	"
③	*Dendrolimus pini*	++	"	needle leaves
④	*Panolis flammea*	++	"	"
⑤	*Bupalus piniarius*	++	"	"
⑥	*Blastophagus piniperda*	+	"	bark
⑦	*Monochamus galloprovincialis*	+++	"	inside of stem
⑧	*Acanthocinus aedilis*	+++	"	"
⑨	*Ips sexdentatus*	+++	"	"
⑩	*Blastophagus minor*	++	"	"
⑪	*Spondylis buprestoides*	++	"	"
⑫	*Pissodes notatus*	+	"	"
⑬	*Aradus cinnamomeus*	+	"	"
⑭	*Melasoma tremulae*	+	*Populus tremula*	leaves

Notes 1. Population density: +++ = high, ++ = medium, + = low

2. In the case of No. 6 and No. 10 on the list, similar species are observed in Japan.

The infection of *Pinus sylvestris* trees by *Lophodermium pinastri* was observed and the tips of the needle leaves were yellow with small black dots showing up on the leaves (the spores are spread in July and August).

Table 97 shows the extent of the damage to *Pinus sylvestris* stands by diseases and harmful insects and also the death rate due to the forest fire.

Table 97 Various Damage to *Pinus sylvestris* Stands

Old Stands					Young Stands			
Plot No.	No. of Trees	Harmful Insects	Trees Diseases	Forest Fire	Plot No.	No. of Trees	Harmful Insects	Forest Fire
1	62	87%	13%	87%	4	145	50%	46%
2	74	86%	14%	86%	5	147	19%	65%
3	40	85%	15%	58%	6	275	45%	56%
Average	59	86%	14%	80%	Average	189	39%	56%

Note: The number of trees given here is the total number of trees per plot.

(2) Life Cycle of Main Harmful Insects

The life cycles of the main harmful insects for *Pinus sylvestris* damaged by the forest fire are described below.

1) *Dendrolimus pini* (type of Eggar)

Dendrolimus pini usually emerges from the pupa in June or July to become an imago (moth) and actively flies during the night for 30 - 40 days. The female lays 250 - 300 eggs on the needle leaves in early August. The eggs are originally a bluish colour and then gradually become a greyish colour. After two weeks, they hatch into larvae (caterpillars) which have two lines on the back and eight pairs of legs. The larvae eat the needle leaves, shed their skin two or three times and descend from the crown from September to early October to spend the winter in the humus layer. In the following spring when the soil temperature is around 10℃, i.e. late April, the larvae begin to climb the tree stem, eating the young needle leaves on their way. They then shed their skin a further three or four times and become pupae which emerge in approximately three weeks to become imagoes. *Dendrolimus pini* has a life cycle lasting one year and the number and habit of *Dendrolimus pini* in

Mongolia generally increase after a forest fire. It appears that damage by this insect occurs in a 9 - 11 year cycle.

2) *Monochamus galloprovincialis* (type of Longihorn)

Monochamus galloprovincialis usually emerges from the pupa in June or July to become an imago. The female lays one or two eggs in turn, totalling 20-30 eggs, on the bark of *Pinus sylvestris*. These eggs hatch in approximately two weeks to become larvae which bore 1 - 1.5 mm holes in the bark to invade the stem and eat the cambium. They shed their skin three or four times and, after one month, create holes of 1 - 3 cm in diameter each in the stem at 1 - 1.5 cm below the cambium where they spend the winter. The following spring, they eat their way through the stem downwards and then become pupae. The timing to become pupae depends on how much is eaten at the larva stage, which in turn is affected by the actual weather conditions. A larva emerges in about one month to become an imago, creating a hole of 5 - 7 mm in diameter in the stem and flies out through an escape hole which is located lower than the invading hole. Larvae and imagoes co-exist side by side in June and July. The life cycle of *Monochamus galloprovincialis* is one year.

3) *Acanthocinus aedilis* (type of Longihorn)

Acanthocinus aedilis spends the winter in the form of an imago and becomes active in May. The female lays one or two eggs in turn, totalling 20 - 25 eggs, beneath the bark of the lower stem in July. The eggs hatch after approximately two weeks to become larvae which eat the cambium. In August, they invade the stem by 1 - 1.5 cm and become pupae. The pupae emerge after approximately one and a half months and create oval shaped escape holes to fly out to spend the winter in the form of imagoes. The life cycle of *Acanthocinus aedilis* is also one year.

(3) Soil Erosion

A forest fire can wipe out shrub, naturally regenerated seedlings, grass, fallen leaves and fallen branches, etc. on the forest floor. A thin Ao horizon resulting from this process was observed during the field survey. At some sloping sites damaged by the forest fire in 1996, soil erosion has occurred due to downpours which often occur in the summer in Mongolia. In general, however, the occurrence of soil erosion is not particularly high except at some south-facing slopes. The relatively short slope length tends to limit the direct discharge of soil to streams, providing an environment for the relatively quick restoration of vegetation. In the case of those south-facing slopes where trees were killed by the fire, these are likely to remain bare for some time because of the adverse impacts of direct sunlight and other causes. It is, therefore, necessary to pay special attention to sites with conservation items.

CHAPTER 7

FOREST MANAGEMENT PLAN GUIDELINES

CHAPTER 7 FOREST MANAGEMENT PLAN GUIDELINES

7.1 Basic Principles of Forest Management

(1) Nature of Forest Management Plan Guidelines

The forest management plan guidelines constitute the basic guidelines to determine the contents of forest management in the Intensive Area and are referred to when a forest management plan is formulated from the long-term perspective while taking into consideration the state of the natural conditions, socioeconomic conditions, forestry and forest products industry and forest resources in the Intensive Area as well as in neighbouring areas (excepting border areas).

Even though the guidelines described here are intended to serve the Intensive Area, they may also be used as model guidelines for the formulation of a forest management plan for elsewhere in Selenge Aimak and other regions.

(2) Provisions of Forest Law and Others

A forest management plan must conform to the Forest Law and other forest-related laws and regulations described below.

- Forest Law; Regulations Regarding Formulation of Forest Plans; Regulations Regarding Selection of Cutting Sites; Regulations Regarding Cutting of Timber and Firewood
- Law on Special Protected Areas
- Forest and Grassland Fire Prevention Law
- Land Law; Natural Plant Law; Hunting Law
- Natural Environmental Protection Law; Water Law

(3) Basic Principles of Forest Management

The following principles are deemed vital for the formulation of a forest management plan in order to encourage the creation and maintenance of healthy forests and to allow forests to fully perform their multiple functions in an integrated manner to achieve development of the local economy and improved welfare of local people.

1) Sustainment of Forest Resources

Forest resources are essentially renewable resources. Once they are destroyed by forest fire, etc., however, a long time is required for forests to restore and re-establish their former values. Accordingly, the sustainment of forest resources should be attempted to sustain the multiple functions of forests by protecting forests from forest fires, etc.

2) Increase of Forest Productivity

The existing forests suffer from degradation due to forest fires and cutting, etc. and reforestation measures at treeless forest land have failed to achieve sufficient results. Efforts should, therefore, be made to sustain and increase the forest productivity by means of promoting the adequate improvement of forest conditions and assured regeneration.

3) Adoption of Appropriate Forest Work

While forests have multiple functions, their social priorities differ depending on the actual location and other factors. In addition, there are limits to the simultaneous full performance of these functions. It is, therefore, necessary to classify forests based on priority functions, taking the locational conditions and legal restrictions, etc. into consideration, and to establish forest work criteria for each type of forest in order to standardise forest work.

In the case of forests mainly aiming at the commercial production of timber, an allowable cutting volume should be determined for each area of a certain size with a view to enforcing quantitative control based on forest productivity.

4) Development of Forest Road Network

Forest roads play an important function for timely and appropriate forest management, including measures to prevent or fight forest fires, reduction of the timber production cost, improvement of the forest products utilisation rate and improvement of the living conditions of local communities. In view of this importance of forest roads, the development of a network of forest roads, including spur roads, is necessary. Efforts should be made to achieve the general development of safe and functional forest roads while noting the need for land conservation.

5) Contribution to Local Economy

Forests are closely linked to local communities through the creation of employment opportunities due to the vitalisation of the forest products industry, the provision of appropriate space for grazing and forest recreation, etc. and conservation of the living environment. Much effort is required to achieve appropriate forest use to ensure the development of the local economy and to improve the welfare of local people.

7.2 Fact-Finding Surveys on Planning Area and Forests

(1) Fact-Finding Survey on Planning Area

The forest management plan for the planning area must reflect the present general conditions of the area which includes the Intensive Area. It is, therefore, necessary to obtain information and to conduct a field survey on the present state of the local natural conditions, socioeconomic conditions and forestry/forest products industry in order to establish an accurate picture. The essential items of such a field survey are listed below.

1) Natural Conditions

① Topography/ geology	: topography, elevation, slope gradient, distribution/ properties of surface soil and others
② Hydrology	: rivers and lakes, etc.
③ Meteorology	: temperature, rainfall, humidity, wind direction and wind velocity, etc.
④ Forest soil	: distribution/properties of soil types
⑤ Vegetation	: plant communities and distribution/growth of plant species
⑥ Wild animals	: types and growth of wild animals

2) Socioeconomic Conditions

① Location	: geographical location and administrative location
② Population	: population and distribution of settlements
③ Land use	: conditions of land and water use, local development plan(s) and laws and regulations
④ Transport and telecommunications	: conditions of roads, railway, electricity supply and telecommunications

⑤ Industries : working population by industry, agriculture, stock raising, transportation and tourism, etc.

3) Forestry and Forest Products Industry

① Log production : cutting volume, log production volume and forestry machinery, etc.

② Forest products production : forest products factories, volume of forest products production, timber supply and demand and by-products, etc.

③ Reforestation : reforestation organizations, nurseries, seedling production volume, reforestation area and reforestation work, etc.

④ Forest roads : state of forest/spur roads and forest road network plan

⑤ Forest conservation : state of landslide sites and erosion control facilities, etc.

⑥ Forest protection : state of damage due to forest fire, weather conditions, diseases and harmful insects and prevention measures

⑦ Research and tests : research, tests and technical diffusion, etc.

4) Local Opinions

① Administrative organizations : opinions of aimak, district and bag organizations

② Council of Representatives : opinions of Council of Representatives

③ Industrial circle, etc. : opinions of industrial circle and academic circle

(2) Fact-Finding Survey on Forest Conditions

The survey items of the fact-finding survey on forest conditions in the planning area are listed below.

① Land category : forest or non-forest

② Forest compartment : compartments, sub-compartments and their respective areas

③ Management type : legal designations and forest management categories

④ Stand structure : species, stand age, number of trees, DBH, height, quality, crown density and forest floor vegetation

⑤ Forest resources : area volume and increment by management type/forest type/age class and status of forest resources

⑥ Regeneration : natural regeneration, planting and state of growth, etc.

⑦ Damage to forests : state of damage due to forest fire/weather conditions/ diseases/harmful insects

⑧ Implementation of previous plans : cutting area and volume, regeneration area, forest roads, erosion control and firebreaks, etc.

(3) Formulation Process of Forest Management Plan

The formulation process of the forest management plan is shown in the flow chart (Fig. 50).

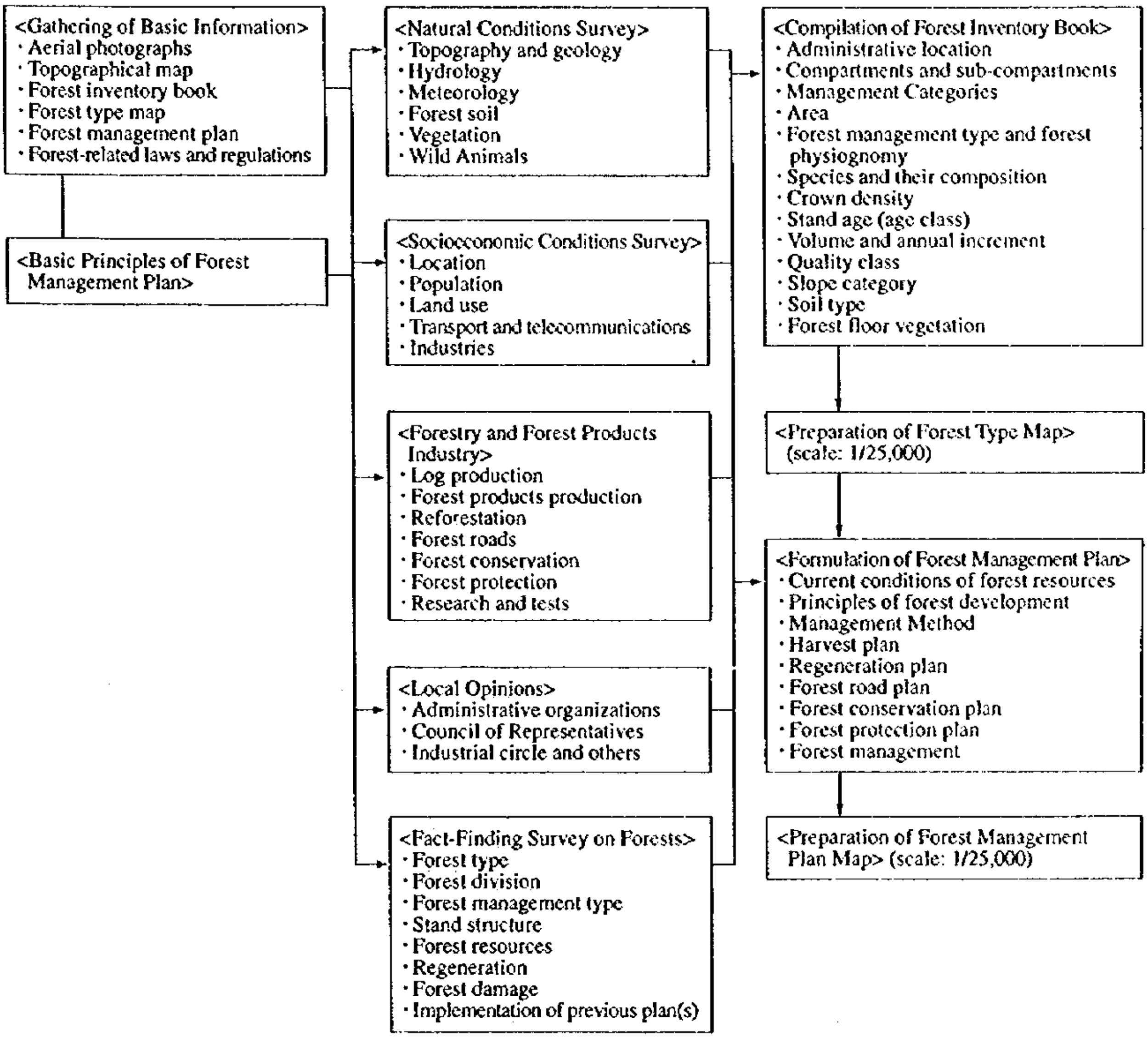


Fig. 50 Forest Management Plan Formulation Process

7.3 Basic Issues of Forest Management Plan

7.3.1 Planning Area, etc.

(1) Plan Period

While a forest management plan should be formulated from a long-term perspective, it is a common practice for the plan contents to be reviewed at regular intervals due to changes of the socioeconomic conditions during the plan period and possible disruption of the plan's implementation, in turn caused by a natural disaster, etc. Considering that the Forest Law of Mongolia stipulates the implementation of a forest resources survey every 10 years and that the present forests slowly grow showing relatively small changes over the years, it has been decided to set a plan period of 10 years for the forest management plan.

(2) Current Forest Conditions

The findings of the forest survey on forest resources in the subject area of the forest management plan will be compiled in terms of area, volume and increment, etc. by management category, forest management type, forest physiognomy and age class together with their summaries.

7.3.2 Forest Classification and Forest Division

(1) Criteria for Forest Classification

Broadly defined forests are classified in the categories of forest and non-forest based on their purpose of use, etc. and these narrowly defined categories of forest and non-forest are further classified into the various categories described below based on the forest characteristics and origin, etc. in the case of the former and the present land use and other aspects in the case of the latter.

① Forest : natural forest; man-made forest
natural regeneration site; planted site
shrub land
hospitable site
logged-over area; fire-damaged area

② Non-forest : river; lake or pond; swamp; sandy area; landslide area
rocky area; inhospitable site
farmland; grassland

nursery; forest road; firebreak; forest recreation site
: road; water channel; electric transmission route; mining site; settlement; others

Note : Natural regeneration sites and planted sites are forest land where regeneration has not been completed and the stands are insufficiently formed with the height of the regenerated trees generally being less than 2 - 3 m.

(2) Criteria for Compartmentation

As forests are distributed over an extensive area, it is necessary to divide them into reasonable compartments from the viewpoint of efficient forest management to ensure appropriate forestry work. The management unit to be introduced for the forest management plan are compartments and sub-compartments which will be established within the administrative units, i.e. aimak and district.

1) Compartments

Compartments are fixed areas to facilitate the planning, implementation and recording of forest management as their locations, shape and land area, etc. in a forest or on a map are clearly determined. The compartment boundaries usually consist of clear topographical or geographical lines, roads and administrative boundaries. In the case of hill forests, etc., artificial boundaries are introduced.

2) Sub-Compartments

Sub-compartments are unit areas for forest management work and are established by further dividing compartments in order to clearly show the type and current state of land use and different management purposes. Sub-compartments are established in places which show conspicuous differences regarding the following items compared to neighbouring areas. No such additional compartmentation is conducted for small compartments or those compartments where there is little need for sub-compartments. The minimum land area of a forest sub-compartment is 1 ha.

① Administrative location, forest classification, legal designation, management category
② Species, stand age (age class), forest management type, forest physiognomy type and crown density
③ Topographic feature and stand quality class

The renewal of the sub-compartment numbers every time the plan is reviewed is undesirable and an additional number or section number should instead be given to those sub-compartments where changes have taken place so that the history of forest management can be traced.

7.3.3 Forest Improvement Targets and Selection of Cutting and Regeneration Methods

(1) Forest Improvement Targets

In principle, forests should be classified as protected or conservation forests and those serving for timber production and each type of forest must be improved in a manner which is appropriate vis-a-vis its specific target(s).

The present forests have many stands containing a fairly large number of poor quality trees due to over-maturity and degraded stands due to forest fire and cutting, etc. In addition, the planted areas have not yet reached the stage of showing a sizable volume. Consequently, the annual increment is rather small. It is, therefore, necessary to put forward a long-term improvement target in the form of a numerical figure for each stocked area while trying to improve forests to forests of high growth by means of maintaining high quality trees with a suitable stand density. In the case of unstocked areas, forest management should facilitate regeneration to turn them into stocked areas.

Despite the above needs, in reality it is difficult to put forward a forest improvement target in the form of a numerical figure given the fact that the growth characteristics of trees and the productivity of natural forests and man-made forests are not currently fully understood. Consequently, the following descriptions of forest improvement targets are adopted for the guidelines.

- Improvement target for forests to be protected/conserved: to manage these forests so as to maintain their functions
- Improvement targets for forests mainly serving for timber production: ① to systematically improve these forests to high growth forests while maintaining high quality trees with a suitable stand density and ② to systematically convert cut-over areas and fire damaged areas, etc. to forests through the encouragement of regeneration

(2) Selection of Cutting and Regeneration Methods

1) Selection of Cutting Method

In the formulation of the forest management plan, it is essential to employ a basic cutting method taking the natural conditions, current state of forests and growth characteristics of the tree species into consideration. The local climate during the early season for tree growth is characterised by little rainfall, cool temperature, low humidity and strong wind, the planted trees are vulnerable to such meteorological conditions as drought and frost due to low temperature and occasional snow.

Meanwhile, natural forests consisting of *Pinus sylvestris*, *Larix sibirica* and broad-leaved trees tend to show a communal structure and the healthy growth of young trees of these light demanding species is hindered without plenty of sunlight. In fact, the existing naturally regenerated young trees show poor growth due to suppression except for some *Pinus sylvestris* and broad-leaved trees. Clear cutting is prohibited by the Forest Law.

Under these circumstances, the basic form of regeneration cutting will be selective cutting combined with shelterwood cutting. The main form of selecting cutting will be group selective cutting and single tree selective cutting will also be employed depending on the legal restrictions and other conditions. As most of the forests are damaged by forest fire, there are many low quality and/or damaged trees with damaged trunks with bark pockets and caves together with dead and fallen trees. Efforts to utilise these low quality trees are essential. Given the virtual absence of thinning in the past, thinning will be conducted for old stands with a high crown density to improve the stand health and to encourage an increase of the tree diameter.

2) Selection of Regeneration Method

Forest regeneration takes the form of either natural regeneration (seeding regeneration or regeneration by sprouting) or artificial regeneration (reforestation). The latter is conducted to achieve assured regeneration, shortening of the regeneration period and change of the species, etc. *Pinus sylvestris* and *Larix sibirica* which are currently the main species for timber production are light demanding species and take more than 100 years to reach maturity. Their timber prices are not particularly high and, therefore, it does not appear profitable to employ ordinary artificial regeneration from the viewpoint of investment efficiency. *Pinus sylvestris* forms a relatively dense stand at forest land with sandy soil, providing very good potential for natural seeding regeneration. In contrast, *Larix sibirica* forms a relatively thin stand and the growth of broad-leaved trees and shrubs in the lower layer makes it difficult for this needle-leaved species to regenerate by seeding. Broad-leaved trees are capable of regenerating by sprouting.

Based on these observations, natural regeneration will be adopted as the main regeneration method for stocked areas. Enrichment (work to assist natural regeneration) which involves the active planting of seedlings while utilising naturally regenerated young trees and removing disruptive shrubs and grass, etc. will be introduced to facilitate speedy and assured regeneration. In short, natural seeding regeneration which expects nature to take care of itself over a long period of time will be adopted and regeneration by sprouting will be practiced in broad-leaved forests.

In contrast, the regeneration method will, in principle, be used to regenerated unstocked areas or to change the growing species from broad-leaved species to needle-leaved species. In this case, the principle of the right tree on the right site should be adopted so that the planted trees can properly grow to form new stands with special attention paid to the investment efficiency and reduction of the reforestation and tending costs.

7.3.4 Management Categories

(1) Classification of Forest Functions

Forest management must be conducted in an appropriate manner for each forest from both a long-term and wide perspective, taking the natural conditions, socioeconomic requirements and legal restrictions, etc. into consideration. The Forest Law of Mongolia principally classifies forests into three categories, i.e. strict zone forests, protected zone forests and utilisation zone forests. There are, however, forests of which the protection or conservation necessity is high from a local point of view even if these forests are not classified as either strict zone forests or protected zone forests. Accordingly, it is necessary to categorise each forest based on the specific functions which it is expected to play among the many forest functions so that standardised forest management can be conducted for each management category while conforming to the provisions of the Forest Law.

(2) Management Categories of Forests

The following management categories of forests are introduced based on the priority function, in turn determined by the site conditions and legal restrictions, etc. The site conditions consist of location of forests (altitude, distance from river or wood market, etc.), slope, scope of slope, size in area, etc.

1) Nature Preservation Forests

Strict zone forests as defined by the Forest Law, forests with emphasis on preservation of the natural environment, including the preservation of locally rare forest ecosystems, protection of wild plants and animals and preservation of genetic resources, and forests of which the ecosystem should be preserved because of the difficulty of restoring vegetation once the forest state has been destroyed

- Sub-alpine forests, pristine and conservation zones of strictly protected areas and special zones of national conservation parks (all of the above are defined as strict zone forests by the Forest Law)
- Nature reserves for scientific research, natural monuments and historical and cultural monuments

2) Soil and Water Conservation Forests

Of the protected zone forests under the Forest Law, woods on south-facing slopes, isolated woods (on slopes), woods on steep slopes and shrubs, forests with emphasis on soil and water conservation, including the prevention of soil erosion, soil loss and collapse, headwater conservation and water quality preservation, from a local point of view and forests with emphasis on the prevention of meteorological disasters, including wind damage and damage by flying sand, etc.

- Woods on south-facing slopes, isolated woods (on slopes), woods on steep slopes, shrub forests, lake/pond conservation forests, headwater forests, riverside forests, fountain conservation forests and national road/railway track protection forests (all of the above are defined as protected zone forests by the Forest Law)
- Windbreak forests and erosion control belts, etc.

3) Public Health and Culture Promotion Forests

Of the protected zone forests under the Forest Law, green zone forests and forests with emphasis on such public health and culture promotion functions of forests as greenbelt and scenic beauty conservation in suburban areas, forest recreation, nature education and scientific experiments/research, etc. from a local point of view

- Green zones (these are defined as protected zone forests by the Forest Law)
- Scenic beauty forests (including forest recreation sites) and forestry experiment forests, etc.

4) Timber Production Forests

Forests for timber production as defined by the Forest Law, excluding those listed in 1) through 3) above, where industrial activities, such as timber production, are permitted (including those forests where industrial activities are feasible but have been suspended for the time being due to their location in remote areas or other reasons)

7.4 Forest Management Criteria

7.4.1 Forest Management Standards for Each Management Category

The types of forest management for each management category are described in this section. When the management categories for the same forest overlap, the type of forest management with stricter forest management restrictions should be given priority.

(1) Nature Preservation Forests

Nature preservation forests are those where preservation of the natural environment should be emphasised and those where preservation of the forest ecosystem should be particularly emphasised because of the difficulty of restoring the vegetation once the forest state has been destroyed. In view of these requirements, the following forest management standards will be adopted for these forests.

Cutting will be strictly prohibited and other forestry activities will be permitted as long as they meet the legal restrictions.

(2) Soil and Water Conservation Forests

1) Forests with Main Emphasis on Soil Conservation

The subject forests are woods on south-facing slopes (including those on inhospitable sites), isolated woods (on slopes), woods on steep slopes, shrub lands and erosion control belts, etc., all of which are listed in the Forest Law and where it is difficult to restore the forest state if the site conditions are destroyed. In order for these forests to perform their expected functions of soil conservation and/or prevention of soil discharge or collapse, it is desirable for them ① to have a well developed, deep root system, ② to have a ground surface protected by fallen leaves/branches and forest floor vegetation and ③ to be vigorous forests. In view of these requirements, the following forest management standard will be adopted for these forests.

Cutting will be prohibited and other forestry activities will, in principle, also be prohibited.

2) Forests with Main Emphasis on Water Conservation

These include headwater forests, lake/pond conservation forests, riverside forests and fountain conservation forests as listed in the Forest Law. In order for these forests to perform their expected functions of water conservation and water quality preservation, it is desirable for them ① to have forest soil with high porosity, high water retention and high permeability, ② to have a ground surface protected by fallen leaves/branches and forest floor vegetation, ③ to maintain an adequate crown density, ④ to have vigorous growth and ⑤ to spread over a certain area. In view of these requirements, the following forest management standards will be adopted for these forests.

a. Cutting

In principle, cutting will be prohibited. However, selective cutting to obtain firewood for home use will be permitted as long as it does not hamper the preservation of the headwater conservation function.

b. Regeneration

Natural regeneration will be adopted for selective cutting sites to obtain firewood for home use. Reforestation will, in principle, be conducted for the regeneration of unstocked areas.

c. Miscellaneous

Improvement cutting and the clearance of damaged trees by the Forestry Office will only be conducted when there is a need to protect forests and to stimulate natural growth and regeneration. The use of forest by-products will be permitted as long as it does not hamper the preservation of the water conservation function.

3) Forests with Main Emphasis on Prevention of Meteorological Damage

These include national road/railway track protection forests, isolated wood (on slopes) and windbreak forests, etc. as listed in the Forest Law. In order for these forests to perform their expected function of preventing such meteorological damage as wind damage and damage due to flying sand, etc., it is desirable for them ① to have a well developed, deep root system, ② to have a ground surface protected by fallen leaves/branches and forest floor vegetation, ③ to maintain an adequate crown density and ④ to have vigorous growth. In view of these requirements, the following forest management standards will be adopted for these forests.

a. Cutting

In principle, cutting will be prohibited. However, selective cutting to obtain firewood for home use will be permitted as long as it does not hamper the preservation of the meteorological damage prevention function.

b. Regeneration

Natural regeneration will be adopted for selective cutting sites to obtain firewood for home use. Reforestation will, in principle, be conducted for the regeneration of unstocked areas.

c. Miscellaneous

Improvement cutting and the clearance of damaged trees by the Forestry Office will only be conducted when there is a need to protect forests and to stimulate natural growth and regeneration.

(3) Public Health and Culture Promotion Forests

1) Forests with Main Emphasis on Public Health and Recreation

These include green zones and scenic beauty forests (including forest recreation sites) as listed in the Forest Law. In order for these forests to perform their expected functions of maintaining the natural environment in suburban areas, public health and recreation, it is desirable for them ① to have an adequate tree spacement, ② to have a diverse stand composition and ③ to have forest floor vegetation. In view of these requirements, the following forest management standards will be adopted for these forests.

a. Cutting

In principle, cutting will be prohibited (strictly prohibited in those areas where a mantle community should be preserved).

b. Regeneration

In principle, reforestation will be conducted to regenerate unstocked areas.

c. Miscellaneous

Improvement cutting and the clearance of damaged trees by the Forestry Office will only be conducted when there is a need to protect forests and to stimulate natural growth and regeneration. The use of forest by-products will be permitted as long as it does not hamper the public health and culture promotion functions.

2) Forestry Experiment Forests

Forestry experiment forests are established for the development and dissemination of forests and forestry techniques. The cutting and regeneration methods must be appropriate vis-a-vis the experiment or study objectives.

Other forests serving special purposes must be managed to suit such purposes.

(4) Timber Production Forests

These are forests where industrial activities, such as timber production, are permitted. In order for these forests to perform their expected function of producing timber, etc. to reflect the natural conditions and the demand for forest products, etc. while preserving the functions to benefit the public, it is desirable for them ① to have forest soil suitable for tree growth, ② to maintain an adequate crown density with good quality trees and ③ to have a high rate of increment. In view of these requirements, the following forest management standards will be adopted for these forests.

a. Cutting

In principle, cutting will comprise either shelterwood cutting or selective cutting. Single tree selective cutting will be employed for those stocked areas where long-term natural regeneration is anticipated.

Meanwhile, cutting will, in principle, be prohibited at those stands located on steep slopes along main ridgelines and other places, those along rivers, etc. and those of a certain width which are located adjacent to grassland for windbreak or soil conservation purposes.

Thinning will be conducted for mature forests with a high crown density.

b. Regeneration

In principle, enrichment will be conducted to regenerate former group selective cutting sites while natural seeding regeneration or regeneration by sprouting will be used to regenerate former shelterwood cutting or single tree selective cutting sites. In principle, reforestation will be employed for the regeneration of unstocked areas or to change the species from broad-leaved species to needle-leaved species.

7.4.2 Cutting Standards

(1) Cutting Methods

The cutting methods to be used are selective cutting (group and single tree) and shelterwood cutting for regeneration cutting, and thinning. Selective cutting is classified as group selective cutting which focuses on groups of trees constituting a natural forest and single tree selective cutting which focuses on single trees. In each case, an appropriate cutting method should be adopted in accordance with the current conditions of the subject stand in terms of species, crown density, tree form and quality, DBH class and growth of succeeding trees, etc. in order to ensure the effective use of timber resources and to increase the stand productivity while securing the health of the remaining stand.

The clearance of damaged trees will be conducted in the case of soil/water conservation forests and public health/culture promotion forests damaged by forest fire, etc. when it is necessary to tidy the physiognomy of these forests to protect the remaining stands and to facilitate normal growth and the restoration capability.

1) Group Selective Cutting

Group selective cutting will be employed for those stands with mainly large and medium diameter trees where enrichment is conducted as the regeneration method due to the small number of small diameter trees as well as needle-leaved succeeding trees. Groups of trees constituting a natural forest will be divided into cutting groups and reserved groups. Enrichment will be conducted for the regeneration of the cut-over sites of the cutting groups. No cutting will be conducted at those stands of which the crown density is less than 50%.

A cutting cycle will be established and an appropriate tree selection method will be employed for the selective cutting of upto 25% of the trees.

2) Single Tree Selective Cutting

Single tree selective cutting will be employed for ① stands of timber production forests which are composed of mainly large and medium diameter trees with the presence of small diameter trees and where enrichment is not required because of the presence of many succeeding trees or the favourable state of natural regeneration, ② stands of soil/water conservation forests and public health/culture promotion forests where the cutting of firewood for home use is permitted as such cutting does not hamper the expected functions of the subject forests and ③ stands where natural seeding regeneration is expected over a long period of time.

The maximum selective cutting rate will be set at 25% and a cutting cycle will be established to proceed with single tree cutting.

3) Shelterwood Cutting

Shelterwood cutting will be employed for *Pinus sylvestris* stands where natural regeneration by seeding from overhead trees can be anticipated and *Pinus sylvestris* stands where the sufficient growth of succeeding trees with the present selective cutting rate cannot be anticipated due to insufficient sunlight despite the presence of many succeeding trees. Broad-leaved stands where regeneration by sprouting can be anticipated will also be subject to shelterwood cutting. The maximum cutting rate will be 40% and cutting will be conducted on several separate occasions at an interval of approximately 10 years, taking the state of regeneration into consideration.

4) Thinning

Thinning will be conducted at those stands of which the age has not yet reached the final cutting age and which have a high tree density when alleviation of the tree competition is required to improve health, to facilitate thickening growth and/or to achieve the effective utilisation of timber resources. The maximum thinning rate will be 20% and the work will be conducted with careful consideration of the state of stand closure.

5) Clearance of Damaged Trees

The clearance of damaged trees will be conducted at those stands of soil/water conservation forests and public health/culture promotion forests which are damaged by forest fire, etc. and which require clearance to protect the remaining stands and to ensure the normal growth and restoration capability of such stands.

Cutting will be conducted in accordance with the stand conditions, taking the preferable regeneration method into consideration.

(2) Cutting Age

The cutting age indicates the standard tree age for cutting when trees reach the cutting age for actual utilisation. The cutting age is decided for each species to suit the objectives of forest management from the viewpoints of the use value of the produced timber, state of increment, degree of intensity of forest management and economy, etc. In general, the use value of the produced timber increases in accordance with a small end diameter. At present, natural forests are generally composed of trees of different ages and diameter classes. Under the present cutting system which decides the subject stands for cutting based on the average forest age, the presence of relatively many mature trees in a stand does not necessarily prompt cutting if the average tree age of the stand in question falls short of the cutting age, failing to achieve the effective utilisation of forest resources as over-mature trees are often damaged by rotting fungi.

The results of the annual ring survey using stumps show that the tree growth of *Pinus sylvestris* hill forests on sandy soil with poor water holding capacity tends to significantly slow down from approximately 120 years of age. Meanwhile, the Regulations Regarding Cutting of Timber and Firewood (hereinafter referred to as "the Cutting Regulations") set a minimum cutting age of 121 years for needle-leaved trees and 61 years for broad-leaved trees.

Based on the above considerations, the cutting ages given below will be adopted for the present guidelines. These cutting ages can, however, be altered in the future depending on the accumulation of relevant data and the trends of timber use.

- *Pinus sylvestris*; *Larix sibirica* : 130 years
- *Betula platyphylla*; *Populus tremula* : 65 years

At present, the minimum small end diameter of logs used to produce general timber is 18 cm. According to the above-mentioned annual ring survey, there is no significant correlation between the tree age and DBH (Figs. 38 and 39). It is, therefore, inappropriate to use the tree diameter as the only yardstick to select trees for cutting although the tree diameter is one criterion to be used in such selection. Consequently, the selection of trees for cutting should be made based on a comprehensive judgement of the leaf volume, crown shape and size and state of timber use, featuring mature trees with a certain diameter (approximately 50 cm for *Pinus sylvestris*).

(3) Cutting Cycle

In the case of selective cutting, it is necessary to rotate the cutting based on the cutting cycle which is, in principle, the period required for a stand subject to selective cutting to recover its volume at the time immediately prior to selective cutting. Therefore, the cutting cycle is closely related to the selective cutting rate. The following equation expresses the relationship between the cutting cycle and the selective cutting rate. The cutting cycles calculated with a stand increment rate of 0.5 - 2.5% and a selective cutting rate of 10 - 40% are shown in Table 98.

$\ell = - \log (1 - s) / \log (1.0 p)$

Where, ℓ : cutting cycle
s : selective cutting rate
p : increment rate

Table 98 Relationship Between Cutting Cycle and Selective Cutting Rate

(Unit: years)

Selective Cutting Rate/ Stand Increment Rate	10%	15%	20%	25%	30%	35%	40%
0.5%	21	33	45	58	72	86	102
1.0%	11	16	22	29	36	43	51
1.5%	7	11	15	19	24	29	34
2.0%	5	8	11	15	18	22	26
2.5%	4	7	9	12	14	17	21

In general, intensive forest management where a low selective cutting rate is employed to shorten the cutting cycle is desirable. As the main trees found in the Intensive Area are light-demanding species, a higher selective cutting rate is desirable for generation and growth. A shorter cutting rotation is, however, essential to remove the many poor character trees found in natural forests. The growth survey estimates the stand increment rate for each forest type category as follows: 2% for *Pinus sylvestris* forests, 0% for *Larix sibirica* forests, 0.5% for needle-leaved forests and 1.5% for broad-leaved forests. The Cutting Regulations set a cutting cycle of 20 - 30 years for needle-leaved forests and 6 - 8 years for broad-leaved forests. Given the above, the cutting cycle should be decided for each forest type based on the actual stand conditions.

As the increment becomes temporarily stagnant or even negative immediately after cutting and logging, the cutting cycle must also be determined taking the period required for the increment to recover into consideration.

In the case of shelterwood cutting, the timing of the second and further cutting should be decided based on the observed state of natural regeneration. An interval of 10 - 20 years is deemed appropriate in consideration of the damage to young trees due to cutting and logging, the stagnant growth of young trees due to suppression by upper-storey trees and the occurrence of dead trees due to various reasons, etc.

(4) Allowable Cut Volume

1) Significance of Allowable Cut Volume

As the sustainment of forest resources is the fundamental principle of forest management, it is necessary to clearly determine the permitted cut volume for each stand. It is also necessary to control the total cut volume for forests located in a specific area. The upper limit of the cut volume for a specific area is defined as the allowable cut volume. At present, it is reasonable to use a district as the unit for a specific area and to determine the allowable cut volume based on the annual increment. The allowable cut volume should be determined for the regeneration cutting of timber production forests. In the case of thinning, no upper limit for the total cut volume is set to facilitate thinning.

Incidentally, the allowable cut volume will be counted separately by needle-leaved trees and broad-leaved trees so that the forest resources of needle-leaved trees be not degraded by overcutting for its market popularity.

2) Calculation Method

While there are many ways of calculating the allowable cut volume, a relatively simple equation using the numerical regulation method below is used as this suits the actual state of timber production forests and also the volume of available data on forests.

$$E = \frac{Ip}{2} + \frac{Vp}{T}$$

Where, E : annual allowable cut volume for regeneration cutting (m^3)
Ip : present rate of annual increment (m^3)
Vp : present volume (m^3)
T : average cutting age (years)

Although such damaged trees as hollow trees and those damaged by fungi, etc. are useful from the viewpoint of the public welfare function as feeding trees or resting trees for birds, etc., they have only limited value as timber. It is, therefore, necessary to ensure that cutting is confined to fine trees only.

(5) Permitted Cutting Sites

Permitted cutting sites are selected from stands which are required to achieve the improvement targets of forests in order to comply with the cutting limit set by the allowable cut volume while assuming a specific cutting order for each major watershed and taking the efficient use of forest roads, etc. and local conditions into consideration. In the case of the cutting of firewood for home use, convenience for users must be considered.

7.4.3 Regeneration Standards

(1) Regeneration Methods

The regeneration methods to be used are reforestation, enrichment, natural seeding and sprouting. An appropriate regeneration method with a higher investment efficiency will be employed based on the site conditions of each regeneration site to achieve assured regeneration.

1) Reforestation

Reforestation will be conducted at unstocked former fire damaged site and cut-over sites where reforestation or natural regeneration is insufficient and at those sites of timber production forests where a change from broad-leaved forests to needle-leaved forests is required but the creation of a new forests is difficult without the planting of seedlings. The implementation priority for reforestation will be given to that forest land with high forest productivity and good site conditions.

While the main species for planting will be *Pinus sylvestris* and *Larix sibirica*, such broad-leaved trees as poplar and elm, etc. will also be planted to create windbreak forests, etc.

The standard planting density is set at 3,000 seedlings/ha in view of the low survival rate. In order to improve the present situation where the survival rate of seedlings and their growth are both poor, land preparation will be conducted by means of ① shallow ploughing of the ground vegetation in strips to one side so that the ground vegetation can be replaced after planting or ② clearing of the ground vegetation in strips to avoid exposure of the soil under the ground vegetation. The deep planting of seedlings and the drying of roots will also be avoided. In addition, mulching to lay fallen leaves and dead grass at the base of the planted seedlings will always be conducted to suppress evaporation from the ground surface.

2) Enrichment

Enrichment will be employed for those stands subject to group selective felling or for sporadically existing unstocked areas where active planting is required due to the difficulty of natural seeding regeneration or the poor prospect of naturally regenerated young trees forming proper stands.

The species for planting will be *Pinus sylvestris* and *Larix sibirica* and a standard planting density of 3,000 seedlings/ha for actually planted areas will be employed.

3) Natural Seeding Regeneration

Natural seeding regeneration will be employed at those sites where no special action appears necessary as the succeeding trees are already growing or the regeneration and growth prospects for natural young trees are good at those stands subject to shelterwood cutting, selective cutting and selective cutting to obtain firewood for home use. This method will also be employed for those places where natural regeneration over a long period of time is opted for based on the site conditions and/or legal restrictions, etc.

4) Regeneration by Sprouting

Regeneration by sprouting will be employed at those places where the regeneration of broad-leaved trees is opted for following the cutting of currently growing broad-leaved trees.

(2) Regeneration Period and Completion of Regeneration

In principle, regeneration will be conducted within two years of cutting. When the regenerated trees reach a height of 2 - 3 m to form a reasonable stand, the regeneration process is generally deemed to have been completed.

(3) Regeneration Area and Regeneration Sites

The regeneration area during the plan period is, in principle, set at eight-tenths (8/10) of the total cutting area during the plan period plus the new regeneration area (existing cut-over sites, forest damaged sites and feasible regeneration sites) at the time of plan formulation. When the required regeneration area far exceeds the planting capacity or access to the required regeneration sites is poor, a regeneration area reflecting the actual planting capacity is planned.

The regeneration priority should be given to those sites with favourable weather conditions, sites with good land productivity and sites which have good access to labour and high quality seedlings.

(4) Tending

Excluding those stands where cutting is prohibited, clearance of the forest floor vegetation or the removal of obstructive broad-leaved trees should be conducted according to need if the growth of the regenerated trees appear to be obstructed by the forest floor vegetation or nearby broad-leaved trees.

(5) Nursing

1) Seedling Supply System

In order to eradicate un-regenerated sites among such unstocked areas as fire damaged sites and cut-over sites and to improve the forest productivity through planting, it is necessary to obtain a sizable production volume of high quality seedlings. As seedlings for planting are currently produced by nurseries run by the Forestry Office and timber companies, these will be relied upon for some time given the fact that the production of seedlings requires certain technical expertise and experience. Efforts will, however, be made to improve the technical aspects of these nurseries in terms of soil preparation of the nursing beds (improved water holding capacity and fertility of the soil) and root development (use of fertiliser, thinning and root pruning, etc.) and also to mechanise nursery operation to reduce the seedling production cost with a view to establishing a high quality seedling supply system.

2) Produced Species and Production Volume

The species produced by nurseries are mainly *Pinus sylvestris* and *Larix sibirica* and rooted cuttings of poplar are also produced.

The production volume will be determined by the required quantity of high quality seedlings to conduct reforestation and enrichment during the plan period.

3) Specifications of High Quality Seedlings

Although the present nursing system will basically be adopted, it will be necessary to produce high quality planting stock with good survival and growth prospects and good adaptability to the environment of the planting sites to improve the present situation where such high quality seedlings are not produced in sufficient quantity. The required specifications of the planting stock are described below.

① *Pinus sylvestris* and *Larix sibirica*

3 - 4 years old; 25-30 cm in height; 6 - 7 mm in basal diameter; straight stem with good terminal buds; well-developed branches all round and short, straight roots with a well-developed root system (the ratio of the basal diameter to the height is 50 or higher; the ratio of the height to the total weight is 2 or higher; the T/R ratio is not more than 4)

② Poplar

2 years old; 1 m or taller in height with a well-developed root system (the section above the ground should be cut short when planted on mountain land)

7.4.4 Forest Road Standards

(1) Character of Forest Roads

Most of the existing forest roads have not been systematically planned and have basically become established by travelling vehicles. The sloping section become slippery and the flat sections become muddy at the time of rain, making it difficult for vehicles to travel. As a result, vehicles are forced to travel on the adjoining grassland, creating strips of dirt roads. Hardly any maintenance work is conducted.

A forest road is an essential facility created in a forest area, mainly for the purpose of logging to an ordinary road which is connected to it. It is also closely related to the life of the local community. The roles of a forest road include the speedy transportation of forest products, reduction of the logging cost, facilitation of worker movement and the speedy and accurate gathering of forest management-related information, all of which are made possible by shortening of the transportation or communication distance by a forest road. Forest roads also act as firebreaks at the time of a forest fire and provide convenience for the life of the local community. They are essential to conduct the management of a vast forest in a timely and appropriate manner.

In view of the diverse roles of forest roads, their division from the viewpoint of investment efficiency into trunk forest roads, which are always usable, and spur roads, the use of which is temporary to assist cutting, logging and/or reforestation work, is necessary. It is, therefore, natural that the construction and management methods of these two types of forest roads differ. Inappropriate route selection can lead to the creation of a poor forest road which does not fully function in the years to come. Moreover, poor construction results may induce a landslide or other disaster.

It is, therefore, important to establish route selection criteria and structural standards from a long-term and wide area perspective at the timing of formulating a forest management plan in order to create forest roads and spur roads in an appropriate manner.

(2) Forest Road Plan

The forest road plan must take the investment efficiency, as well as the distribution and composition of forest resources in the same watershed, into consideration. The present dirt roads become muddy during and after rain, making them difficult to use. However, they can support large and heavy special vehicles in winter due to freezing. Given these seasonal characteristics of dirt roads, it is necessary to upgrade trunk forest roads to gravel roads to allow traffic all year road. In the case of minor forest roads and spur roads branching from trunk forest roads, a dirt surface is sufficient to support logging work, commonly conducted in winter, except at those sections which are used to transport seedlings and workers for reforestation purposes. Accordingly, the forest road plan will be prepared for trunk forest roads and spur roads. As it is necessary for even spur roads not to compromise the conservation of forest land and their functional role, a timber company planning to construct a spur road for logging must obtain the approval of the competent forest management organization in advance.

(3) Route Selection

In the selection of a forest road route, it is essential to take such issues as ① expected high usage, ② low construction and maintenance cost and ③ overall conservation of forest land into consideration. Whether or not a forest road meets these requirements depends on its location. A forest road constructed at a valley bottom usually satisfies ① and ③ while a forest road on a ridgeline tends to satisfy ②. In general, it is difficult for any forest road to meet all three requirements. The most appropriate choice appears to be the construction of forest roads at larger valley bottoms and the construction of spur roads at smaller valley bottoms, ridgelines or mid-slopes to link with trunk forest roads with special attention being paid to the conservation of forest land in order for route selection to meet the following alignment requirements.

- Avoidance of soft ground, particularly swamps
- Moderate alignment, eliminating zero or steep longitudinal gradients
- Priority selection of small gradient sites to reduce cutting and banking work; avoidance where possible of bridge construction and alignment with ground undulations
- Passing above topographical points of change on hillsides

(4) Structural Standards for Forest Roads, etc.

As the transportation of logs is mainly conducted using a trailer, this vehicle is used as the reference vehicle to determine the structural standards for forest roads and spur roads. The standard structure shown in Table 99 will be adopted for actual road construction purposes so that the broad shoulders and lane width will allow forest/spur roads to act as firebreaks at the time of a forest fire. While the decision on the forest (spur) road construction method should be based on the topographical conditions, geological conditions and expected construction cost, etc., it is essential to ensure safe travelling on the roads and environmental conservation along the routes. In general, efforts will be made to achieve a balance between cutting and banking to minimise changes of the land features and the transfer of sediment. It is necessary to avoid a steep longitudinal gradient in order to prevent road erosion by running rainwater. Similarly, a zero longitudinal gradient should also be avoided to prevent standing water which softens the road surface, making vehicle passage difficult due to the muddy state of the surface. The lower the grade of road, i.e. dirt road, the more important it is to secure a longitudinal gradient of 2 - 5%. It is also necessary to effectively utilise such locally produced materials as logs, stones and gravel, etc. to minimise the cost of side ditches as well as cross ditches to drain water from the road surface and adjoining slopes and of structures traversing rivers or streams.

Table 99 Structural Standards for Forest and Spur Roads

	Forest Roads	Spur Roads	Remarks
Design Speed	40 km/hour	20 km/hour	
Road Width	10.0 m	5.0 m	
Roadway Width	4.0 m	3.0 m	
Shoulder Width	3.0 m each	1.0 m each	May be reduced to 0.5 m each at sloping sites
Minimum Curve Radius	40 m	25 m	
Widening of Curved Sections	The cant at curved sections will be 6% or less and widening will be introduced in accordance with the curve radius	as left	
Visible Distance	40 m	20 m	
Longitudinal Gradient	Maximum: 7% (10%)	2 - 5%	10% or less if measures are implemented to prevent the longitudinal erosion of the road surface by running water in the case of forest roads; no flat spur road construction will be permitted
Road Surface	Gravel	Earth	
Cross-Sectional Gradient	Maximum: 5%	—	
Drainage Facilities	Side ditch (grass-covered) Cross ditch Water plumbing	Side ditch (L shape) Cross ditch (log) Water plumbing	Large side ditch (bottom width: 0.5 m, depth: 1 m with a sectional form of a trapezoid) for the flat sections of forest roads
Lay-by	Width: 5 m or wider Effective length: 20 - 300 m	Use of natural topographical features or soil disposal site, etc.	
Slope	Appropriate gradient and greening with a mechanical finish to suit the nature of the soil (minor unevenness and bends, etc. will be tolerated)	as left	- Cut slope gradient Ordinary soil: 8% Rocky surface: 3% - Banked slope gradient Ordinary soil: 15% Stone wall: 3%

7.4.5 Forest Conservation Standards

(1) Forest Land Conservation

The existence of a sloping site which is located near a conservation object in a forest management area or which threatens its extension makes vegetative restoration necessary by establishing erosion control belts by planting, etc. In the case of forests in the Intensive Area, the introduction of special forest land conservation measures is not particularly necessary due to the predominance of flat or gently sloping land, low rainfall and the coverage of most forest land by vegetation. However, some eroded sites due to the failure of vegetation recovery are observed at southwest-facing slopes damaged by forest fire. Sediment control belts should be created by planting and other words for those slopes near conservation objects to facilitate the recovery of vegetation.

While the over-grazing of sloping land must be avoided to prevent bare land leading to soil erosion, no sites are currently observed where the ground surface vegetation has been lost due to grazing.

The roadbed of the existing spur roads constructed for the logging of fire damaged trees has been eroded by rainwater at those sections where the longitudinal gradient is steep. The structural standards described earlier should be used for the construction of spur roads to ensure forest land conservation.

(2) Conservation of Rare Forest Vegetation

When growing forest is found to be particularly rare from the viewpoint of academic research in a particular region, the necessity for its protection must be comprehensively examined. If protection is deemed necessary, the area should be designated a nature reserve for scientific research to ensure its conservation.

7.4.6 Forest Protection Standards

(1) Forest Fires

A forest fire occurs almost every year under the meteorological conditions of low humidity and little rainfall and can develop into a conflagration when abnormal drought, strong wind and high temperature coincide. Although forest fire prevention activities have long been implemented by the aimak government, district offices and other related organizations, the following measures will be introduced in view of the fact that most forest fires are caused by human carelessness, including the throwing away of burning cigarette ends and matches and the inadequate extinguishing of open-air fires.

① The liaisoning between various administrative organizations and also between the said organizations and local people will be strengthened to establish aimak and district forest fire prevention and extinguishing systems capable of a quick response.

② Wide ranging public relations and other activities will be actively introduced, including those aimed at urban and rural residents, through radio, TV and publications, intensification of patrols in important forests and forests frequently used by local people, provision of guidance for people using forests and education of children in schools. In addition, a reliable communication system to warn related organizations as well as local people of fires will be established.

③ In view of the vital importance of the early extinguishing of forest fires, a communication channel (portable telephone or radio) between the aimak/district offices and field offices will be established to ensure swift and accurate communication. Topographical maps will be provided at all offices to accurately determine the sites of fires.

④ The fire-fighting vehicles and tools will be improved together with the improvement of forest roads to ensure swift fire-fighting activities to prevent the spread of fires. In addition, more water reservoirs will be introduced for fire-fighting purposes.

⑤ As the present clearance practice at cut-over sites of piling up the limbs and tops could help a ground fire to become a crown fire, this practice will be discouraged. Pruning of upto some 3 m from the ground will be conducted to prevent ground fires from becoming crown fires.

(2) Damage to Trees Due to Logging, etc.

As the present logging practice is not only tree length logging but also full tree logging in some cases, such damage as the barking of the remaining trees and the over-turning of young trees can occur. The skidding of tree length logs also causes the barking of remaining trees at curved road sections. In order to prevent damage to remaining trees and succeeding young trees due to logging and skidding, full tree logging will be prohibited. If necessary, logging and skidding will be modified to reduce full length logs to half length logs or specific length logs.

(3) Weather Damage

Damage to reforestation sites by such weather conditions as freezing temperatures and drought occurs in and around the Intensive Area. Although the occurrence of such damage in the future is expected to decline because of the prohibition of clear cutting, it may still occur to planted trees at large unstocked areas, such as fire damaged areas, where reforestation is attempted. It is, therefore, very important to select appropriate species while tending those broad-leaved trees which creep into the reforestation sites.

(4) Damage Due to Diseases, Harmful Insects and Animals

1) Damage Due to Diseases and Harmful Insects

Those forests of which the vigour has declined due to uniform reforestation over a large area with a single species or due to forest fire often suffer from major damage due to diseases or harmful insects. In addition to avoiding uniform reforestation over a large area, it is necessary to regularly patrol reforestation sites to detect the early signs of damage due to diseases or harmful insects, followed by careful observation of the damage development. If a major outbreak is feared, early control is required. Once damage due to a fire, etc. occurs, the damaged trees should be quickly cut and removed from the forest to prevent secondary damage by diseases and/or harmful insects. Such quick action will also ensure the effective use of damaged trees.

Forests in and around the Intensive Area were severely damaged by the forest fire in 1996 and efforts should be made to cut, log and use the damaged trees as quickly as possible to prevent the spread of secondary damage by diseases or harmful insects. In this case, the cutting volume of the damaged trees should, in principle, be counted as part of the allowable cut volume of live trees.

2) Damage by Wild Animals

Sporadic damage to the bark or stem by deer and bears, etc. can be observed. While the protection of wild animals is stressed in forests other than timber protection forests, the co-existence of trees and animals/birds in timber production forests is also important for hunting insects. Accordingly, the present level of damage by wild animals should be tolerated.

(5) Damage Due to Domestic Animals

Reforestation around grazing land carries a risk of damage due to domestic animals depending on the planted species. The erection of protective fencing and the assignment of guards should be conducted, if necessary, to prevent domestic animals from damaging the planted trees.

7.5 Preparation Standards for Forest Management Plan Maps, etc.

In line with the formulation of the forest management plan, the following maps and documents will be prepared as appendices.

(1) Forest Inventory Book

Based on the findings of the field survey, which is conducted using aerial photographs and the forest type maps, etc. as reference materials, the current conditions of the subject forests will be compiled in the forest inventory book, the entry items of which are listed below.

- Administrative location; compartment; sub-compartment; legal designation; management category
- Area; stand quality class; slope class; soil type; forest floor vegetation
- Species; stand age; forest management type; forest physiognomy; tree height; DBH; crown density; volume composition by species
- Volume; volume/ha; annual increment; others

(2) Forest Type Map

The forest management type, forest type, species and crown density, etc. will be plotted on the forest type maps (scale: 1/25,000 or 1/50,000) using the sub-compartment as the mapping unit.

(3) Forest Management Plan Map

The management categories, permitted cutting sites, regeneration sites and forest road routes, etc., all of which constitute the forest management plan, will be plotted on the forest management plan map (scale: 1/25,000 or 1/50,000).