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Effects of Site Preparation on the Regeneration of Larch Dominant Forests after a Forest Fire in the Daxinganling Mountain Region, Northeast China

Shi, Fuchen [1]*, Zu, Yuangang [1], Suzuki, K.[2], Yamamoto, S.[3], Nomura, M.[4] and Sasa, K.[5]

[1] Open Research Laboratory of Forest Plant Ecology, Northeast Forestry University, Harbin 150040, China
[2] Laboratory of Forest Botany, Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo 113-8657, Japan
[3] National Institute for Resources and Environment, 16-3, Onogawa, Tsukuba 305-8569, Japan
[4] Teshio Experiment Forest, Hokkaido University, Horonobe, Hokkaido 098-2943, Japan
[5] Hokkaido University Forests, Sapporo 060-0809, Japan

Abstract

A large-scale forest fire occurred in the Daxinganling Mountain area in May, 1987. The burnt area extended up to 1.345 million hectares. An investigation was carried out on the effects of site preparation in the burnt area on the natural regeneration of tree species. Natural regeneration of *Larix gmelinii* Rupr. and *Pinus sylvestris* var. *mongolica* Litv. was facilitated by the site preparation after forest fires of light and intermediate intensity. Seedlings of *Pinus sylvestris* var. *mongolica* were very few irrespective of the fire severity. A large number of seedlings of *Betula platyphylla* was found in the heavy-fire site, which regenerated mainly from 1991 to 1993. The results suggest that the arrangement of mother trees play an important role in the recovery of forests after forests fires in the Daxinganling area.

Key words: Larch (*Larix gmelinii*) forests, Forest fires, Natural regeneration, Daxinganling area, Site preparation.

Introduction

Forest fires occur frequently in the Daxinganling Mountain area in northeast China. In this region, there were ca. eight forest fires for almost every 12 years in the last years(Xu 1997). Therefore, forest fires have a great impact on forest succession and regeneration in the Daxinganling Mountain area. This region is located at the southern edge of the discontinuous permafrost zone (Hayashida 1989, Zhu 1989). Studies on plant species composition and age structure of forest stands established after forest fires are few (Wang 1989, Chou and Liu 1995). Without disasters such as large and intensive forest fires, the vegetation would change through a successional development along the environmental conditions (elevation, micro-topography and soil fertilities, etc.) (Wang 1989, Kayama *et al.* 2000).

Previous studies on the vegetation recovery after a forest fire mainly concentrated on the establishment of the practices of tree plantation (Shi *et al.* 1996), however, a few studies on the natural regeneration in the burnt area have been conducted in relation to global climate change (Cao *et al.* 2000, Shi *et al.* 2000).

To explore the basic characteristics of vegetation recovery and effects of the site preparation on natural regeneration of trees after forest fires, this study was connected to analyze the regeneration success of trees. Based on the survey, we detail the recovery and regeneration of forest vegetation in areas affected to various intensities by a forest fire in the Daxinganling Mountain area in 1987.

Materials and Methods

1. Study sites

The study site was located in The Amur Forestry Bureau of the Daxinganling Mountain area in Heilongjiang Province (123° 10' E, 52° 45' N). At this site (Fig. 1), the tree growing period is ca. 70-100 days from the early June to the end of August, and the annual mean temperature is 5℃, the lowest temperature is -47 ℃ and the highest is 35℃. The frost-free period is 65-75 days in a year. The annual precipitation is 400-500 mm, and 80-90% of the annual precipitation is concentrated in July and August. The soil type is classified into the brown conifer forest soil, and the discontinuous permafrost layer is broadly distributed (Hayashida 1989). The deepest frozen layer is approximately 2.5 m in depth.

The dominant vegetation type in the Daxinganling Mountain area is *Larix gmelinii* Rupr. forest mixed with *Pinus sylvestris* var. *mongolica* Litv., *Betula platyphylla* Suk. and

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* Corresponding author: prborl@public.hr.hl.cn

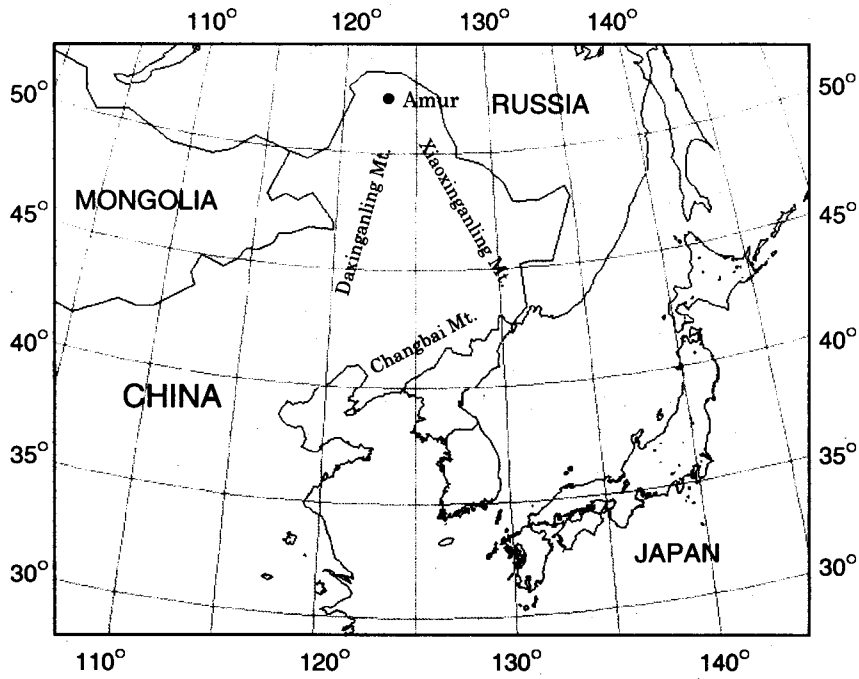

Fig.1. Sampling sites after the forest fires in the Daxinganling Mountain.

Populus davidiana Dode. The shrub layer in larch stands is generally dominated by *Ledum palustre* Linn. mixed with *Rhododendron dauricum* L., *Rosa davurica* Pall. and *Vaccinium vitis-idaea* L. (Chu and Lui 1995, Shi *et al.* 2000).

Large-scale forest fire occurred in this area in May 1987, and the burnt forest area was up to 1.345 million hectare (Shi *et al.* 1996). The volume of timbers burnt was 0.38 billion m^3. The forest fire also caused a decrease of forest coverage, which was about 14%, and at the same time the permafrost layer became shallower and swampy sites appeared in many forested areas.

2. Methods

The Amur Forestry Bureau is located in the central area affected by a large-scale forest fire in 1987. After the fire, local foresters and we made site preparations in spring 1988 in order to observe the regeneration processes of trees after the disturbance. In the present study, the burnt area was classified into three types according to the fire intensity; light, intermediate and heavy fire affected areas. The light fire means the ground surface fire, and trees were not burnt to the extent of killing them. Intermediate fire means the ground surface and canopy fire, and some trees were burnt to the extent that they died. It also reduced the growth of dominant trees. The heavy fire means very serious forest fire disaster. Trees were burnt completely and the burnt site changed into a secondary bare land.

In the site-prepared plots, 40cm-wide and 10cm-deep furrows were made, and the distance between furrows was 1m. Further, natural regeneration plots without any site preparation were set up in the three types of burnt area.

We investigated the above-mentioned plots in June 1994, and the size of each plot was 20m x 20m. Among these plots, 4 natural regeneration plots and 4 site prepared plots were designated in the light fire area, 5 natural regeneration and 5 site-prepared ones in the intermediate fire area, and 4 natural regeneration and 4 site-prepared ones in the heavy fire area. Age of all the tree individuals in every plot was investigated.

Results

1. Natural regeneration on sites of different fire intensity

Seedlings of four tree species regenerated naturally in the burnt area which had previously been larch forests namely *Larix gmelinii, Pinus sylvestris* var. *mongolica, Betula platyphylla* and *Populus davidiana* (Figs. 2-4). Seedlings were very few in the three years (1988-1990) immediately after the fire. No seedlings occurred in all the natural regeneration plots in 1988 and less than 15 seedlings were recorded in the plots from 1989 to 1990. The number of regenerated seedlings of *Larix gmelinii* had been increasing continuously from 1991 in most of the plots.

The number of seedlings after the light fire was more than those after the intermediate and heavy fires. Total number of seedlings were more than 70 in all plots in 1993 and/or 1994 (Figs. 2-4). The regenerated seedlings of *Pinus sylvestris* var. *mongolica* were less than those of *Larix gmelinii*

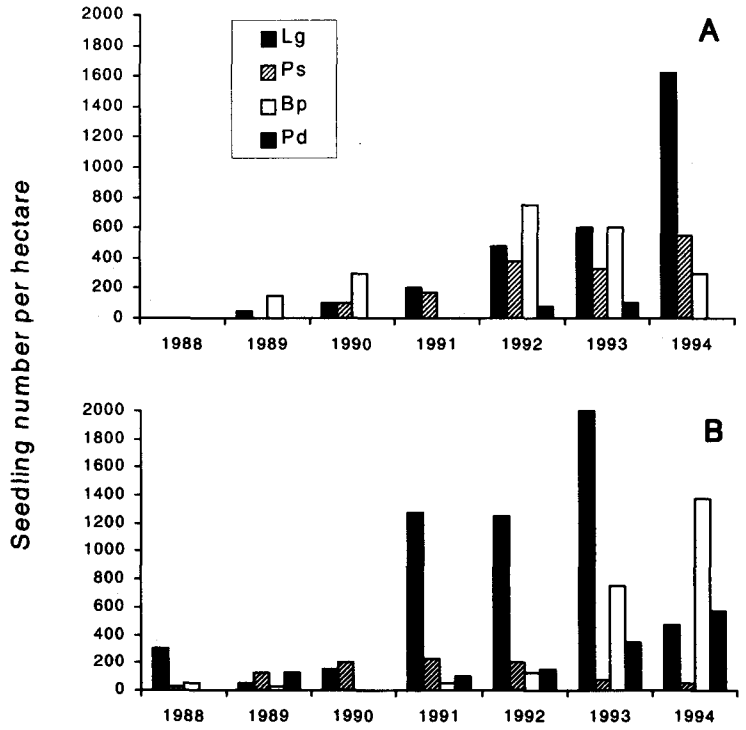

Fig. 2. Seedling number of tree species that occurred on the sites burnt by light fire without (A) and with (B) site preparation.

Abbreviations, Fig.2-4; Lg: *Larix gmelinii* Rupr., Ps: *Pinus sylvestris* var. *mongolica* Litv., Bp: *Betula platyphylla* Suk., Pd: *Populus davidiana* Dode.

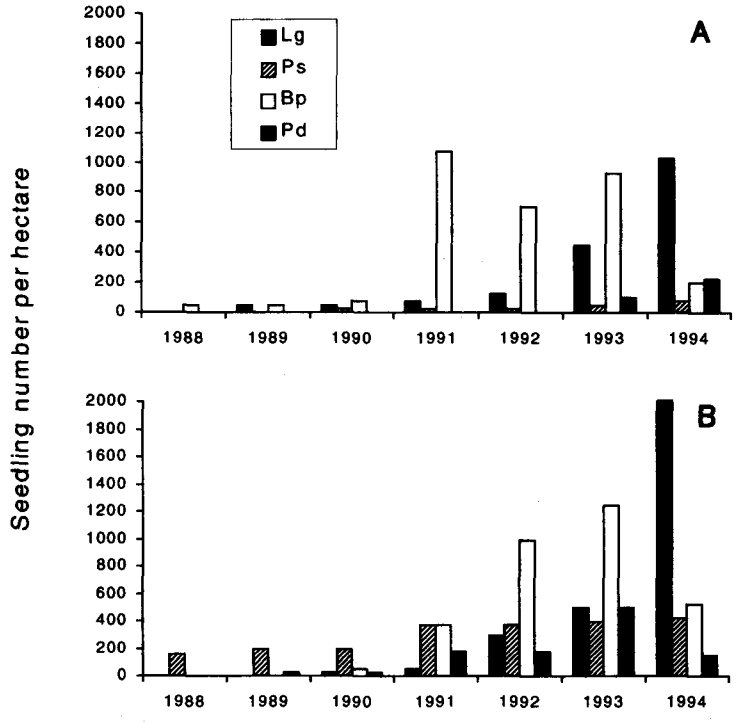

Fig. 3. Regeneration sequence after the intermediate level of forest fire of 1987.
A: No ground treatment
B: With site preparation on the ground

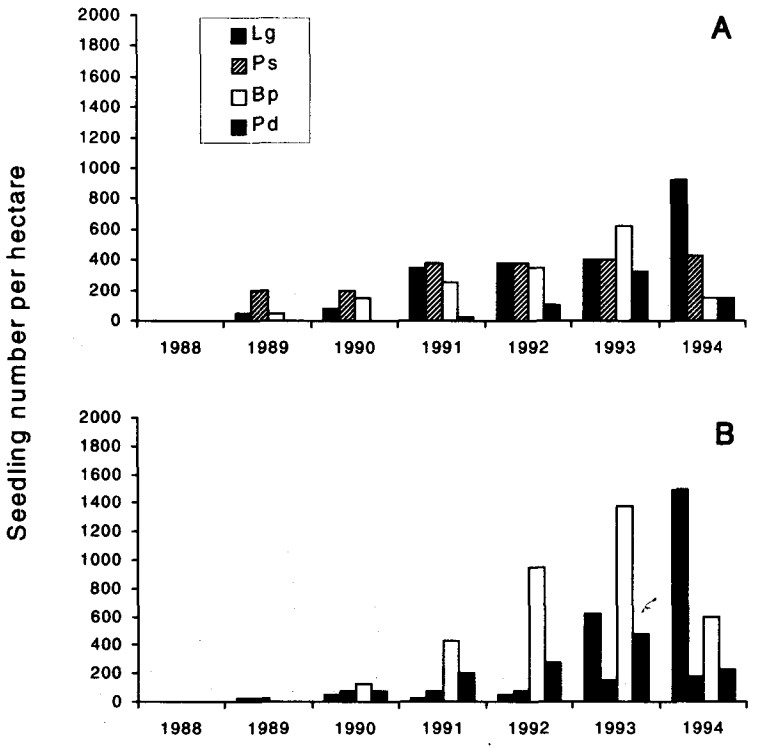

Fig. 4. Regeneration sequence after the heavy level of the forest fire of 1987.
A: No ground treatment
B: With site preparation on the ground

in all plots. Seedlings of *Betula platyphylla* were the most abundant on the prepared site after the heavy fire, which regenerated mainly from 1991 to 1993. Seedlings of *Populus davidiana* were relatively fewer, however, seedling establishment was successful in the heavy burnt area. The maximum number of seedlings of *Populus davidiana* were only 600 per hectare.

2. Effects of the site preparation on tree regeneration in the different fire intensity areas

Effects of the site preparation on the regeneration of tree species are shown in Figs. 2-4. The site preparation markedly facilitated natural regeneration of seedlings of *Larix gmelinii* in order of the light-prepared sites and intermediate-fire sites. Regeneration in the plots with site preparation started earlier than in plots without site preparation. Moreover, the numbers of regenerated seedlings of *Betula platyphylla* on the prepared sites increased gradually and in 1994 were more than sites without site preparation. However, the number of seedlings of *Pinus sylvestris* var. *mongolica* and *Populus davidiana* apparently did not increase on the prepared sites.

3. Regeneration response in regeneration of each species to site preparation

The total numbers of seedlings that occurred from 1988 to 1994 are shown in Table 1. Without site preparation, the number of seedlings of *Larix gmelinii* decreased with increasing fire intensity. By the site preparation, the number of seedlings of *Larix gmelinii* increased in all burnt areas. The regeneration characteristics of *Pinus sylvestris* var. *mongolica* was the same as *Larix gmelinii*, but the degree of increase of the seedling number was smaller. The numbers of seedlings of *Betula platyphylla* and *Populus davidiana* had an increasing trend with the site preparation.

Discussion

Among the small-sized shrubs, dominant species such as *Ledum palustre* Linn. form a thick vegetation cover which usually inhibits seed germination in natural larch forests. Forest fires eliminate such shrubs and then the conditions for the regeneration of seedlings of light demanding species may be improved by fires. In the light and intermediate burnt area with site preparation, the number of seedlings of *Larix gmelinii* was 5500ha^{-1} and 3200ha^{-1}, respectively. This number of seedlings allows the larch stand will be able to rehabilitate without any further reforestation practices (Shi *et al.* 2000).

In the heavy-burnt area, since the original vegetation was completely burnt, the ground layer had no factors to limit regeneration.

Table 1. Total numbers of seedlings that occurred from 1988 to 1994 (20m x 20m)
Figures in parenthesis show the number of seedlings per hectare

Species	Site preparation	Number of seedlings/Fire severity/ Light	Intermediate	Heavy
Larix gmelinii	Non-prepared	122(3050)	87(2175)	71(1775)
	Prepared	220(5500)	128(3200)	91(2275)
Pinus sylvestris var. *mongolica*	Non-prepared	61(1525)	58(1450)	19(475)
	Prepared	36(900)	85(2125)	23(575)
Betula platyphylla	Non-prepared	84(2100)	123(3075)	71(1775)
	Prepared	95(2375)	128(3200)	139(3475)
Populus davidiana	Non-prepared	7(175)	13(325)	24(600)
	Prepared	52(1300)	42(1050)	50(1250)

Therefore, the effect of site preparation on the acceleration of natural regeneration was not clear compared with the light and intermediate burnt areas. The relative growth rate between 1988 and 1996 was estimated to be larger at the heavy burnt area because of small number of seedlings there. (Cao *et al.* 2000).

If no fires in the Daxinganling Mountain occurred, not larch but spruce would dominate because of its shade tolerant capacity (Uemura *et al.* 1990). Berg and Chapin (1994) pointed out that deciduousness has an advantage in avoiding the strong water deficit at needle flushing period in the permafrost region. As a tentative conclusion, dominant species in the Daxinganling Mountain may be determined by the physiological traits of water relations or shade tolerant capacities.

Of course, the seed resource of mother trees is a key factor in natural regeneration. The larch species has a masting year with a three-year interval. The masting year of the larch forest around the study sites was observed in 1993 (Shi *et al.* 1996), therefore there was a peak of regeneration in many plots in 1994. In the heavy-fire sites, the effect of the site preparation on the regeneration of *Pinus sylvestris* var. *mongolica* and *Larix gmelinii* was not clear. This might have resulted partly from the lack of seed resource. In contrast, the regeneration of *Betula platyphylla* and *Populus davidiana* occurred well at the prepared sites, because they have a high ability of sprouting and long-distance spreading of seeds.

Vegetation recovery will occur by natural regeneration even at the heavy-fire sites if tree seeds are sufficiently dispersed. If seedling density after fires is small, then we should make reforestation practices. Also, the typical light-demanding species, such as *Betula platyphylla* and *Populus davidiana* will dominate at many sites after heavy fires. We will continue to study on the quantitative aspects of forest dynamics and the ecological characteristics of each tree species to predict the vegetation change under the effects of global climatic change.

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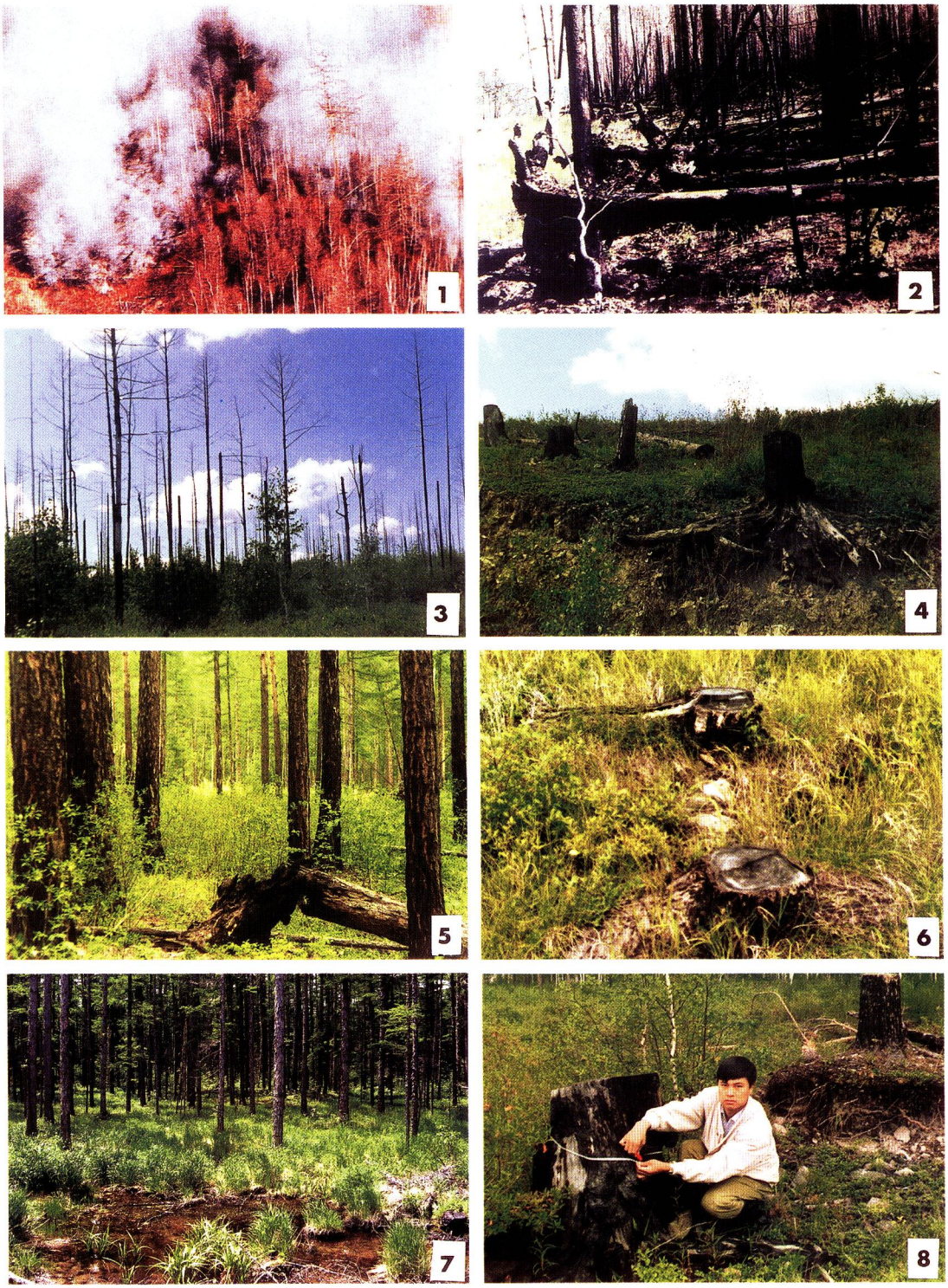

Photo, 1. A view of forest fire in the Daxinganling Mountain region (Photo by Li, J.).
Photo, 2. Example of the heavy burnt area (Photo by Li, J.). Poorly developed root of larch grown under the shallow soil layer. Many dead trees were standing, which may induce an insect problem.
Photo, 3. Natural regeneration after a heavy forest fire. White birch started to regenerate after the fire.
Photo, 4. Dead stump in the shallow soil condition after fires. Horizontal roots were well developed.
Photo, 5. Example of the regeneration of larch and birch after a light forest fire. There was a trace of burning on the lower part of a stem.
Photo, 6. Cutting of dead trees to avoid the insect outbreak following the forest fire.
Photo, 7. Larch forest regenerated at a high density after the forest fire.
Photo, 8. Measurement of a dead stem for reconstructing the forest conditions before a forest fire. The person in this photo is the first author of the present study.