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# Vegetation Characteristics of a Larch-dominant Site for $CO_2$ Flux Monitoring Study at the Laoshan Experimental Station in Northeast China

SHI Fuchen[1,2]* CHEN Xiangwei[1], WANG Wenjie[1,2], TAKAGI Kentaro[3], AKIBAYASHI Yukio[4], SASA Kaichiro[5] and UEMURA Shigeru[4]

[1] Northeast Forestry University, Harbin 150040, P.R.China
[2] Graduate school of Agriculture, Hokkaido University, Sapporo 060-8589, Japan
* Present address: Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Building 917, Datun Road Anwai, Beijing, 100101 P.R. China
[3] Teshio Experimental Forest, FSC for Northern Biosphere, Hokkaido University, Horonobe 098-2943, Japan
[4] Northern Forestry Research and Development Office, FSC for Northern Biosphere, Hokkaido University, Nayoro 096-0071, Japan
[5] Hokkaido University Forest, FSC, Sapporo 060-0809, Japan

## Abstract

Carbon flux of larch forest ecosystems, broadly dominating in the permafrost zones of the northeastern Eurasian continent, is a quite useful indicator for the monitoring of the global warming. To integrate the biomass and vegetation dynamics data for evaluating the $CO_2$ fixation capacity of larch forests, an international cooperative research project has been conducted at a larch plantation in the Laoshan Experiment Station (LES) in Northeast China. One of the objectives is to test the hypothesis that larch forest is further important as a $CO_2$ sink because of the longer life span among the northern trees. Besides the monitoring of $CO_2$ flux, we surveyed the vegetation characteristics of forest understory, and compared with the larch plantation in the Teshio Experimental Forest (TEEF), northern Japan, governed by coastal climate. A total of 53 plant species was recorded in the forest site of LES including two dominant tree species such as *Larix gmelinii* and *Fraxinus mandshurica* in the canopy layer. The forest understory vegetation was quite different from that in TEEF, where dwarf bamboo *Sasa* completely occupied the forest floor and the species composition was very simple. The difference in understory vegetation was expected to lead different net primary production of the ecosystem, and therefore, we should conduct further comparative experiments to reveal the $CO_2$ flux in these sites.

*Key words*: light demanding species, microclimate, net primary production, permafrost, regeneration, understory

## Introduction

Larch species are the dominant deciduous conifers in the northeastern part of the Eurasian continent, where continuous or discontinuous permafrost layers are well developing (e.g. van Cleve and Dyrness 1983). The discontinuous permafrost layers are widely distributed in Northeast China, where forest ecosystems are dynamically maintained by forest fires frequently occurred (Hotta 1974, Uemura *et al.* 1990). In relation to the function of moderating the recent global warming, importance of the ecological succession and forest regeneration in this region has been recognized. We have been applying demographic approach to reveal the natural forest regeneration after fires (Shi *et al.* 2000). It is an urgent subject for us to make clear the $CO_2$ fixation capacity of forest, because the ecosystems are regarded as a big carbon sink (IGBP 1998). Based on the research for 6 years, trees of larch, birch and poplar known as typical early-successional species can rapidly fix $CO_2$ due to the high photosynthesis ability, and thus, they sufficiently act as a $CO_2$ sink there. They can quickly occupy the post-fire habitats specifically depending on the intensity of burning. On the places after a light burning, for instance, larch trees would germinate soon and dominate through artificial ground treatments (Shi *et al.* 2000).

Larch may have further advantage as a $CO_2$ sink because of its longer life span of more than 250 years. In contrast, longevity of birch, one of other pioneer species, is generally 100 years or less. To integrate the data of biomass and vegetation dynamics for the monitoring of $CO_2$ fixation capacity, we have been yearly estimating net primary production of the representative tree species native to Northeast China, such as *Larix gmelinii*, *Betula platyphylla* and *Pinus sylvestris* var. *mongolica*. Plantation of these species and monitoring of their biomass for nearly 40 years have been conducted in the Laoshan Experiment Station (hereafter, LES) belonging to Northeast Forestry University (Photo 1-2). These man-made larch forests are established under continental

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* Corresponding author: e-mail: fcshi@cern.ac.cn

climatic conditions, i.e., a little precipitation less than 800 mm is provided per year (Walter 1979). One of the other environmental features of this region is the underlying permafrost acting as an important water pool.

In this paper, we show the outline of the climatic features in LES and list up the species composition in the forest understory, because the ground vegetation usually share the function of $CO_2$ sink during leafless period of the overstory. Moreover, we attempt to compare the vegetation features in LES with those in the Teshio Experiment Forest (hereafter, TEEF) of Hokkaido University in the northernmost Japan. In contrast with LES, TEEF is located under coastal climate conditions with much precipitation of around 1000-1200 mm per year (Takaoka and Sasa 1996), although the two study sites locate on the same latitude of 45°N in northeastern Asia. In general, *Sasa* bamboo densely dominates in the forest floor in the snowy region of Japan, and is regarded as a big $CO_2$ sink due to their evergreen leaf habit in the deciduous forest (Lei and Koike 1998). We dedicate this report to further study of the $CO_2$ flux monitoring in the two larch plantation sites for evaluation of the $CO_2$ sink capacity of larch forest ecosystems.

## Materials and methods

### 1. General property of *Larix gmelinii*

Larch species are broadly distributed in the Northern Hemisphere, especially in the boreal forest zone of the northeastern part of the Eurasian continent. One of the typical habits of larch species is deciduousness in winter, which facilitate their successful survival in the dry and cold environments, and even on the permafrost soil, they can withstand the severe environments well. Among the members of the genus, *Larix gmelinii* is the most widespread species probably due to the ecophysiological adaptability to various stresses such as drought, freezing, fire and herbivores (Dylis 1961, Sakai 1983). The northern distribution limit of *Larix gmelinii* reaches at about 72° N in the basin of Lena River, eastern Siberia (Ishizuka *et al.* 1994), and they often form the transition zone between boreal forest and arctic tundra formations there, while the southern limit is situated at 43° N nearby the Korean Peninsula overlapping with the distribution of *Larix olgensis* (Shi 1999).

### 2. Location and climate of the study sites

The location of LES is northwestern part of Mt. Zhangguangcai belonging to the Changbai Mountain Chain, Jilin Province, Northeast China, approximately situating in the southernmost part of the distribution area of *Larix gmelinii*. Geographical coordinates of the research site is 45° 20′N, 127° 34′ E, and the altitude is about 340 m a.s.l. (Fig. 1). Soil type is the typical dark-brown forest soil, viz., fertile and mesic. The climate is typical continental monsoon climate characterized by distinct four seasons usually with long winter and short summer. Winter is dry and cold while summer is humid and hot. Mean annual precipitation and mean annual evaporation are 723.8 mm and 1093.9 mm, respectively. Precipitation almost provided by rainfall concentrates in July and August. Annual mean air temperature and humidity are about 2.8°C and 70%, respectively. Mean duration of sunshine is 2471.3 hours per year. Frost-free period is about 120-140 days per year. There is much evaporation and little amount of rainfall in spring usually with strong and dry storms. In autumn, air temperature is somewhat higher than in spring, and the weather condition is relatively stable. Mean monthly values of

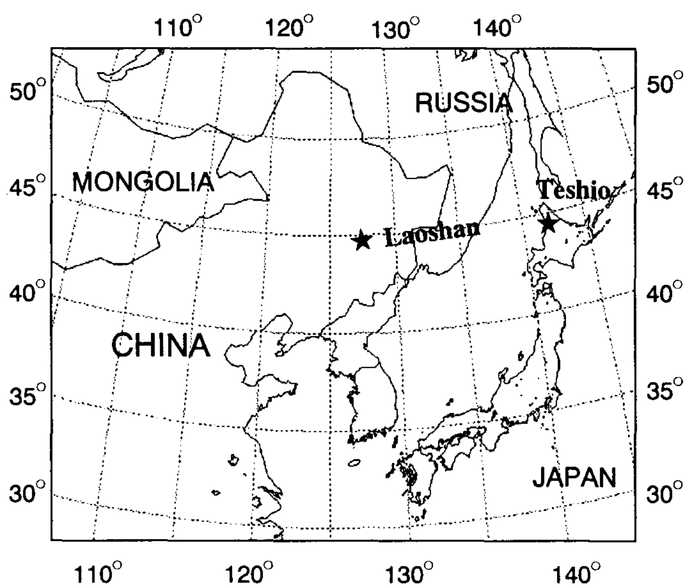


Fig. 1. Study sites

meteorological conditions observed at the LES office from 1961 to 1966 are shown in Figs. 2-5 (NEFU 1984, Li 1993): i.e., air temperature, ground surface temperature, rainfall, evaporation, snowfall, and duration of sunshine. In addition, microclimate of inside and outside of larch forest was observed from 1980 to 1989 (Figs. 6-11): i.e., mean air temperature, maximum and minimum air temperatures, relative humidity, ground surface temperature, and soil temperature at 20 cm depth.

TEEF is located at 45° 03′ N, 142° 07′ E, and the altitude is about 70 m a.s.l. Mean annual temperature is 5.7°C (maximum and minimum temperatures are 35°C and –35°C, respectively). Annual precipitation is around 1,000 mm and the maximum snow depth is about 2 m in midwinter. The forest site studied is a plantation of F1 hybrids of *Larix kaempferi* from central Japan by *Larix gmelinii* from Sakhalin Island, Russia. The afforestation by larch trees was made in 1970. The soil is mesic and clayey and belongs to Pseudogley (Dystric gleysols by FAO classification or Epiaquepts by Soil Taxonomy). Permafrost is not distributed here, and seasonal frozen soil is not formed because of the low heat conductivity of thick snow pack throughout a winter.

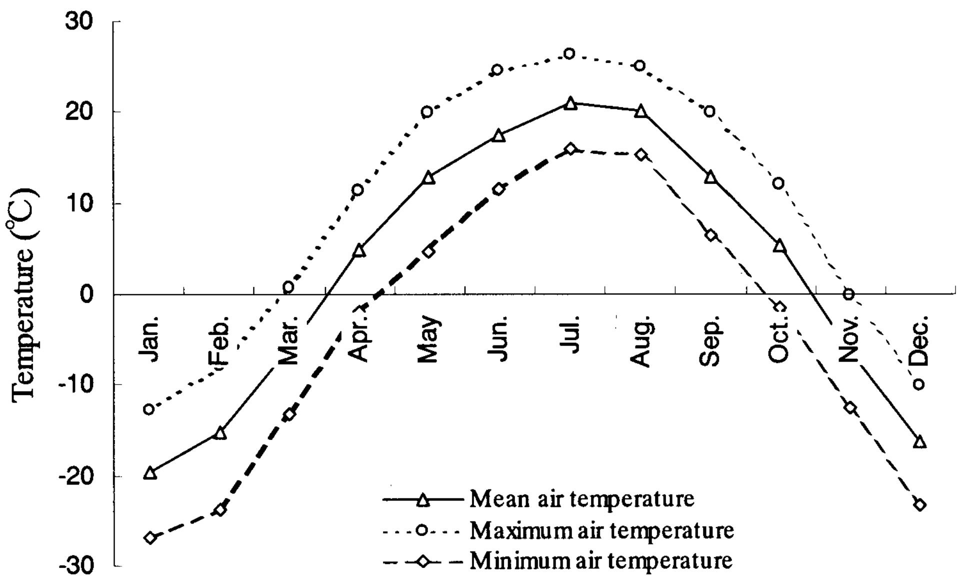


Fig. 2. Seasonal change in monthly mean air temperature with maximum and minimum values of the LES (1961-1966)

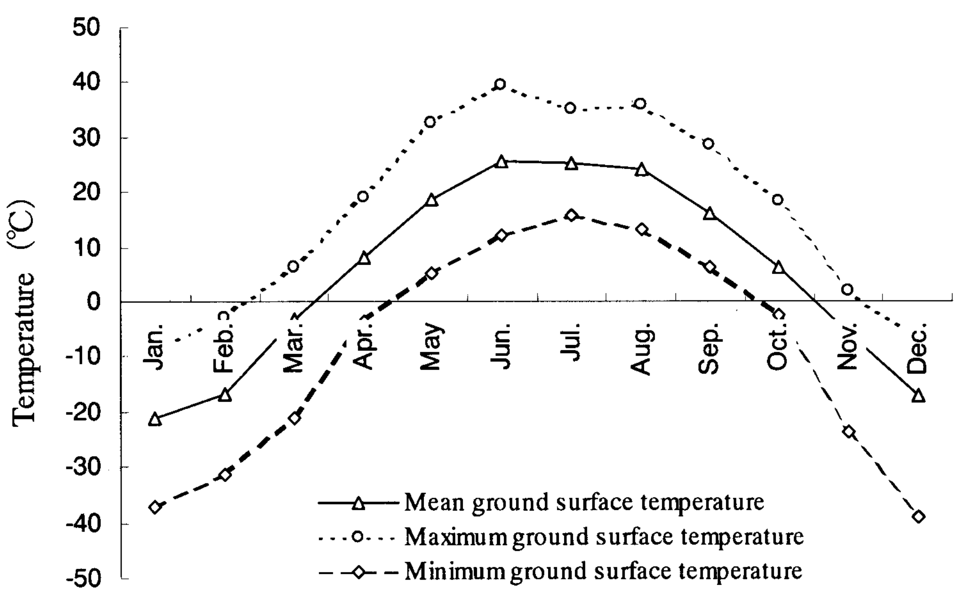


Fig. 3. Seasonal change in monthly mean ground surface temperature with maximum and minimum values of the LES (1961-1966)

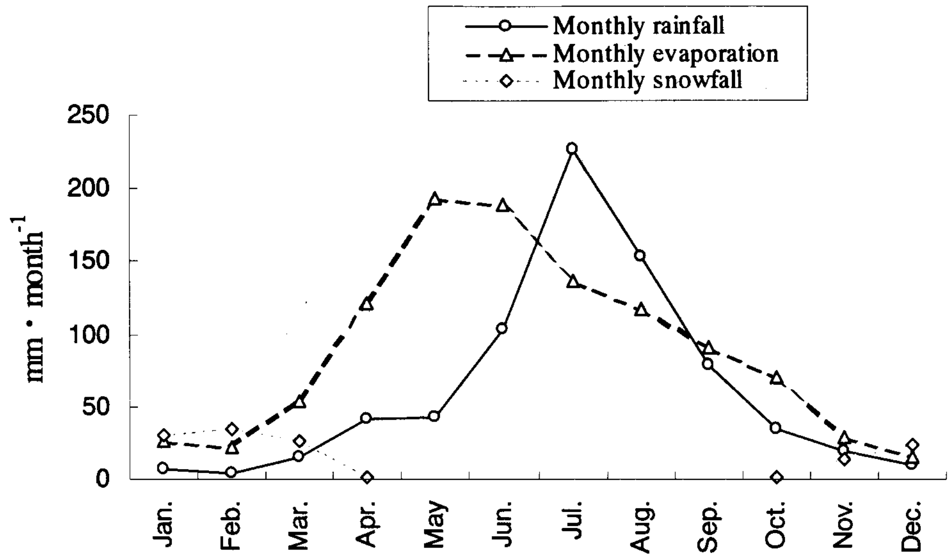


Fig. 4. Manthly precipitation evaporation and snowfall of the LES (1961-1966)

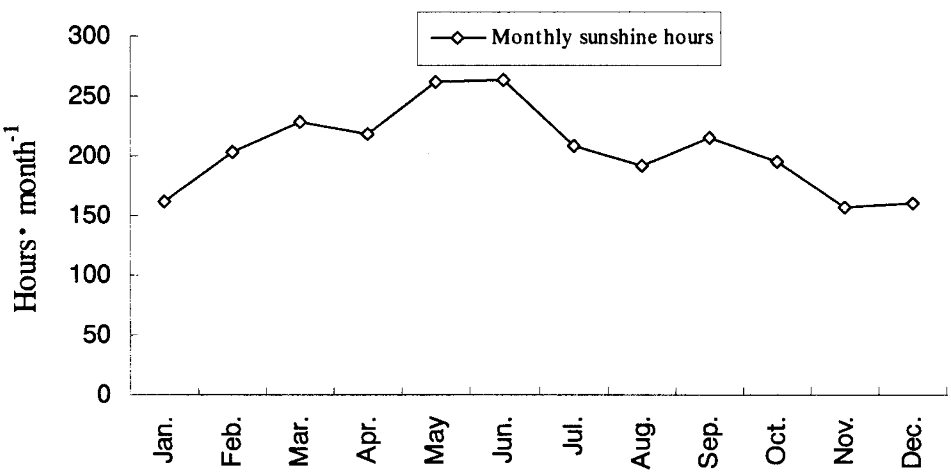


Fig. 5. Monthly sunshine hours of the LES (1961-1966)

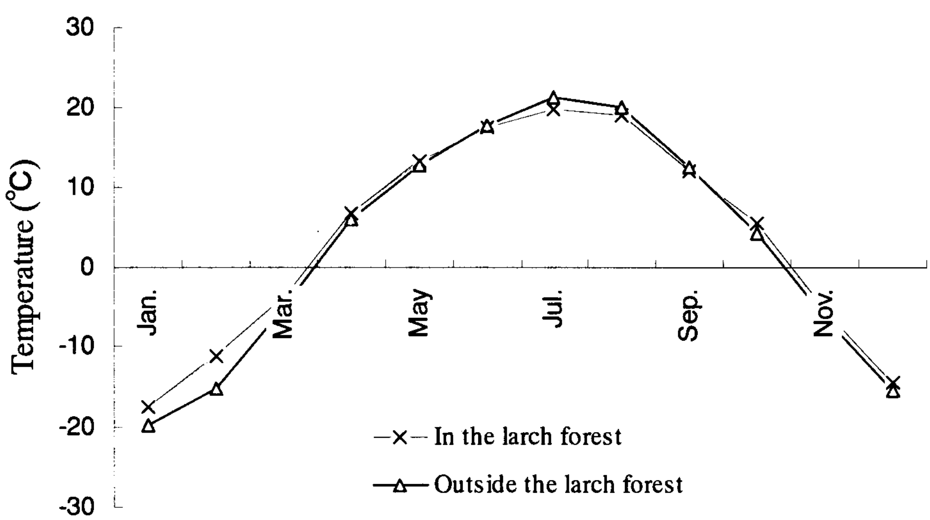


Fig. 6. Monthly mean air temperature in the larch forest and outside the larch forest (1980-1989)

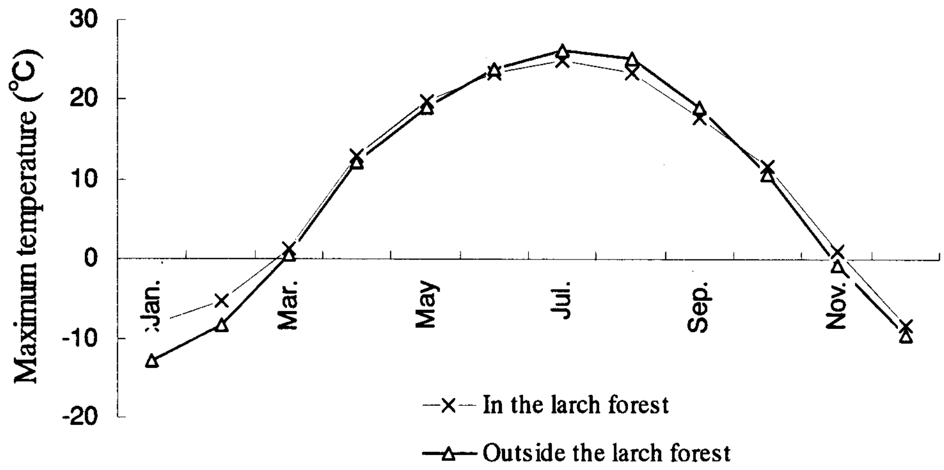


Fig. 7. Monthly maximum air temperature in the larch forest and outside the larch forest (1980-1989)

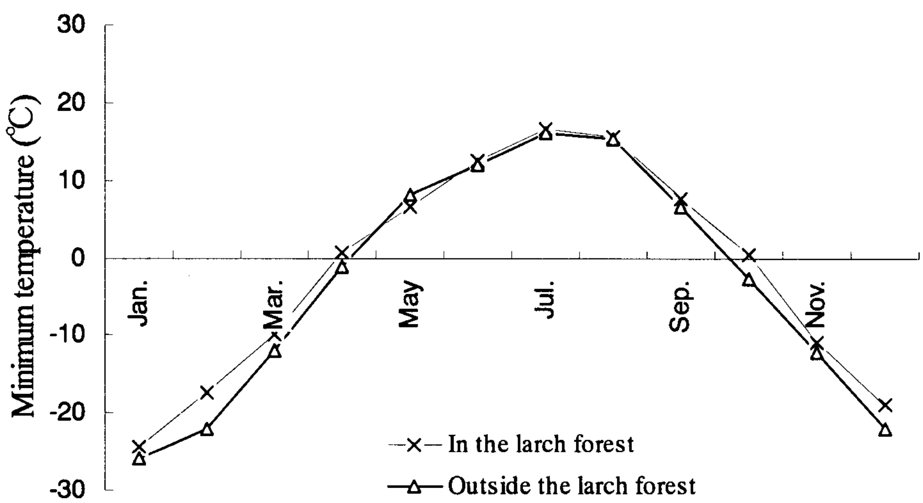


Fig. 8. Monthly minimum air temperature in the larch forest and outside the larch forest (1980-1989)

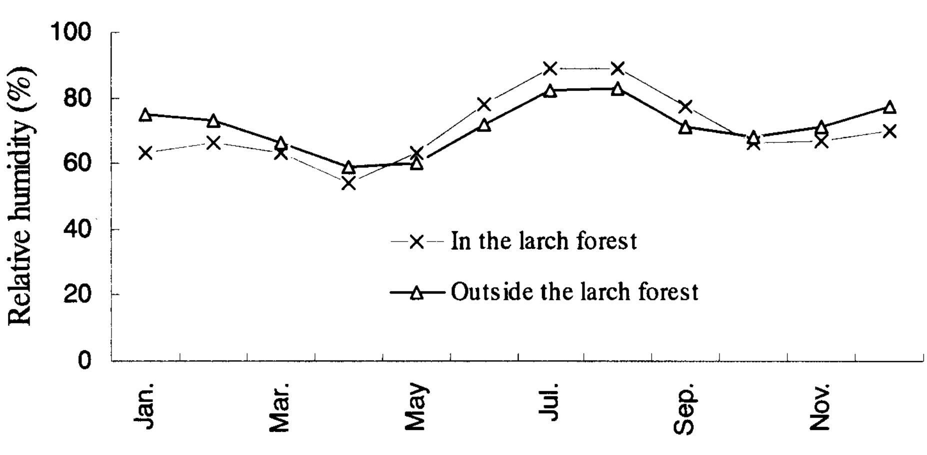


Fig. 9. Monthly mean relative humidity in the larch forest and outside the larch forest (1980-1989)

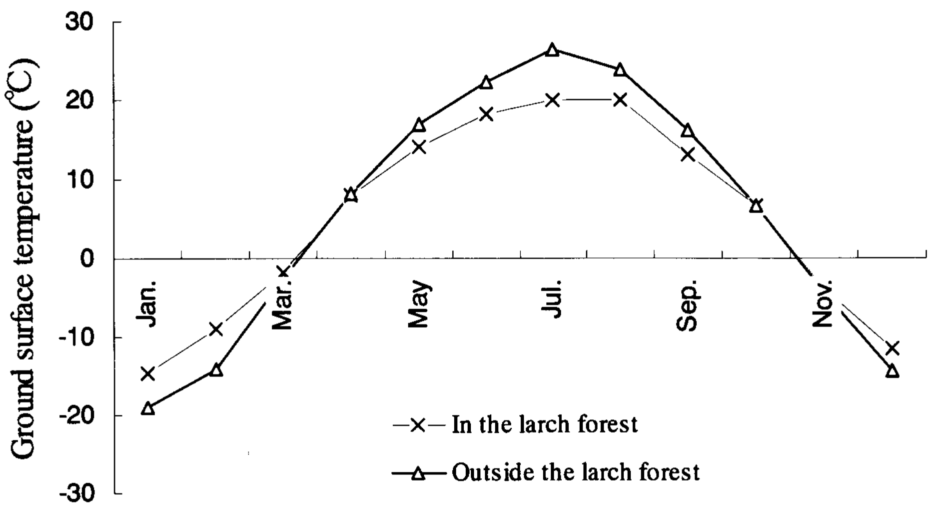


Fig. 10. Monthly mean ground surface temperature in the larch forest and outside the larch forest (1980-1989)

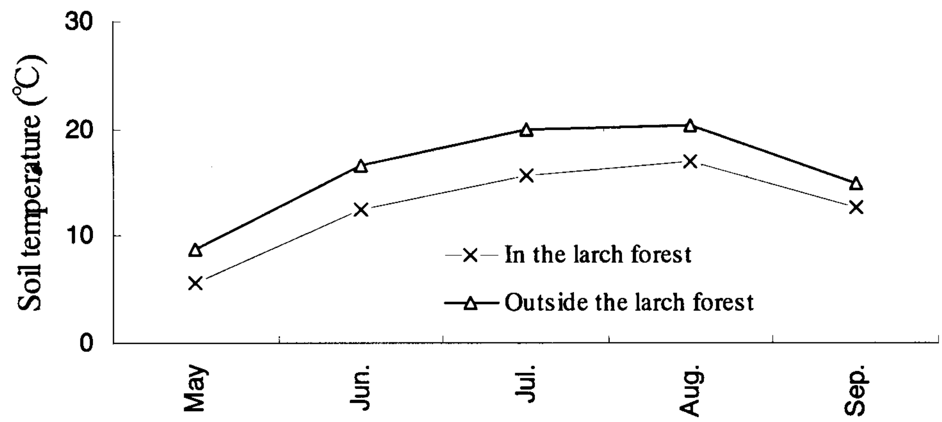


Fig. 11. Soil temperature at 20cm depth in the larch forest and outside the larch forest (1980-1989)

**3. Study facilities and vegetation survey**

An international cooperative research project between China and Japan started from 2000 in LES. The main research work is $CO_2$ flux monitoring of a larch forest to estimate the net ecosystem production (NEP). The study site was afforested with 3,300 larch seedlings per hectare after the clear cutting of a low-grade secondary forest in 1969. A permanent quadrat (0.4 ha) was set in a larch plantation in 2000, and a canopy accessible tower using steel cage for the monitoring was built in the quadrat (Photo 3-6). Height of the canopy tower was 24 m in initial, and then it was reconstructed with additional steel poles to access until 27 m height (Photo 7). We established several permanent plots for the monitoring of vegetation to measure the biomass increments in the quadrat, and measured the diameter at the breast height (DBH) of all trees larger than 10 cm in these plots. For the monitoring of vegetation, we assessed the coverage of vascular plant species growing in the permanent plots by means of Braun-Blanquet (1964). Moreover, watershed research has been made as a part of long-term ecological study of a larch plantation (Photo 6).

In order to eliminate the influence by human activity for field works on the $CO_2$ flux monitoring, a standard plot (0.4 ha) was constructed close to the permanent quadrat. Vegetation survey for the forest floor was conducted to detect the environmental heterogeneity of the forest stand. Litter fall data was regularly monitored to evaluate the net primary production (NPP) of the forest stand (Photo 3-5). Seasonal changes in the photosynthetic rates of larch and birch were measured with a portable infra-red gas analyzer (LI-6400, LiCor, Nebraska, USA).

Photo. 1. A view of canopy of a larch plantation mixed with few white birch in LES

Photo. 2. A stand view of the larch ( *Larix gmelinii* ) plantation mixed with white birch

Photo. 3. Litter traps for estimating litter fall production of a stand ( Area of open side is ca. 1.0 $m^2$ )

Photo. 4. Litter bags for estimating the decomposition rate of larch needles

Photo. 5. Measurement of soil respiration with trenching method. White cycles are holders of a chamber for respiration measurement.

Photo. 6. Setting pF meters for measuring soil moisture condition

Photo. 7. A view of $CO_2$ flux monitoring tower (height 24m plus a 3m pole for setting $CO_2$ monitoring)
Left: Field laboratory for operating $CO_2$ analyzers with air conditioner.

## Results and discussion

### 1. Forest structure and biomass of the larch forest

Figure 12 shows the frequency distribution of DBH class in the permanent plots. The dominant species of the plots was *Larix gmelinii* with some individuals of *Fraxinus mandshurica*, although the largest DBH class was merely composed of *Fraxinus mandshurica*. The tree density was controlled by the artificial thinning carried out for three times during the 31 years after the afforestation. The height of canopy trees at the beginning of the project was 16.2 m in average. Density of *Larix gmelinii* was approximately 600 per hectare. In addition, a number of seedlings and saplings of *Fraxinus mandshurica* was found on the forest floor, whose density was about 125 per hectare, and a number of other tree species also grew there with a density of ca. 200 per hectare. Average DBH of *Larix gmelinii* was about 16.3 cm, and the total volume of timber was estimated as 117.86 $m^3 \cdot ha^{-1}$ (Fig. 13). The growth rate of stem volume was 3.8 $m^3 \cdot ha^{-1} yr^{-1}$, indicating that this forest was in an early stage characterized by rapid growth within the sequential development of larch forest ecosystem.

### 2. Species composition of larch plantations

A total of 53 species including trees, shrubs and herbaceous plants, belonging to 33 families, were recorded in the larch plantation in LES (Table 1). Tree layer (10-18 m) was composed of only two species such as *Larix gmelinii* and *Fraxinus mandshurica*. With co-existence of these species, original vegetation of the plantation of *Larix gmelinii* had become a mixed forest of broad-leaved hardwoods and conifer trees such as *Pinus koraiensis*. Shrub layer was composed of 10 species, which

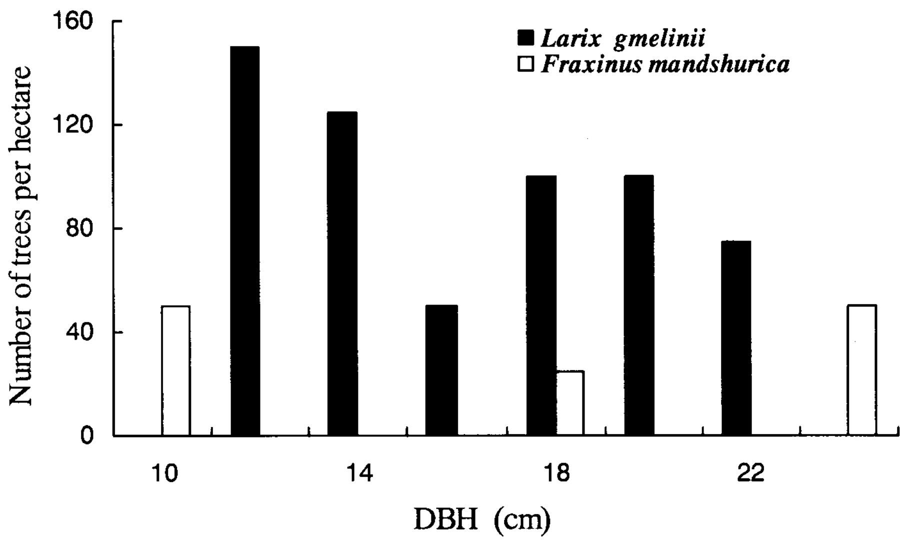


Fig. 12. Frequency distribution of DBH class in the tree sites of the LES

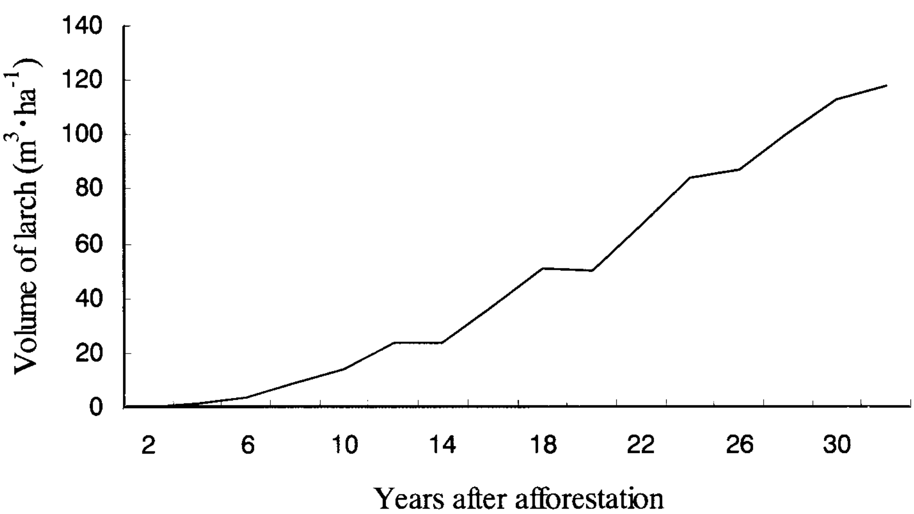


Fig. 13. Stem production of *Larix gmelinii* forest per hectare

Table 1. Species composition of larch forest at Laoshan Experimental Station

| Species | Family | Height (m) | Coverage* |
|---|---|---|---|
| *Larix gmelinii* | Pinaceae | 10-18 | 4 |
| *Fraxinus mandshurica* | Oleaceae | 10-18 | 1 |
| *Quercus mongolica* | Fagaceae | 1-3 | + |
| *Juglans mandshurica* | Juglandaceae | 1-3 | + |
| *Acer mono* | Aceraceae | 1-3 | + |
| *Pinus koraiensis* | Pinaceae | 1-3 | 1 |
| *Phellodendron amurense* | Rutaceae | 1-3 | + |
| *Tilia amurensis* | Tiliaceae | 1-3 | + |
| *Ulmus propinqua* | Ulmaceae | 1-3 | + |
| *Corylus heterophylla* | Betulaceae | 1-3 | 2 |
| *Acanthopanax senticosus* | Araliaceae | 1-3 | 1 |
| *Acer ginnale* | Acearceae | 1-3 | + |
| *Lonicera ruprechtiana* | Caprifoliaceae | 1-3 | + |
| *Viburnum sargenti* | Caprifoliaceae | 1-3 | + |
| *Syringa mandshurica* | Oleaceae | 1-3 | + |
| *Rubus sachalinensis* | Rosaceae | 1-3 | + |
| *Sorbaria solbifolia* | Rosaceae | 1-3 | + |
| *Philadelphus schrenkii* | Saxifragaceae | 1-3 | + |
| *Ribes mandshuricum* | Saxifragaceae | 1-3 | + |
| *Sambucus mandshurica* | Caprifoliaceae | 1-3 | + |
| *Schisandra chinensis* | Magnoliaceae | 1-5 | + |
| *Clematis brevicaudata* | Ranunclaceae | 1-5 | + |
| *Vitis amurensis* | Vitaceae | 1-5 | + |
| *Arisaema amurense* | Araceae | < 1 | + |
| *Campanula punctata* | Campanulaceae | < 1 | + |
| *Pseudostellaria davidii* | Caryophyllaceae | < 1 | + |
| *Adenocaulon himalaicum* | Compositae | < 1 | + |
| *Cardamine leucantha* | Cruciferae | < 1 | + |
| *Carex callitrichos* | Cyperaceae | < 1 | + |
| *Carex campylorhina* | Cyperaceae | < 1 | 2 |
| *Carex lanceolata* | Cyperaceae | < 1 | 2 |
| *Dioscorea nipponica* | Dioscoreaceae | < 1 | + |
| *Lamium album* | Labiatae | < 1 | + |
| *Asparagus schoderioides* | Liliaceae | < 1 | + |
| *Convalaria keiskei* | Liliaceae | < 1 | + |
| *Lilium distichum* | Liliaceae | < 1 | + |
| *Maianthemum bifolium* | Liliaceae | < 1 | 1 |
| *Polygonatum humile* | Liliaceae | < 1 | + |
| *Polygonatum sibiricum* | Liliaceae | < 1 | + |
| *Smilacina japonica* | Liliaceae | < 1 | + |
| *Circaea quadrisulcata* | Oenotheraceae | < 1 | + |
| *Liparis japonica* | Orchidaceae | < 1 | + |
| *Chelidonium majus* | Papaveraceae | < 1 | + |
| *Polemonium liniflorum* | Polemoniaceae | < 1 | + |
| *Aquilegia viridiflora* | Ranunclaceae | < 1 | + |
| *Filipendula palmata* | Rosaceae | < 1 | + |
| *Galium mandshuricum* | Rubiaceae | < 1 | + |
| *Astilbe chinensis* | Saxifragaceae | < 1 | + |
| *Chrysosplenium alternifolium* | Saxifragaceae | < 1 | + |
| *Aegopodium alpestre* | Umbelliferae | < 1 | 2 |
| *Heracleum barbatum* | Umbelliferae | < 1 | + |
| *Urtica angustifolia* | Urticaceae | < 1 | + |
| *Viola collina* | Violaceae | < 1 | + |

*Notes: 5 is 80%～100%; 4 is 60%～79%; 3 is 40%～59%; 2 is 20%～39%; 1 is 5%～19%; + is <5%

Table 2. Species composition of a larch plantation in TEEF

| Species | Family | Height (m) | Coverage |
|---|---|---|---|
| *Larix* F1 (*L. kaempferi* x *L. gmelinii*) | Pinaceae | 12-13 | 4 |
| *Rhus ambigua* | Anacardiaceae | 5 | + |
| *Schizophragma hydrangeoides* | Saxifragaceae | 5 | + |
| *Hydrangea petiolaris* | Saxifragaceae | 5 | + |
| *Vitis coignetiae* | Vitaceae | 5 | + |
| *Sasa senanensis* | Graminae | 1.5 | 5 |
| *Actinidia kolomikta* | Actinidiaceae | 1.5 | + |
| *Circium kamtschatica* | Compositae | 1.5 | + |
| *Carex sachalinensis* | Cyperaceae | 0.3 | + |
| *Dryopteris crassirhizoma* | Aspidaceae | 0.3 | + |

showed the same level of other types of secondary forest in this region, implicating that the species composition of larch forest was rather abundant. The dominant species in the shrub layer are *Corylus heterophylla*, *Acanthopanax senticosus* and *Pinus koraiensis*. In the herb layer less than 1 m in height, 30 species were listed up. Of these, species of Cyperaceae and Liliaceae were significantly abundant: i.e., *Carex campylorhina, Carex lanceolata, Carex callitrichos, Maianthemum bifolium, Asparagus schoderioides, Convalaria keiskei, Lilium distichum, Polygonatum humile, Smilacina japonica*, and so on. These species are considered to be adaptive to the cold climate in this region and are good indicators of cold regions (Zhou 1991).

Species composition in the forest understory in LES was quite different from that in TEEF, as shown in Table 2. The latter is completely occupied by dwarf bamboo such as *Sasa senanensis*, and the species composition of the forest floor is very simple. Another feature of the forest in TEEF is the presence of woody vines such as *Vitis coignetiae, Hydrangea petiolaris, Schizophragma hydrangeoides, Rhus ambigua* and *Actinidia kolomikta* (Tatewaki and Igarashi 1971, Uemura 1993). Before the afforestation by larch trees, however, tree species composed of the canopy are considered rather richer than those in LES. For instance, *Abies sachalinensis, Picea glehnii, Juglans ailanthifolia, Alnus hirsuta, Betula ermanii, Quercus monglica* var. *grosseserrata* and *Magnolia obovata* are commonly found around the larch plantation and usually form mixed conifer-hardwood forests (Uemura 1993). Therefore, original forest before the establishment of larch plantation is considered to be remarkably diverse. In these forests, *Corylus siebodiana* var. *brevirostris, Rosa acicularis, Rubus ideaum* var. *aucleatissimus, Sorbaria sorbifolia* var. *stellipila, Cornus canadensis* and *Maianthemum dilatatum* might abundantly grow in the shrub and herb layers (Tatewaki and Igarashi 1971, Koike *et al.* 2001).

## Conclusions

Larch forest is an important forest ecosystem in the boreal forest zone, and would be an important carbon sink for the global carbon balance. Assimilated carbon by larch trees is stored within the ecosystem, and it contributes to biomass sequestration of the increasing $CO_2$ in the atmosphere (Koike *et al.* 1988, 2000). LES is located in the area governed by typical continent climate, and the forest understory vegetation and soil substrate were completely different from the larch plantation in TEEF, northern Japan, governed by coastal climate, even though both sites are located at the same latitude of 45°N. The difference in the species composition and soil substrate may lead to the different $CO_2$ utilization and NEP. With further research on the photosynthesis, soil respiration and other parameters of the ecosystem, we should make clear the function of *Larix gmelinii* forest ecosystem widely developing through the northeastern Eurasian continent. It will give us an evaluation on the $CO_2$ deposition capacity of larch forests under different climatic conditions.

We should also investigate the soil respiration rates to estimate the NEP. Further experiments are necessary to analyze the relationships between soil respiration rates and litter flux in the forest ecosystem. To achieve these purposes, we begin to carry out a $CO_2$ flux study in a plantation of *Larix gmelinii* of LES in 2001, and this research work should dedicate to the elucidation of larch forests in the global scale.

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## Appendix

**Table Ⅰ. Climatic conditions of the larch plantation in Laoshan experiment station, Northeast China (1961-1966)**

| Climatic conditions | | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Air temperature (℃) | Mean | -19.6 | -15.3 | -5.9 | 4.8 | 12.9 | 17.5 | 20.9 | 20 | 12.9 | 5.4 | -6.3 | -16.3 |
| | Maximum | -12.9 | -8 | 0.6 | 11.2 | 19.9 | 24.4 | 26.2 | 25 | 19.8 | 11.9 | -0.2 | -10.2 |
| | Minimum | -26.9 | -23.8 | -13.3 | -1.9 | 4.6 | 11.5 | 15.8 | 15.3 | 6.5 | -1.6 | -12.6 | -23.3 |
| Ground surface temperature (℃) | Mean | -21.1 | -16.8 | -3.4 | 8.1 | 18.5 | 25.6 | 25.1 | 24.2 | 16.2 | 6.3 | -5.8 | -17 |
| | Maximum | -8.8 | -2.9 | 6.1 | 19.1 | 32.6 | 39.5 | 35.2 | 35.9 | 28.4 | 18.3 | 1.9 | -7 |
| | Minimum | -37.1 | -31.5 | -21.2 | -3.8 | 5 | 11.9 | 15.8 | 13 | 6.2 | -2.6 | -23.9 | -39.2 |
| Relative humidity (%) | | 74 | 71 | 64 | 52 | 56 | 70 | 82 | 86 | 77 | 64 | 69 | 76 |
| Rainfall (mm/month) | | 6.6 | 4.5 | 15 | 41.9 | 43.5 | 103.4 | 227.1 | 153.7 | 78.2 | 34.9 | 19.7 | 9.8 |
| Evaporation (mm/month) | | 26.3 | 21.6 | 54.1 | 121.3 | 193.7 | 189.2 | 136.9 | 117.5 | 91.8 | 70.5 | 28.9 | 14.8 |
| Snowfall (mm/month) | | 30.0 | 35.0 | 26.5 | 1.0 | - | - | - | - | - | 1.0 | 14.0 | 24.0 |
| Sunshine (hours/month) | | 162.1 | 203.0 | 229.0 | 217.9 | 262.3 | 263.8 | 208.4 | 191.8 | 215.2 | 194.5 | 156.8 | 160.4 |

**Table Ⅱ. In side and outside climatic conditions of the larch plantation in Laoshan experiment station Northeast China (1980-1989)**

| Climatic conditions | Location | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly mean air temperature (℃) | In the larch forest | -17.5 | -11.2 | -3.9 | 6.7 | 13.2 | 17.5 | 19.8 | 19.0 | 11.9 | 5.3 | -5.6 | -14.4 |
| | Outside the larch forest | -19.8 | -15.2 | -5.2 | 6.0 | 12.7 | 17.8 | 21.3 | 20.0 | 12.5 | 4.2 | -6.4 | -15.5 |
| Monthly maximum air temperature (℃) | In the larch forest | -8.3 | -5.4 | 1.2 | 13.0 | 19.8 | 23.5 | 25.0 | 23.4 | 17.9 | 11.8 | 1.1 | -8.3 |
| | Outside the larch forest | -12.8 | -8.4 | 0.5 | 12.2 | 19.2 | 23.8 | 26.1 | 25.1 | 19.1 | 10.7 | -0.7 | -9.5 |
| Monthly minimum air temperature (℃) | In the larch forest | -24.3 | -17.4 | -9.8 | 0.6 | 6.5 | 12.5 | 16.7 | 15.6 | 7.5 | 0.5 | -10.9 | -18.9 |
| | Outside the larch forest | -24.3 | -17.4 | -9.8 | 0.6 | 6.5 | 12.5 | 16.7 | 15.6 | 7.5 | 0.5 | -10.9 | -18.9 |
| Monthly mean ground surface temperature (℃) | In the larch forest | -14.7 | -9.0 | -1.8 | 8.0 | 14.0 | 18.1 | 20.1 | 20.0 | 13.1 | 6.6 | -3.9 | -11.6 |
| | Outside the larch forest | -18.9 | -14.1 | -2.6 | 8.2 | 16.8 | 22.2 | 26.5 | 23.9 | 16.2 | 6.6 | -4.4 | -14.4 |
| Monthly mean soil temperature at 20cm depth (℃) | In the larch forest | - | - | - | - | 5.6 | 12.5 | 15.7 | 16.9 | 12.7 | - | - | - |
| | Outside the larch forest | - | - | - | - | 8.8 | 16.5 | 19.9 | 20.4 | 15.0 | - | - | - |
| Monthly mean relative humidity (%) | In the larch forest | 63 | 66 | 63 | 54 | 63 | 78 | 89 | 89 | 77 | 66 | 67 | 70 |
| | Outside the larch forest | 75 | 73 | 66 | 59 | 60 | 72 | 82 | 83 | 71 | 68 | 71 | 77 |