Spatial Pattern of *Larix gmelini* in a Spruce-fir Valley Forest of Xiaoxing’an Mountains, China

Guangze Jin¹, Liang Liu¹, Zhili Liu¹ and Ji Hong Kim²*

¹School of Forestry, Northeast Forestry University, Harbin, 150040, China
²College of Forest & Environmental Sciences, Kangwon National University, Chuncheon 200-701, Korea

**Abstract**: On the basis of vegetation data in the 9.12 ha (380 m × 240 m) permanent sample plot of the spruce-fir valley forest in Liangshui National Reserve of Xiaoxing’an Mountains, the study was conducted to evaluate spatial distribution pattern and spatial association by using point pattern analysis for living and dead trees of *Larix gmelini* by DBH size class. The number of *L. gmelini* were counted as 59 living stems/ha (6.42 m²/ha of basal area) and 34 dead stems/ha (2.86 m²/ha of basal area). The distributional curve of diameter class exhibited bimodal shape. The analysis of spatial distribution patterns of all living larch stems noted the clumped distribution on the whole. The size of larch aggregates of dead stems was decreased as diameter class was increased. The distribution of dead stems became gradually randomized with decreased clumped size as the scale increased. Living stems and dead stems of the larch had positive spatial association at most of scales, illustrating that the occurrence of mortality of the larch tree was closely related to the distribution pattern of living larch trees.

**Key words**: dead stem distribution, large permanent sample plot, O-ring statistics, point pattern analysis, spatial association

**Introduction**

The spatial distribution pattern of a population is the consequence of integrative processes associated with the eco-physiological characteristics of the population, intra-specific and inter-specific relationship, and environmental conditions (Greig-Smith, 1983). Dale (1999) emphasized importance of spatial distribution of individuals in a species, playing major role in plant ecological theory. Condit et al. (2000) have been assembling a long-term, large-scale, and global research effort on spatial patterns and dynamics of forest ecosystems.

*Larix gmelini* has been naturally distributed in far eastern Siberia of Russia, and Daxingan mountains, Xiaoxing’an mountains, and Zhangguangcai mountains beyond 42°30’ north latitude in China (Zhou, 1986). The *L. gmelini* forests have extended in the area of around 3,300,000 ha and the growing stock of the forests has been estimated more than 300,000,000 m³ (Li, 1993), occupied 8% of total forest carbon storage and 30% of timber production in China (Zhou et al., 2000).

Numbers of scientific studies for *L. gmelini* have been carried out on account of ecological importance in China (Xu, 1998). Of these several researches have been reported on the spatial distribution pattern of *L. gmelini* individuals mainly growing throughout Daxingan Mountains. Xu et al. (1994) analyzed different age structure of the species by using the analytical method of spatial distribution pattern proposed by Greig-Smith (1983). Han (1994) investigated regeneration pattern on the size of 2 m × 2 m and Ban et al. (1997) reviewed the effect of spatial distribution on the mortality and reproduction patterns. A few of dimensional analyses were examined for spatial distribution pattern of *L. gmelini*, such researches as Ma et al. (1999) on correlation dimension, Ma and Zu (2000a) on information dimension, and Ma and Zu (2000b) on box-counting dimension. Shu et al. (2008) implemented quantitative study of spatial distribution pattern by the analysis of correlation between mean and variance, index of dispersion, and index of clumping for *L. gmelini* trees greater than 5 cm of DBH in two 50 m × 50 m sample plots each of the primitive forest, successive cutting forest, and clearcutting forest. Nevertheless, since most of previous studies concerning the spatial distribution pattern have been subjected to restriction on the size of sample plot and survey method, they were hardly capable of explaining the larger and broader scale of spatial...
distribution pattern for the species.

On the basis of vegetation data in permanent sample plot of 380 m × 240 m in Liangshui National Reserve of Xiaoxing’an Mountains, this study was carried out to evaluate spatial distribution pattern and spatial association by using point pattern analysis for living and dead trees of *L. gmelini* by DBH size class in the spruce-fir valley forest type. This study could provide the fundamental information for the occurrence, mortality, and regeneration capacity of the *L. gmelini* in the Northeast China.

**Materials and Methods**

1. **Study area**

The study was conducted in the spruce-fir valley forest, located in Liangshui National Reserve of Xiaoxing’an Mountains (Figure 1). The reserve is characterized by rolling mountainous terrain with 707.4 m of highest peak above sea level and 300 m of lowest peak above sea level, and average slope gradient is 10-15°. Mean annual temperature is -0.3°C with mean annual highest temperature of 7.5°C and lowest temperature of -6.6°C. Mean annual precipitation is 676 mm with 78% of relative humidity and 805 mm of evaporation rate (Jin et al., 2009).

The trees of *L. gmelini* growing in the spruce-fir valley forest of Liangshui National Reserve are distributed along the southern boundary of Xiaoxing’an Mountains, of which the distribution range would be located in the sensitive areas to the climate change. This susceptible forest ecosystems have been confronted with the change of growing conditions, especially due to the thawing of permafrost by global warming. In 2006 the permanent sample plot of 380 m × 240 m was established to monitor the effects of climate change on the structure and function of the spruce-fir valley forest.

The vegetation types of Liangshui National Reserve are classified into the mixed *Pinus koraiensis*-broadleaved forest type above 300 m sea level, and types of spruce-fir forest, *Alnus hirsuta* forest, and *Salix revarine* forest below 300 m sea level in valleys. The spruce-fir valley forest type is distributed on permafrost in patches characterized by cold and moist site condition. Dominated by *Picea koraiensis* and *Abies nephrolepis*, the type is commonly composed of *Larix gmelini*, *Betula platyphylla*, *Betula costata*, *Acer ukurunduense*, *Acer mono*, *Prunus padus*, *Acer tegmentosum*, and *Alnus sibirica* (Jin et al., 2009).

2. **Data collection and analysis**

The vegetation data were collected from the 380 m × 240 m rectangular permanent experimental plot established in the spruce-fir valley forest in 2006. The plot was divided into nine hundred twelve 10 m × 10 m square sub-plots of which four corners were marked with driving stakes. For every woody plant greater than 2 cm of DBH in each sub-plot, we attached the aluminum number tag, placed coordinates on the grid map, measured DBH and height, and recorded existing type of dead stems.

All *L. gmelini* individuals of DBH ≥ 2 cm in 9.12 ha plot of the spruce-fir valley forest were subjected to dividing into three DBH size classes, trees of 2 cm ≤ DBH < 10 cm, 10 cm ≤ DBH < 40 cm, and DBH ≥ 40 cm (Figure 2). The spatial distribution pattern and spatial association were analyzed by the univariate O-ring statistic and bivariate O-ring statistic, respectively, for all living and dead stems of each DBH size class. We used Programma software devised by Wiegand and Moloney (2004). The analysis was implemented 99 times of Monte