# Atmospheric Deposition of Pine Pollen in Canada and Korea

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## 1. Introduction

In many temperate forest ecosystems, large quantities of pine pollen are deposited over a short period in early summer (Doskey and Ugoagwu 1989). Because pollen grains decompose rapidly and have macronutrient concentrations, the pollen rain may be an important component of nutrient dynamics in natural terrestrial and aquatic ecosystems (Stark 1972). Foster and Morrison (1976) did not consider pollen in their model of nutrient dynamics in boreal jack pine forest, despite the fact that jack pine produces considerable quantities of pollen annually. Annual pine pollen production ranges from 0.6 kg/ha from *Pinus jeffreyi* (Stark 1972). Jack pine begins to produce male strobili at five to ten years of age (Rudolph and Laidly 1990). In west-central Manitoba mixed boreal forest stands, and to range as high as 24.5 kg/ha in a 25 year-old regenerating pure jack pine stand (Lee 1997). Pine pollen is also rich in nutrients and may contribute up to one third of the nutrients cycled in some pine forest ecosystem (Maggs 1985). In jack pine stands, annual pollen rain cycle, up to 0.45 kg/ha of N, 0.065 kg/ha of P, and 0.186 kg/ha of K (Lee 1997). In the Jeffreyi pine forests of montane Nevada, Stark (1972) found pollen to be a critical source of macronutrients to the soil litter fermentation zone during the dry, summer months. Doskey and Ugoagwu (1989) determined that pine pollen was an important source of macronutrients to oligotrophic lakes in northern Wisconsin.

This study was designed to examine early summer (1991-1993 and 1999-2000) deposition of pine pollen in the boreal Manitoba, Canada and Mt. Kwan-ak, Korea and to estimate fluxes of pollen macronutrient based on measured rates of pollen deposition and the macronutrient content of the pollen. Also the relationship between the climate and pine pollen deposition was investigated.

## 2. Materials and Methods

The study area is located in west-central Manitoba (54° 40′N, 101° 30′W), approximately northwest of Cranberry Portage, Canada. Mean elevation is approximately 300 m asl. The climate is subhumid continental, with mean annual precipitation of 484 mm and a mean annual temperature of –0.5°C.

Another study was carried out at mixed forest in Mt. Kwan-ak located in Seoul, Korea and the site is located at the north-west side of the mountain between the altitudes of 170 m and 285 m asl. According to Korea Meteorogical Adiministration (1999-2000) the study area has an average rainfall of 1733.1 ㎜/yr and its mean annual temperature is 13.2℃. In particularly, the average monthly temperature is 17.5℃ in May 1999, 2000 and the average monthly rainfall is 109.7 ㎜ in May 1999, 75.2 ㎜ in May 2000.

Pine pollen deposition along transect was determined during the study periods.. Durham gravity pollen collectors were employed in this study. This sampling device is approved by the National Pollen Survey Committee as the standard for sampling atmospheric pollen by the gravity method. The Durham pollen collector consists of two horizontal disks (Horizontal 23 ㎝, Vertical 23 ㎝, 15 ㎝ apart), with the cover disk elevated 10 ㎝ from ground. A standard 2×8 ㎝ glass slide covered with a thin film of petroleum jelly was placed on the lower disk to collect pollen. Slides were exposed for 24 hours and kept in a tightly sealed slide box before and following exposure to prevent contamination. Slides were examined within 24 hours under a microscope (100 ×, Olympus. BX50) to estimate pine pollen amounts.

## 3. Results and discussion

Total jack pine pollen deposition was similar over the 3 sampling years: 4476 grains/cm$^2$ in 1991, 4607 grains/cm$^2$ in 1992, and 3980 grains/cm$^2$ in 1993. Peak periods of deposition occurred on June 3, June 12-13, and June 7-8, respectively. Warmer than normal spring temperatures in 1991 resulted in early deposition, whereas below seasonal temperatures in 1992 delayed deposition. Jack pine pollen release in 1992 did not occur until June 6-10, during which time the maximum daily temperature rose from 11 to 31°C. Spruce pollen deposition varied between years, with mean annual deposition in 1992 of 1673 grains/cm$^2$ but only 1060 grains/cm$^2$ in 1993.

Large quantities of jack pine pollen were liberated over about 10-14 days, with peak diurnal deposition occurring during daylight hours. Deposition was positively correlated with air temperature ($r = 0.95$) and windspeed ($r = 0.86$), and negatively correlated with

relative humidity (r = -0.93). Very little pollen was deposited in the early morning (03:00-06:00). We also noted that pollen deposition was low during cool, wet weather. These results suggest that jack pine anthesis occurs during the daylight hours, though climatic conditions also play a role. Pollen deposition lasted for about 2 weeks, with pollen release occurring earlier in flowering plants than in spruce or jack pine. Pollen release in jack pine varied between years, reflecting differences in ambient air temperatures in May and early June. Previous studies have found that the timing and extent of pollen release is strongly dependent on ambient air temperature (Bringfelt et al. 1982). In longleaf pine (*Pinus palustris*), low temperatures delay and extend the period of pollen release (Boyer 1973). Temperature and precipitation in early summer were found to affect jack pine reproductive success at the northern limit of its distribution (Houle and Filion 1993).

High tree pollen yields often occur in years following a warm, dry summer (Ritchie 1977). Our observation of higher amounts of spruce pollen in 1992 than 1993 is consistent with this finding. Total growing degree-days (temperature > 5°C) from May to June 1991 were ca. 940, compared with only 660 for the same period in 1992 (the 27-year mean is ac. 850). The cool 1992 summer may have affected staminate bud production in spruce, resulting in low pollen production in 1993.

Jack pine pollen deposition occurs mainly in the daylight hours, when temperature and windspeed are highest and relative humidity is lowest. Such diurnal periodicity has also been observed in both temperate and European boreal species (Janzon et al. 1977). Rempe (1937) demonstrated that pollen trapped in the early morning mainly represents sedimentation of grains released during daylight hours.

**References**

Bringfelt, B., Engström, I., and Nilsson, S. 1982. An evaluation of some models to predict airborne pollen concentration from meteorological conditions in Stockholm, Sweden. Grana 21: 59-64.

Boyer, W. D. 1973. Air temperature, heat sums, and pollen shedding phenology of longleaf pine. Ecology 54:420-426.

Doskey, P. V., and Ugoagwu, B. J. 1989. Atmospheric deposition of macronurients by pollen at a semi-remote site in northern Wisconsin. Atmospheric Environment 23: 2761-2766.

Foster, N. W., and Morrison, I. K. 1976. Distribution and cycling of nutrients in a natural *Pinus banksiana* ecosystem. Ecology 57: 110-12.

Houle, G., and Filion, L. 1993. Interannual variations in the seed production of *Pinus banksiana* at the limit of the species distribution in northern Québec, Canada. Am. J. Bot. 80: 1242-1250.

Janzon, L. Å., Engström, I., and Nilsson, S. 1977. *Alnus* pollen incidence in the Stockholm area, 1973-1976. Grana 16: 191-194.

Lee, E. J. 1997. Importance of pollen rain in boreal Manitoba, Canada. Ph. D. thesis, Dept. of Botany, University of Manitoba, Manitoba.

Maggs, J. 1985. Litter fall and retranslocation of nutrients in a refertilized and prescribed burned *Pinus elliottii* plantation. For. Ecol and Manag. 12: 253-268.

Rempe, H. 1937. Untersuchugen ber die Verbreitung des Bl tenstaubens durch die Luftströmungen. Planta 27: 93-147.

Richie, J. C. 1977. The modern and late-Quaternary vegetation of the Campbell, Dolomite Uplands near Inuvik, NWT, Canada. Ecol. Monogr. 47: 410-423.

Rudolph, T. D., and Laidly, P. P. 1990. *Pinus banksiana* Lamb. In silvics of North America, Vol. 1. Edited by R. M. burns., and B. H. Honkala. U. S. D. A., For Serv., Washington, D. C. Agriculture Handbook 271. pp. 338-354.

Stark, N. 1972. Nutrient cycling pathways and litter fungi. Bioscience 22: 355-360.