# Tamarack Pollen Dispersal[1]

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ABSTRACT.----Pollen dispersion patterns of tamarack, *Larix laricina* (du Roi) K. Koch, were investigated from a single tree source in 1983 and 1984. Pollen was trapped in glycerine-loaded impingement traps at 48 stations along 8 compass-direction transects. Results indicate that heaviest pollen deposition occured within 15 m of the source tree, and the dispersion pattern corresponds closely with wind direction and force during pollen fall.

## INTRODUCTION

Tamarack is receiving much attention as a candidate for forest tree improvement in Maine and the Maritime provinces. Its extensive geographic range and site adaptability suggest that tamarack has great potential to provide the wide genetic variability desired in forest tree improvement. It grows fast, with a rotation of 20-25 years, yields a high-quality fibre, and is much less susceptible to the spruce budworm than the spruce-fir forest that it could replace, especially in Maine. Since seed production is a basic requirement in a tree improvement program, our research is addressing the mortality factors of seed production in natural stands of tamarack.

There appear to be two kinds of factors which result in tamarack's typically low seed yield: insect predation of cones and seeds (Duncan, 1954), and pollination problems. This paper reports results of experiments on pollen dispersion patterns, one aspect of our research on tamarack seed production problems.

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PROBLEM

Successful tamarack seed production will be aided by an explanation of the population structure and breeding characteristics of the species under natural conditions. Pollen dispersal patterns are critical elements in understanding the breeding history of a species, and are especially important in tamarack, which is typically found in small, discontinuous stands over its natural range. This spatial separation may be a serious barrier to outcrossing, resulting in high levels of inbreeding within local populations.

Unlike other conifer pollen grains, tamarack pollen has no air bladders or surface sculpturing and resembles miniature cannonballs as it is shed from the pollen sacs (Wodehouse, 1935). The pollen grain size of 67 microns, although in the small range for conifer pollen, is well above the "optimum" size of 20-40 microns for aerosol particles (Chamberlain, 1975). Quaternary palaeoecologists have only recorded tamarack pollen in bog core samples associated with macrofossils, which indicates that historically, the pollen disperses no farther than the needles and seeds. In addition, tamarack pollen is conspicuously absent from the aerosol pollen studies reported by Hyland, et al., (1953), and the "pollen alert" samples taken by allergists and environmental monitoring agencies. The bulk of evidence suggests that tamarack pollen may not be a good disperser, thus contributing to the inbreeding potential of tamarack seed.

Previous work on other conifers shows that most pollen will be deposited between 30 and 200 m from the source tree (Colwell, 1951, Silen, 1962, Wang, et al., 1960), and that after 50 m, the rate of deposition decreases as the inverse square of the distance from the source tree. This leads us to expect that the pollen dispersion patterns of tamarack may be represented by a simple decay function, decreasing rapidly with distance from the source.

This research was designed to measure the pollen dispersion patterns around a single, isolated mature tamarack tree; pollen deposition was determined in relation to distance from the source and corresponding wind patterns, and was compared in terms of pollen deposited per unit area, as would be the case with a receptive conelet.

METHODS

A single, mature, isolated tamarack tree was located and used for this study. The tree is over 16 m tall, and shows evidence of bearing heavy cone crops regularly. It is located on a well-drained upland site at the perimeter of a private golf course, and within 50 m of an old gravel/sand pit. The woody shrubs and small trees were cleared to a radius of 35 m away from the study tree to eliminate interference with pollen fall and minimize turbulence from their branches. Six pollen impingement traps were constructed at 5 m intervals along eight compass-direction transects, starting at the tree's drip line. This arrangement formed a catchment grid of 48 stations (Fig. 1). Each station consisted of 2 (8.9 cm) Petri dishes mounted on a 45 cm square masonite platform, which was nailed to the top of a wooden stake 100 cm from the ground. Each Petri dish was half-filled with liquid glycerine to act as a substrate for capturing pollen as it impinged on the surface. Physiological mechanisms of anthesis require the dry, warm conditions which prevail during the fair weather of daylight hours after dew has evaporated (Ogden, et al., 1969): therefore, the Petri dishes were only opened during daylight, starting before dew evaporated, and were covered during darkness and rainfall.

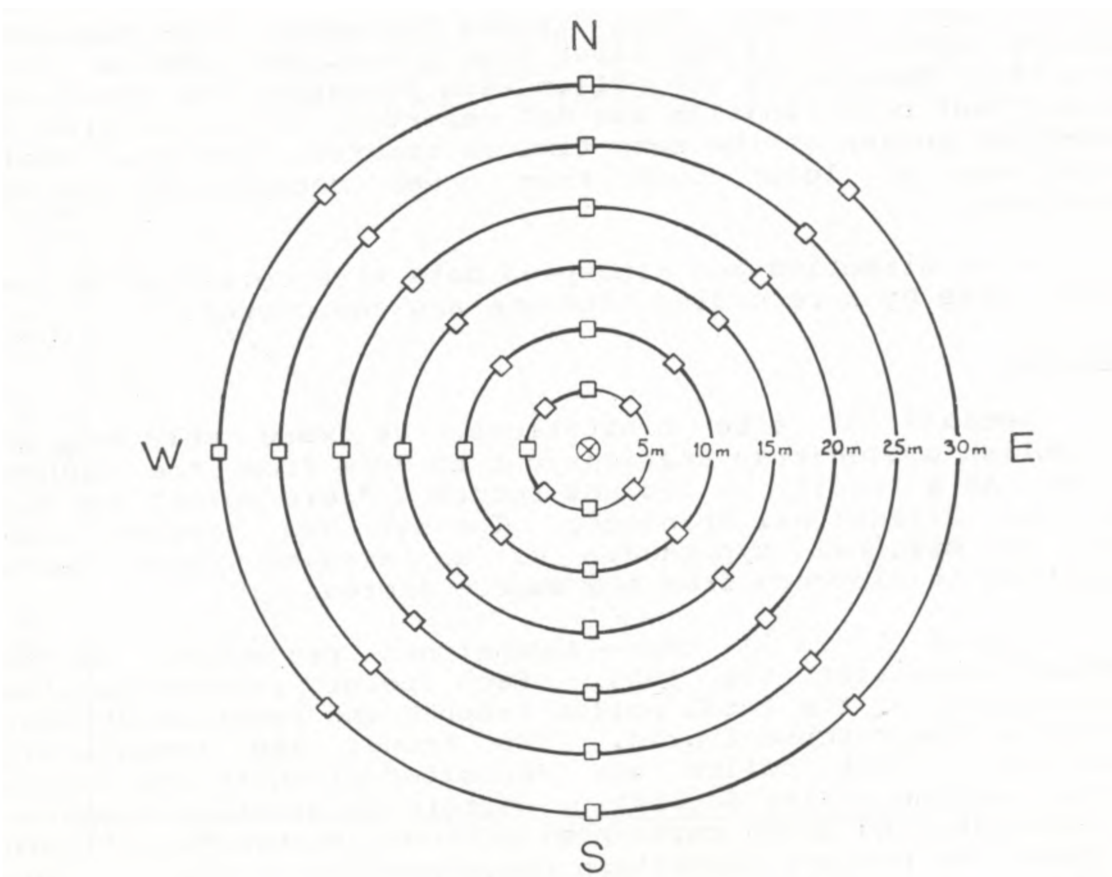


Figure 1. Catchment grid for pollen-trapping stations around source tree.

The onset of anthesis was determined by monitoring male strobilus-bearing branchlets which were cut from the study tree and forced in the laboratory. Once pollen from the laboratory sample was detected within 12 hours of cutting, the pollen traps in the field were opened to record pollen dispersion. During 1983 the traps were exposed for 6 days (two 3-day periods interrupted by 4 days of rain), and in 1984 for 2 consecutive days, during which time the pollen supply of the tree was exhausted. At the end of an exposure period, the Petri dishes were covered, labeled, and returned to the laboratory for analysis.

In the laboratory, the Petri dish samples were stained with a dilute solution of safranin and stored for 10 days. The sample was next washed with tap water into a Buechner funnel vacuum filtration apparatus, yielding a stained pollen sample on filter paper. The filter paper was then examined under 30x magnification to count pollen grains. A 20% sample was counted, using a microscope slide with its borders taped and marked to delineate a 5% sample of the filter paper surface. This "window transect" slide was then placed across the filter paper four times, and grains were counted. Samples of the pollen were preserved for verification, but contamination was not observed, as little else is shedding pollen at the same time as tamarack, and the study tree was at least 500m from other conspecific pollen sources.

Wind direction and windspeed data were collected at the study site by a recording windvane and anemometer.

## RESULTS

Because of site limitations, we were only able to establish pollen trap stations out to 30 m from the source tree. As a result, we did not record a "zero point" for any of the directional transects. The data did, however, support the original hypothesis of an assumed rapid decay function as distance from the source increased.

Figure 2 is a three-dimensional projection of the pollen deposition for 1984. Each point represents the proportion of the total pollen trapped and recorded at that point on the catchment grid. Two trends are immediately apparent: most pollen was deposited close to the source tree, and the pollen deposition pattern is disproportionately concentrated along certain directional transects. Figure 3 shows the percent deposition corresponding to the 6 concentric rings of pollen traps : each point is the sum of the 8 stations' (percentage of total) pollen deposition at the given distance from the tree. The 2 years' data differ somewhat in their location of a point of maximum deposition,

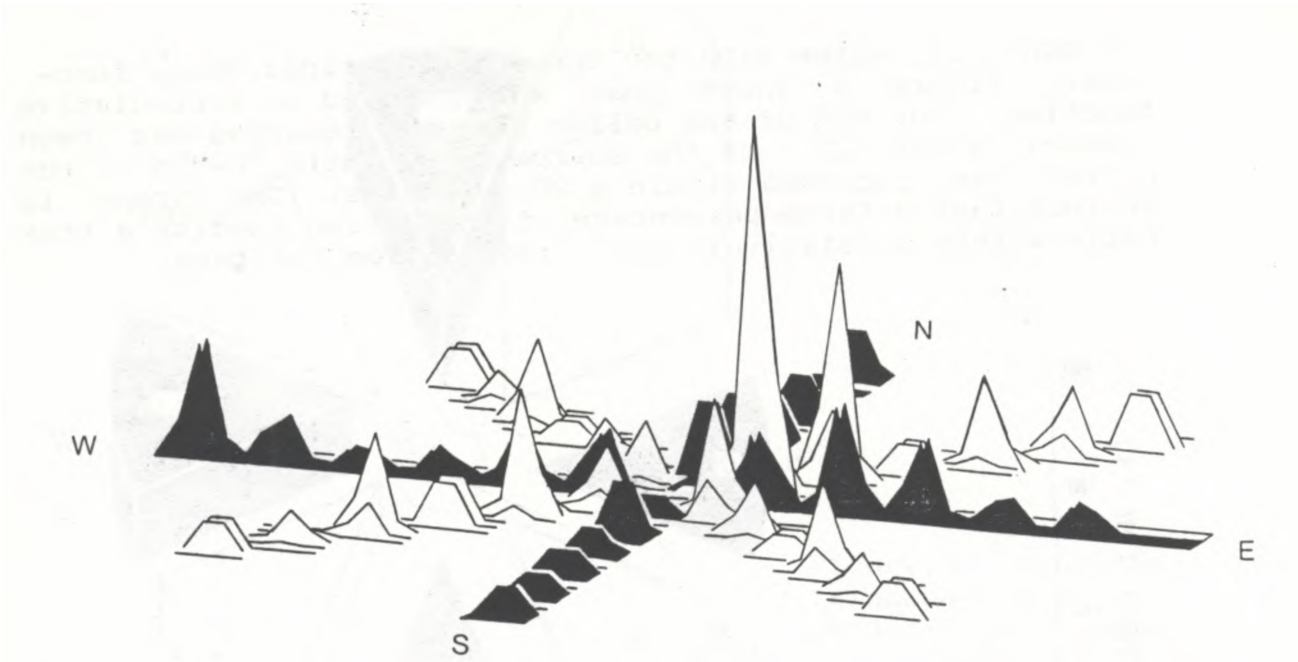


Figure 2. Pollen dispersion pattern along compass transects. Points represent % of total recorded at trap station, at 5 m intervals from source tree in 1984.

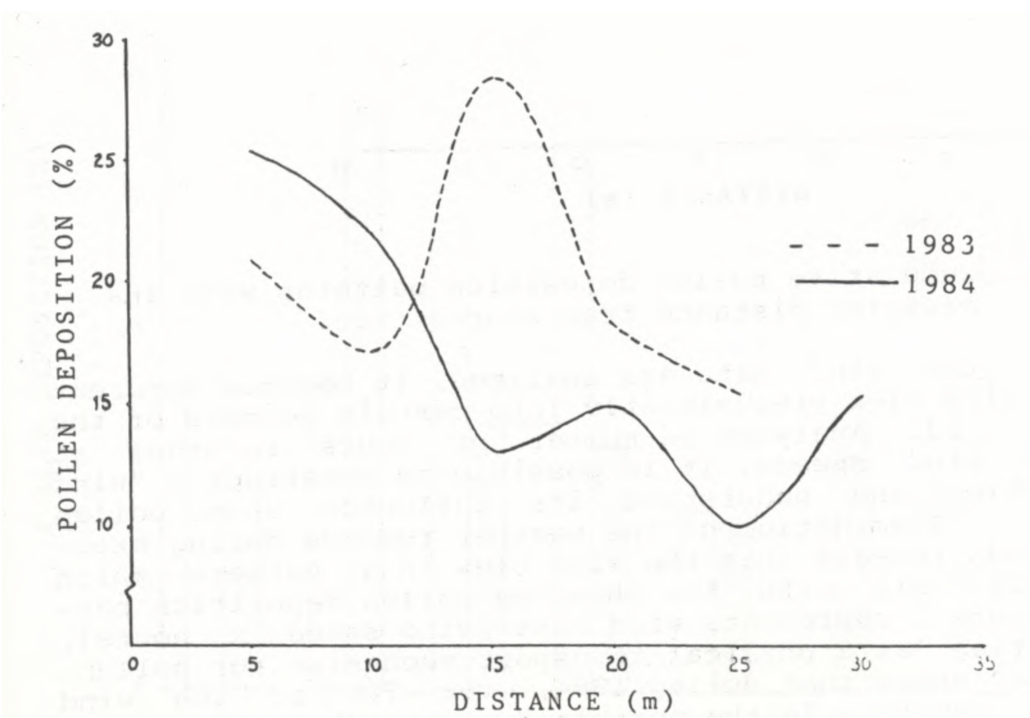


Figure 3. Pollen deposition decay functions for 1983 and 1984 (% of pollen deposited at each radius from source).

but generally agree with the concept of a rapid decay function. Figure 4 shows that when viewed as a cumulative function, over 60% of the pollen that was recorded had been trapped within 15 m of the source tree, while 70-85% of the pollen was recorded within a 20 m radius. The trend is obvious that a large percentage of the pollen shed by a tree falls within a relatively small radius from its base.

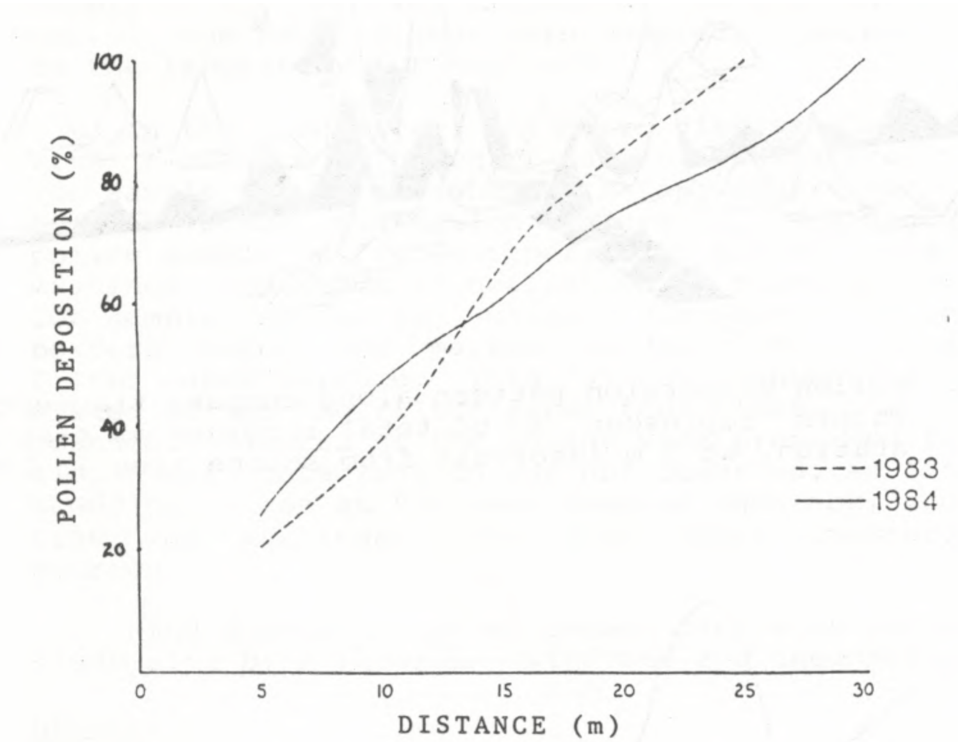


Figure 4. Cumulative pollen deposition patterns with increasing distance from source tree.

When the wind data are analyzed, it becomes apparent that the wind blew predominantly <u>into</u> certain sectors of the catchment grid. Analyzed as number of hours recorded at different wind speeds, it is possible to construct a "wind mass function" and understand its influence upon pollen transport. Examination of the weather records during exposure periods reveals that the wind blew in a pattern which corresponds well with the observed pollen deposition pattern. Figure 5 represents wind mass (wind speed x hours), which serves as a physical transport mechanism for pollen. This figure shows that during 1984, over 70% of the wind mass was recorded in the north and northeast sectors; this corresponded to over 50% of the pollen deposition (Fig. 6). The wind mass of the west sector (15%) also had a sizeable amount of pollen associated with it.

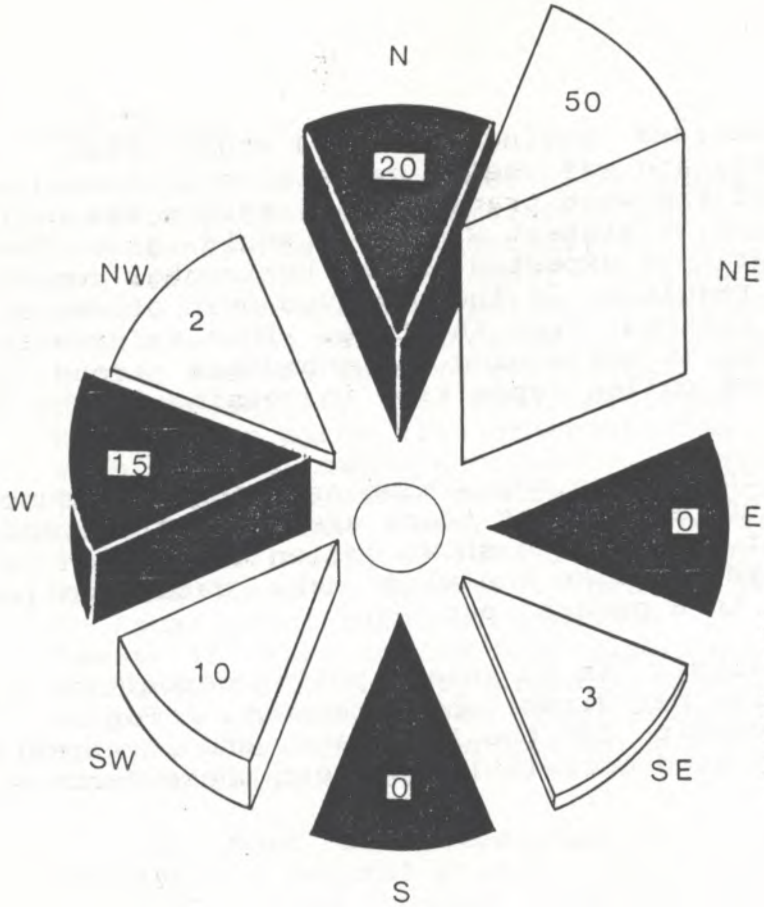


Figure 5. Wind mass (windspeed x hours) recorded per sector during pollen-fall in 1984 (Numbers = % of total per sector).

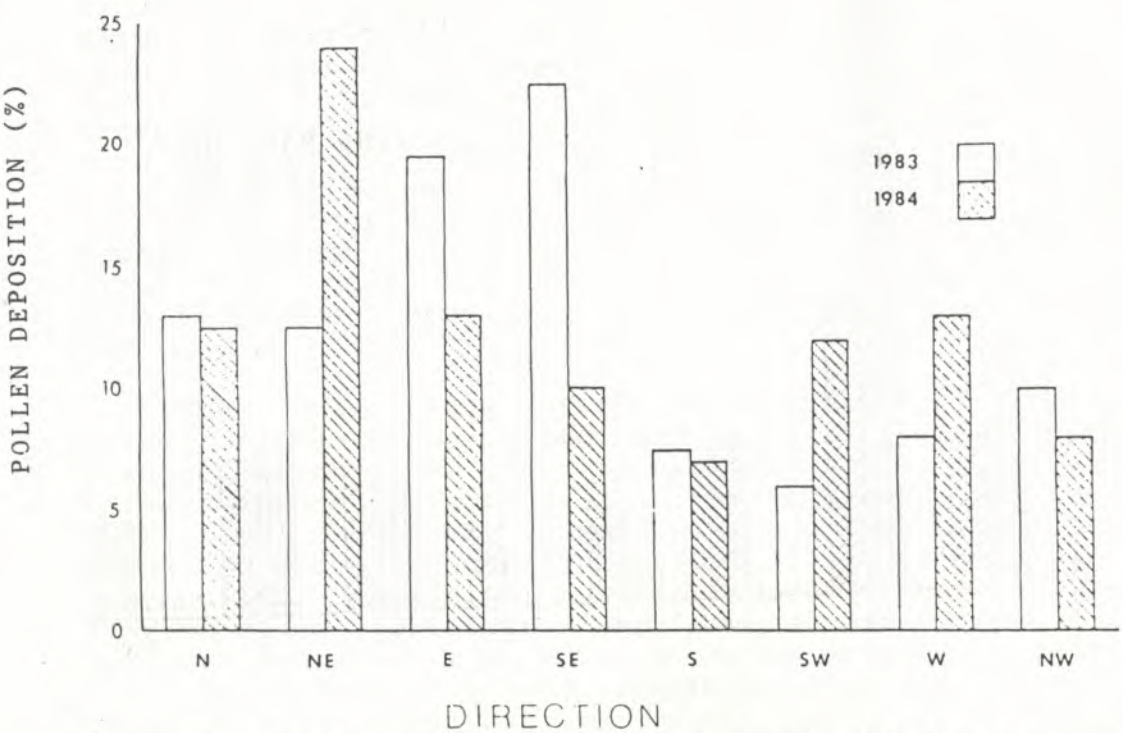


Figure 6. Pollen dispersion patterns recorded per compass sector for 1983 and 1984.

The windspeeds recorded during our 1984 study often exceeded 10-15 knots, and may help explain the anomolous point at the end of the west transect. If pollen was being shed during the hours of highest winds, it would have been carried much farther than expected in the horizontal component of the vector, resulting in the observed peak of deposition at the point farthest from the tree. This information would also be helpful in explaining the anomolous trend of Figure 3, which shows pollen deposition increasing at the 30 m radius.

Comparison of the pollen deposition and wind mass functions of 1983 and 1984 shows that there are similar trends from year to year. Figure 6 shows pollen deposition per transect for the 2 years; like the wind mass data, pollen deposition conforms to a general pattern.

The final analysis is to relate pollen deposition to the wind mass function per directional transect. Figure 7 shows this relationship for the 1984 data, and it appears that there is a very good correlation between these factors.

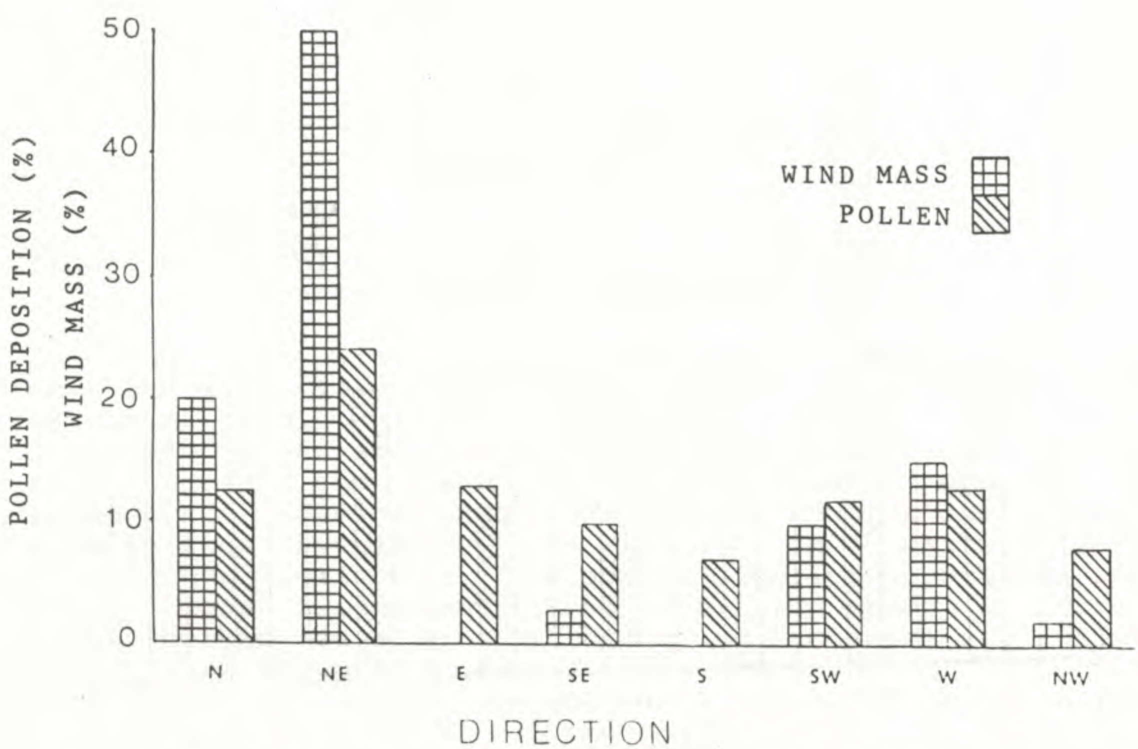


Figure 7. Pollen dispersion pattern and wind mass distribution recorded per compass sector in 1984.

## DISCUSSION

Our results show definite trends in the pollen dispersion patterns of tamarack. The bulk of pollen appears to be transported horizontally little more than the height of the tree, and is strongly influenced by the prevailing winds. The heaviest pollen deposition corresponds directly with the wind mass recorded into these sectors, while neighboring sectors receive substantial amounts of pollen due to the variability of wind patterns and turbulence. These conclusions agree with other studies of pollen transport, with the following exception: tamarack pollen is unlikely, in contrast to other conifer pollen, to be transported over great distances (over 200 m) from its source (Lanner,1966, Tauber,1967, Wright, 1953). Although not conclusive, our results lead us to expect that the potential for inbreeding in local populations of tamarack is considerable, due at least in part to the poor dispersal characteristics of the pollen. It is highly probable that in natural stands, a majority of the pollen cloud around an individual tree will be comprised of its own pollen and pollen contributed by its closest neighbor(s).

It must be noted that this study tree is atypical of tamarack in natural stands. This tree is a mature, isolated individual, and thus not directly comparable to trees grown under natural conditions; it may, however, approximate the conditions in a managed seed orchard. These results may be taken as representing optimal conditions for pollen deposition and (distant) transport. In natural stands, conditions are likely to be much more restrictive: distance between trees and wind turbulence factors differ greatly from the conditions of this study; this was a single, isolated tree, with little potential for wind turbulence/interference created by other sources. Even seed orchards have closer spacing between trees than 30 m. These results suggest that great care must be taken when choosing trees for tamarack tree improvement programs, as the liklihood of inbreeding may be very high.

The implications of the (characteristic) limited dispersal of tamarack pollen and potential for inbreeding disagree with the work of Park and Fowler (1982). Their investigations of inbreeding in tamarack lead them to state that tamarack trees in natural stands are not closely related (relationship coefficient=0.167). We maintain that the pollen dispersion pattern presented here is likely to lead to close inbreeding and demonstrates the need for further research into the population structure, fertilization, and embryology of tamarack. Isozyme studies now underway at locations in Canada should provide valuable information relevant to these questions.

## SUMMARY

In summary, we have found that the highest deposition rates of tamarack pollen are concentrated within a radius which corresponds closely with the height of the tree. In this study, over 60% of the pollen captured in a catchment grid of 60 m diameter was recorded within 15 m of the base of the 16 m tall tree. In addition, the pollen dispersion patterns correspond well with wind patterns; in 1984, the N, NE, and E sectors accounted for 70% of the wind mass, and 50% of the trapped pollen. Other sectors where substantial amounts of the pollen were trapped also tended to be associated with a sizeable wind mass.

## LITERATURE CITED

Chamberlain, A.C. 1975. The movement of particles in plant communities. In: Vegetation and the Atmosphere, Vol.I (ed. J.L. Monteith), Academic Press, New York.

Colwell, R.N. 1951. The use of radioactive isotopes in determining spore distribution patterns. Amer. J. Bot. 38:511-523.

Duncan, D.P. 1954. A study of some of the factors affecting the natural regeneration of tamarack (Larix laricina) in Minnesota. Ecology 35(4): 498-521.

Hyland, F., F.H. Steinmetz, and M.A. Vickers. 1953. Maine air-borne pollen and fungus spore survey. University of Maine, Orono. 97 pp.

Lanner, R.M. 1966. Needed: a new approach to the study of pollen dispersion. Silvae Genet. 15:50-52.

Ogden, E.C., J.V. Hayes, and G.S. Raynor. 1969. Diurnal patterns of pollen emission in Ambrosia, Phleum, Zea, and Ricinus. Amer. J. Bot. 56:16-21.

Park, Y.S., and D.P. Fowler. 1982. Effects of inbreeding and genetic variances in a natural population of tamarack [Larix laricina (DuRoi) K. Koch] in eastern Canada. Silvae Genet. 31(1):21-26.

Silen, R.R. 1962. Pollen dispersal considerations for Douglas-fir. J. For. 60:790-795.

Tauber, H. 1967. Investigations of the mode of pollen transfer in forested areas. Rev. Paleobot. Palynol.3:277-286.

Wang, Chi-Wu, T.O. Perry, and A.G. Johnson. 1960. Pollen dispersion of slash pine (*Pinus elliottii* Englm.) with special reference to seed orchard management. Silvae Genet. 9: 78-86.

Wodehouse, R. 1935. *Pollen Grains.* McGraw-Hill, New York.

Wright, J.W. 1953. Some practical implications of pollen-dispersion studies. J. For. 51:114-118.