

Effect of a local source on ragweed pollen concentrations from background sources

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*Dispersion of pollen from local ragweed sources was studied to determine the effect of contributions from such sources upon the pollen concentrations originating in more distant areas. Since ragweed pollen is produced throughout a large region, concentrations measured at any given location represent contributions from many sources at various distances along the past trajectory of the air sampled. A local source may produce concentrations several orders of magnitude above this background in a small downwind region. These concentrations decrease with distance and at some point become insignificant in comparison to background concentrations. Five experimental plots of common ragweed (*Ambrosia artemisiifolia*) were grown at Brookhaven National Laboratory over a four-year period. Pollen concentrations were measured by arrays of samplers located in concentric rings at several distances from each source. These concentrations were studied in relation to background pollen. The maximum downwind concentration is related to source size. Distances necessary for concentrations to reach specified fractions of background and the areas covered by concentrations greater than specified multiples of background are related to source size, surrounding vegetation, and meteorological conditions. These data should provide guidance to allergists and public health officials in evaluating the importance of local sources.*

During the pollination season, ragweed (*Ambrosia*) pollen originates in a multitude of sources throughout eastern and central United States and southern Canada. Although most pollen which becomes airborne returns to earth near its source, the small percentage from many sources which reaches altitudes well above surface obstacles and travels long distances causes significant concentrations over vast areas. This pollen is transported by the wind and distributed through increasing volumes of air by turbulent mixing.

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At any location, concentrations vary with time because of the non-uniform distribution of sources, the seasonal and diurnal periodicity of pollen emission, and changing meteorological conditions. In the past accurate measurements of pollen concentrations were seldom obtained because of the lack of adequate sampling instruments,¹ but in recent years the introduction of impaction-type pollen samplers by investigators at the University of Michigan^{2, 3} and Brookhaven National Laboratory⁴ has resulted in quantitative data both near and distant from local ragweed pollen sources. Concentrations measured at Brookhaven away from local sources commonly vary from tens of grains to a few hundred grains per cubic meter. Values probably average considerably higher in regions of greater ragweed prevalence. On the downwind side of a local source, however, concentrations may be two to three orders of magnitude higher, although they decrease rapidly with distance at a rate governed by the dispersive capacity of the atmosphere. This gradient of concentration close to a source is greater than that caused by any of the factors mentioned above and has important implications in the location of pollen sampling stations, in the interpretation of sampling data, in the study of pollinosis, and in planning local ragweed control programs.

Recent experimental studies at Brookhaven National Laboratory have resulted in quantitative data on dispersion of ragweed and other airborne pollens. Results of dispersion studies from the 1960 and 1961 ragweed sources have been published.⁵ A study of the areas polluted by ragweed pollen concentrations greater than selected values without reference to background pollen was also completed.⁶ This paper relates contributions from local sources to concentrations of background ragweed pollen, χ_{BK} , which, in the case of an isolated source, is defined as the total ragweed pollen from all sources other than the one under study.

EXPERIMENTAL SOURCES

Dwarf ragweed (*A. artemisiifolia*) was grown in 5 plots in 2 fields over a 4 year period. These plots were wide annular rings 18 to 55 M. in outer diameter around smaller circular pre-season sources which could not contribute to this study. The plants were spaced less than 1 M. apart, grew to about 1.5 M. in height, and covered the planted area uniformly at maturity. Further data on the pollen sources are given in Table I.

During the pollination season the plots were surrounded by 4 or 5 concentric rings of samplers at distances up to 70 M. Samplers were spaced 20 degrees apart in the rings. At the west field in 1960 and 1961, sampling was conducted at the 1.5 M. height only. In 1962 and 1963 samples were taken at 3 additional heights, and deposition was measured. The slide-edge-cylinder sampler,⁴ a vane-mounted device combining the principle of wind impaction on the side of a cylinder with the ease of reading a microscope slide, was used. Sensitive anemometers were mounted at each sampling height, since the volume sampled by this sampler and its collection efficiency for a given particle are functions of wind speed.

In the first 2 years, samples were taken over 24 hour periods. In 1962 and

1963 sampling periods a few hours in length during periods of relatively constant meteorological conditions were selected. The collected pollen grains were counted with the use of a microscope and the counts converted to mean concentrations in units of ragweed pollen grains per cubic meter of air sampled. Concentrations were plotted on scale diagrams of the sampling grid and isopleths of equal concentration drawn.

DATA ANALYSIS

The basic data used in this study were the concentrations measured at the 1.5 M. height, since pollen near ground level is of most interest from a medical viewpoint. Because this is the approximate height of the plants, concentrations are maximum at this level also. On the upwind side of the source these concentrations represent the background pollen only; on the downwind side they include pollen from the source as well. By examination of the isopleth patterns, sampling stations receiving no contribution from the source were selected, and the average of their measurements used as the background concentration. Taking the usable cases, the background concentration was subtracted from the values originally measured, and diagrams were plotted representing only pollen from the source under study. Isopleths of concentration were then drawn for values of 100, 10, 1, 0.1, and 0.01 times the background concentration wherever possible (Fig. 1). The area within each isopleth was then measured by planimeter, and the maximum distance from the isopleth to the nearest point on the source determined. The data were then averaged for each of the five sources and analyzed as described below.

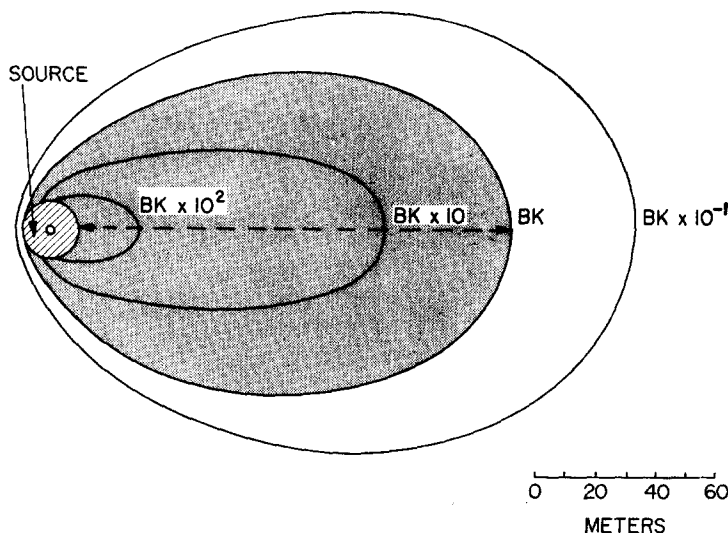


Fig. 1

Plot of a typical ragweed pollen dispersion pattern with isopleths drawn as multiples of the background pollen concentration. The area with concentrations from the source greater than the background concentration is shaded. The dashed line indicates the maximum distance from the source to the χ_{BK} isopleth.

RESULTS

The areas and distances under study are functions of several variables, including the background concentration itself. Other variables include source size, emission rate per unit source area, type, height, and density of surrounding vegetation, wind speed, variability in wind direction, turbulence, and sampling time. Not all the above factors could be measured, and clear-cut relationships with measurable parameters were seldom found because of interaction among the variables. However, several relationships and trends are discernible and are discussed below.

The mean areas within the selected isopleths for all usable cases are plotted in Fig. 2. Areas from 13,000 to 21,000 M.² or from 7 to 62 times as large as the source are covered by concentrations greater than or equal to the background concentration. Concentrations above a tenth of background were found over more than 25,000 M.² Relatively larger areas were covered by smaller sources than by larger ones since a smaller proportion of the pollen produced is lost within the plot by impaction and deposition, and the wind can penetrate the smaller sources more effectively.

The mean maximum distances from the source to the selected isopleths are plotted in Fig. 3 for unimodal cases, those in which the mean wind direction did not shift and the concentration patterns showed only a single peak. Distances to the χ_{BK} isopleth range from 95 to 190 M. or from 1.5 to 10 times the distance

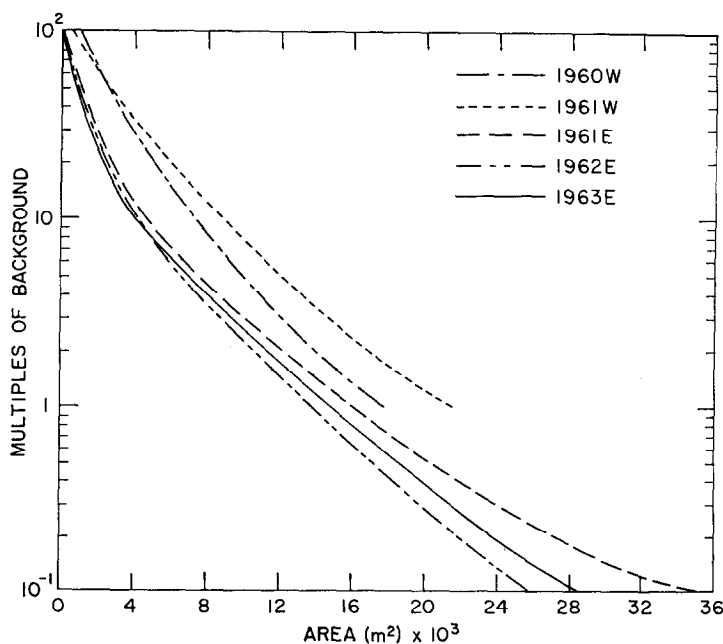


Fig. 2

Mean areas within isopleths of selected multiples of background concentration for each source.

across the source. Concentrations of one tenth of background are found from 130 to 360 M. or 2.5 to 20 times the source diameter. There is no orderly progression from largest to smallest source. Distances to the same isopleths in non-unimodal cases are normally less but are not presented.

Study of the data shows that days of high background concentration were generally days of high output from the local source and that the converse was also true. Because of this correlation the areas within and distances to selected isopleths tended toward a constant multiple of the source areas and diameters

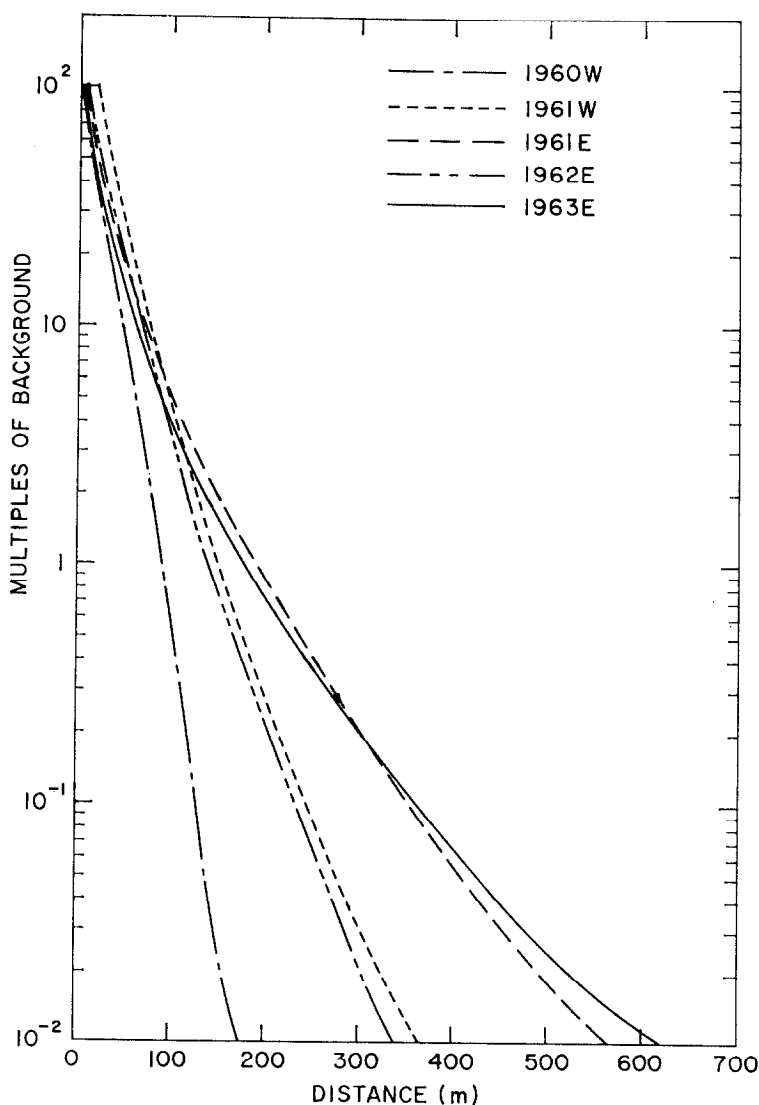


Fig. 3

Mean distances to isopleths of selected multiples of background concentration for each source.

Table I. *Ragweed pollen source data*

<i>Year</i>	<i>Field</i>	<i>Outer diameter (M.)</i>	<i>Distance across planted area (M.)</i>	<i>Planted area (M.²)</i>	<i>Surrounding vegetation</i>	<i>Mean wind speed (M./sec.)</i>	<i>Mean sampling duration (hours)</i>	<i>Mean χ_{BK} (gr./M.³)</i>	<i>Mean down-wind χ_o/χ_{BK}</i>
1960	West	54.9	36.6	2,000	Tall brush	1.0	24	33	199
1961	West	36.6	29.4	1,011	Low brush	1.2	24	55	312
1961	East	27.4	18.2	524	Grass	1.9	24	56	152
1962	East	27.4	18.2	524	Grass	2.3	7	57	134
1963	East	18.3	12.8	239	Grass	1.6	3.5	101	214

and were not greatly influenced by seasonal variations in pollen output. However, enough cases occurred when background and source emission showed opposite day-to-day trends to prevent use of either as a predictor of the other and to increase the scatter of the experimental results.

The surroundings of a local pollen source may influence the dispersion of its pollen output by modifying the airflow characteristics of the area and by direct removal of pollen from the air. In both experimental areas significant terrain features and buildings were absent from the vicinity of the source and sampling network. Vegetation, however, differed greatly around the two fields (Table I). Both deposition and impaction were greater at the west field, resulting in relatively smaller areas covered by specific multiples of background. Similar vegetational effects would be expected at other local sources.

Little direct correlation could be found between mean wind speeds and concentrations relative to background since wind speeds during sampling periods were almost uniformly low (Table I). Other studies, however, show that an increase in wind speed results in increased dilution of the pollen emitted and in lower concentrations. Increased variability in wind direction results in wider areas within a given isopleth but does not significantly change the mean size of the area. No specific relationships were found with turbulence or lapse rate which do not normally vary greatly during periods of ragweed pollen emission.

If pollen were emitted from a source continuously at a uniform rate and other conditions remained constant, no relationship between length of sampling period and mean areas or distances would be expected. However, ragweed pollen is released with a marked diurnal periodicity. Thus a short sampling period at the time of peak emission will result in greater areas within a given isopleth than a longer period even if centered at the same time. A sampling period not including the time of maximum emission would, of course, result in lower values. Therefore the area within a given isopleth is inversely related to the length of the sampling period if the period is centered on the time of peak emission. Otherwise, duration may not be an important parameter.

In summary, the area within and the distance to a given isopleth are related directly to source size and emission rate and inversely to background concentration and mass of surrounding vegetation. Wind speed and sampling dura-

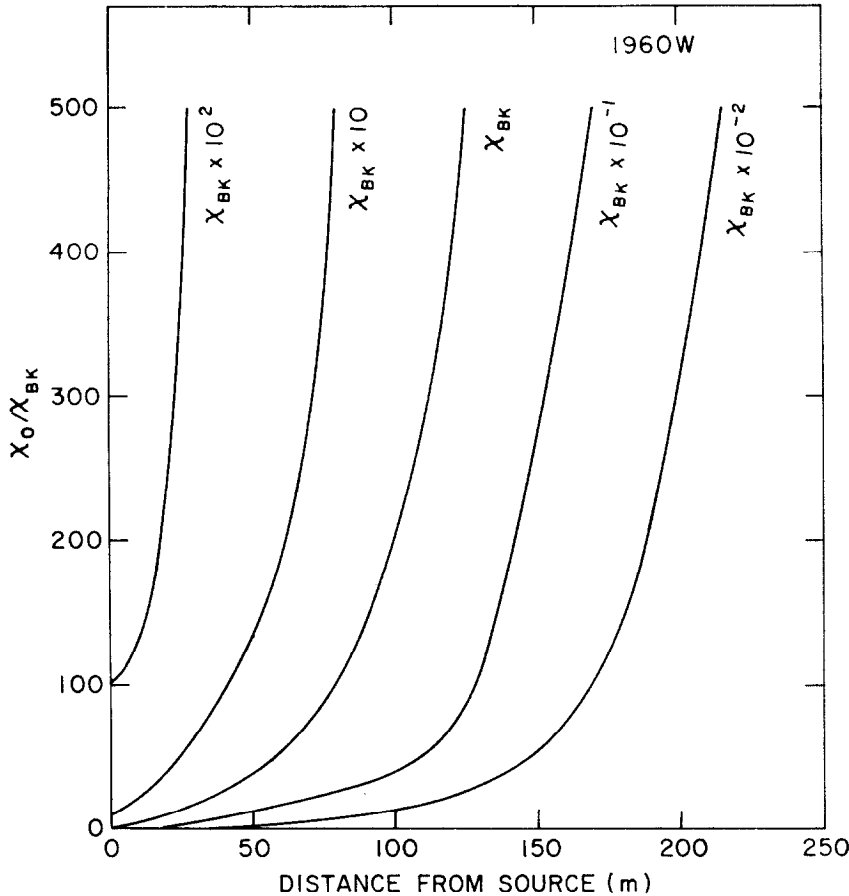


Fig. 4
Mean distance from the 1960 west field source to isopleths of selected multiples of back-ground concentration as a function of the χ_0/χ_{BK} ratio.

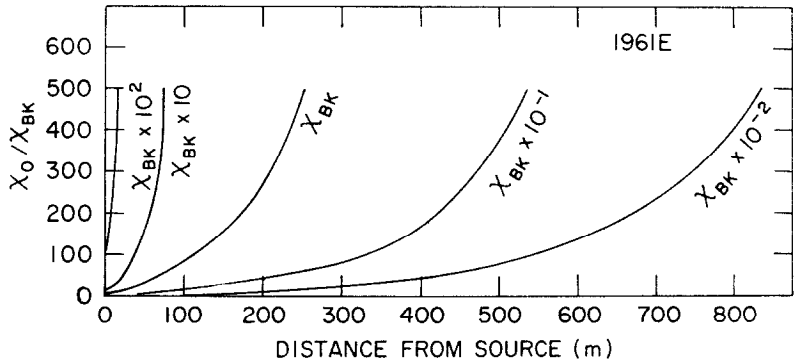


Fig. 5
Mean distance from the 1961 east field source to isopleths of selected multiples of back-ground concentration as a function of the χ_0/χ_{BK} ratio.

tion are less important variables under the conditions of this study. However, if concentrations immediately downwind of the local source can be measured or estimated, a better predictor for the maximum distance at which a given multiple of background concentration will be found is the ratio of the concentration immediately downwind of the source, χ_o , to the background concentration, χ_{BK} . Mean values of this ratio and of the background concentration over each sampling season are given in Table I. Fig. 4 illustrates the relationship between the χ_o/χ_{BK} ratio and the distance to which specific concentration isopleths are found for the 1960 west field source based on daily measurements. If the χ_o/χ_{BK} ratio is 300, for example, concentrations from the source equal to background will be found to about 110 M. and concentrations equal to a tenth of background to 150 M. These are the shortest distances found for any of the 5 sources studied because of the surrounding vegetation and long sampling duration. Fig. 5 shows the same relationship for the 1961 east field which gave the greatest distances. Here for a χ_o/χ_{BK} ratio of 300, concentrations equal to background are found to about 200 M. and concentrations of a tenth of background to nearly 500 M. All other sources gave distances between these two. It should be emphasized that Figs. 4 and 5 present only seasonal mean distances for all the cases from each source and that the greatest distance found for a single sampling period is commonly several times the mean.

DISCUSSION

Although the results presented above may not apply directly in other situations, they should form a basis for reasonable estimates of the effect of other local sources on background pollen concentrations. They also suggest several recommendations. If sampling is expected to give a good estimate of mean pollen concentrations over an extended area, the sampling station should not be located within a few hundred meters of a local source. If a sampling station must be located closer to a source, concentrations measured should be interpreted with caution and with due attention to wind direction. If background pollen in an area is insufficient to cause pollinosis in most susceptible individuals, control of local sources would be a practical preventive measure. If background pollen concentrations are commonly high enough to affect most sufferers, little improvement would be expected from control of local sources. Susceptible patients and their medical advisors should be aware of the relationships between pollens from local and distant origins and then plan the patient's activity schedule accordingly.

SUMMARY

Local sources are capable of increasing the background pollen concentration by several orders of magnitude in a small downwind region. The size of this region is a direct function of source size and emission rate and an inverse function of background concentration and vegetation. Other important variables are sampling time, wind speed, and other meteorological parameters. The effects of local sources of the sizes studied become negligible at distances greater than several hundred to a thousand meters.

Numerous individuals helped in this study by participating in the field sampling programs and by counting collected pollen. Anna Kokinelis and Lester A. Cohen assisted in the reduction and analysis of the data.

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ERRATUM

The names of Drs. Solomon E. Barr and Bernard Zussman were omitted as co-authors of the paper entitled "A Double-Blind Labeled Study of Dexamethasone Nasal Aerosol vs. Placebo in the Treatment of Nasal Polyposis" which appeared on page 10 of the January, 1968, issue of this JOURNAL.