

Variation in ragweed pollen concentration to a height of 108 meters

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Ragweed pollen concentrations were measured at 5 levels from 1.5 to 108 M. on a meteorology tower at Brookhaven National Laboratory. Samples were taken over an 11 year period using both the rotoslide and the slide-edge cylinder samplers. Vertical pollen profiles showed great variability from day to day but, when averaged over pollen seasons or longer periods, little systematic change in height was found. These results suggest that long-term patient exposure at upper levels of tall buildings would be similar to that at ground level in the absence of nearby pollen sources.

The variation in ragweed pollen concentration with height in the lower atmosphere and its relationship to other variables must be known relative to the more frequently measured low-level concentrations in order to assess the exposure of allergic individuals who live or work at higher levels, as in multistory buildings, and to better understand pollen dispersion and pollen removal from the atmosphere. These factors have not been studied previously by use of quantitative sampling methods.

During an earlier survey using the Durham sampler,¹ it was found that pollen catch increased with altitude at several stations, but later experiments at Brookhaven National Laboratory² showed that these increases resulted from the normal increase in wind speed with height. The same experiments showed that increased wind speeds resulted in decreased catches on a filter sampler. Thus, it became obvious that variation in pollen concentration with height could be studied only with a sampler whose efficiency was independent of wind speed or varied with wind speed in some known way so that appropriate correction factors could be applied to the data. Two such samplers were developed and placed in operation at Brookhaven for these studies, which are part of a more comprehensive investigation of airborne pollens in the lower atmosphere.

EXPERIMENTAL SITE

Sampling was conducted from 1960 to 1971 on a 128 M. meteorology tower at Brookhaven National Laboratory in central Long Island, New York. The tower is about 85 Km. east of Manhattan in New York City, about 9.6 Km. south of

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TABLE I. Data on experimental conditions

Year	Heights instrumented (M.)					Samplers at each height		
	1.5	11.3	22.8	45.7	108.2	Inter. roto-slide	Slide-edge cylinder	Total tests
1960		x	x	x	x	0	1	10
1961	x	x		x	x	1	2	9
1962	x	x	x	x	x	1	2	15
1963	x	x	x	x	x	1	2	20
1964	x	x	x	x	x	1	2	24
1965	x	x	x	x	x	1	2	17
Total twenty-four hour tests								95
1966	x	x	x	x	x	1	2	32
1967	x	x	x	x	x	1	2	21
1968	x	x	x	x	x	1	2	25
1969	x	x	x	x	x	1	2	23
1971	x	x	x	x	x	1	0	6
Total short period tests								107

Long Island Sound, and 16 Km. north of the Atlantic Ocean on basically flat terrain. The immediate surroundings are grassy fields and lawns, coniferous and deciduous forests from 10 to 14 M. tall, and scattered buildings. Within a 16 Km. radius, similar ground cover plus numerous small villages and agricultural lands are found. To the west, the island becomes increasingly urbanized, but the percentage of farm land increases to the east.

Little ragweed grows naturally within 2 Km. of the tower, but outside the Laboratory property the plant is found in normal abundance. Other studies have indicated that much of the ragweed pollen in the region is transported from areas west of New York City during periods of westerly winds.

During 1960 and 1961, circular plots of ragweed with diameters of 55 and 37 M. were grown for other experiments about 350 M. west of the tower. In 1963 to 1964 and 1966 to 1968, a plot of ragweed 30 × 15 M. or smaller was grown in the same area. Thus, most ragweed pollen sampled originated at some distance from the tower except for some from these cultivated sources during periods of westerly winds. The presence or absence of local sources is indicated in Table I.

INSTRUMENTS

Beginning in 1960, one or two slide-edge cylinder samplers,³ and beginning in 1961, one intermittent roto-slide sampler⁴ were mounted at 4 or 5 levels near or on the tower (Table I). The samplers were well exposed for most wind directions, although easterly winds passed through the open tower structure before reaching them.

The slide-edge cylinder sampler is a vane-mounted wind impaction sampler in which the narrow 1 mm. wide edge of a microscope slide serves as the sampling surface. The sampler efficiency varies with wind speed, but wind speed measurements were taken at each level and used to correct the data. The intermittent roto-slide sampler is a motor-driven rotating impaction sampler designed to sample automatically for one minute of each 12 minutes. Slide edges in upright

Usable roto-slide tests			Usable slide-edge-cylinder tests			Local source	Sampling period (hr.)
Without local pollen	With local pollen	Total	Without local pollen	With local pollen	Total		
—	—	—	5	2	7	Yes	24
2	2	4	2	3	5	Yes	24
10	0	10	12	0	12	No	24
6	7	13	6	7	13	Yes	24
6	4	10	6	4	10	Yes	24
7	0	7	7	0	7	No	24
31	13	44	38	16	54		
6	5	11	6	7	13	Yes	3-16
0	0	0	9	4	13	Yes	4-8
14	3	17	16	6	22	Yes	2-9
18	0	18	22	0	22	No	2-8
6	0	6	0	0	0	No	1-4
44	8	52	53	17	70		

holders are used to collect the sample and are shielded from wind impaction when not rotating. Silicone grease was used as the adhesive on both samplers.

A moderate amount of instrumental difficulty was experienced with the early model roto-slide samplers, but when problems were observed the data were discarded. Several other cases of obviously incorrect data were also eliminated.

The slide-edge cylinder sampler had no mechanical problems, but in some cases with very light or variable wind speeds, the efficiency factor applied may be somewhat in error. Data taken with appreciable uncertainty in the efficiency were discarded. When two slide-edge cylinder samplers were used at the same level, the average of the data given by the two was used in the analyses.

Variability between counts on the two slides of a roto-slide sampler was described earlier⁴ and depends largely on the care used in applying the adhesive. Average differences in earlier tests ranged from 6 per cent with careful greasing to 29 per cent when adhesive was applied by untrained personnel. Differences found in this study were mostly between these values. In other earlier studies, it was found that catches on adjacent samplers, either roto-slide or slide-edge cylinder, showed a similar variability. However, in most of the tests reported here, differences between levels were appreciably greater than differences between slides or samplers at the same level.

Since wind speeds and pollen concentrations often varied during sampling periods, a mean wind speed is not always representative of the speed prevailing during the time of greatest pollen occurrence, although most of the catch may be taken at that time. A Hirst spore trap⁵ was operated near the base of the tower, in most years, to measure hour-to-hour changes in pollen concentrations. The hourly spore trap counts were used to weight the mean hourly wind speeds to give a weighted mean wind speed, which was then used to determine the most appropriate values of sampler efficiency at each level for each sampling period.

Wind direction and speed were measured by Bendix-Friez Aerovanes at 11 and 108 M. and in some years at 46 M. During some seasons, a sensitive cup anemometer was mounted at 1.5 M. Wind speeds for levels not instrumented were found by graphical interpolation or extrapolation. Wind speeds were used to determine the volume sampled by the slide-edge cylinder sampler and, when weighted, to determine sampler efficiency. Other meteorological measurements such as sky condition, precipitation, and temperature were recorded routinely.

PROCEDURE

During those years when 24 hour samples were taken, test periods were selected only for presence of adequate quantities of ragweed pollen. Tests were not made if appreciable precipitation was expected, but showers or fog did occur during some tests, requiring elimination of the data. In later years, when shorter-period samples were taken, periods were selected for presence of pollen, absence of precipitation, and steady wind direction plus as little change as possible in wind speed, gustiness type,⁶ and cloudiness. Tests were terminated if significant changes occurred or appeared imminent. Most tests were taken during the normal working day, and many included the diurnal period of maximum pollen concentration, but in 1966 a number of tests were made at night.

Samplers were mounted on the tower prior to the ragweed pollen season. At the beginning of each test, previously prepared slides were inserted in the samplers and the rotoslides switched on. At the end of each test, slides were removed in the same order to equalize exposure time. Since the tower is equipped with an elevator, all slides could be put on or removed in less than 10 minutes.

Pollen collected was counted by use of a microscope and the counts used to calculate concentrations from the volume sampled and the sampler efficiency. Concentration data were then analyzed with respect to height and meteorological variables. Since actual concentrations varied widely from one period to another, concentrations at each level were divided by the concentration at the 108 M. level to give normalized concentrations that were expressed in per cent. The upper level was judged most representative of regional concentrations and the least influenced by local conditions. Actual concentrations in tests used varied from about 20 to over 400 grains per cubic meter and did not differ systematically with the presence or absence of the nearby local sources.

The number of tests obtained each year and the number used in the analyses are given in Table I with information on sampling period and presence or absence of a local source of cultivated ragweed. Tests not used were those with instrumental difficulties, those with very low counts, or those taken during rain or fog, which may remove previously collected pollen and cause erroneous counts.

RESULTS

Test periods are divided into 4 categories based on the length of the sampling period and the presence or absence of pollen from the local sources at the

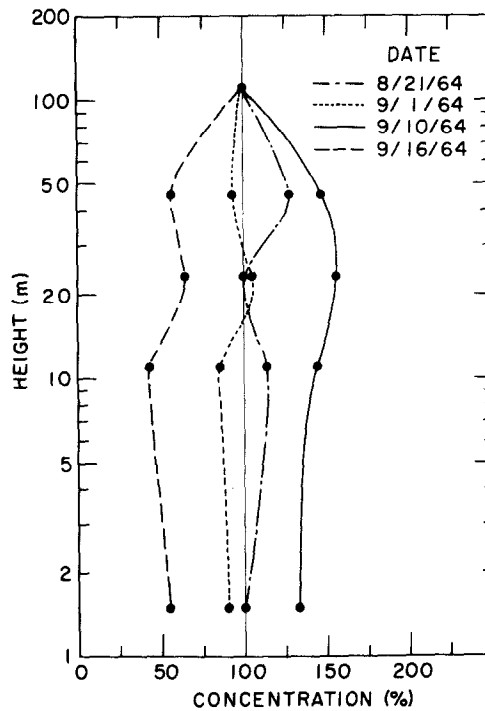


FIG. 1. Vertical profiles of ragweed pollen concentration during 4 days in 1964 shown as percentages of the 108 M. concentrations.

sampling location. Contributions from the local sources were assumed with westerly winds.

Twenty-four hour samples with no local pollen

All tests in 1962 and 1965 and all cases with nonwesterly winds in 1960 and 1961 and 1963 and 1964 are included in this section. Due to the usual diurnal variation in such meteorological conditions as wind speed, lapse rate, and stability, plus frequent variability in wind direction and cloudiness, results from these tests cannot be classified by or related to specific meteorological factors. Each test was examined individually, and averages were computed for each year and for the 6-year period. Much variability in pollen profile was found from case to case (Fig. 1). In some instances, concentrations decreased with height, at other times they increased, and frequently maximum concentrations occurred at intermediate levels. At times the two instruments gave different profiles. However, concentrations seldom differed between levels by more than a factor of 2 or 3. For 24 hour tests, these differences in pattern could not be related to any specific conditions. When a number of cases were averaged together, little variation with height was found (Fig. 2). This is not unexpected, since particulates in the lower atmosphere should be well mixed vertically after traveling moderate distances from their sources. At greater distances, deposition and impaction may remove enough of the lower particles so that maximum concentrations will be found above surface obstacles even from a ground level

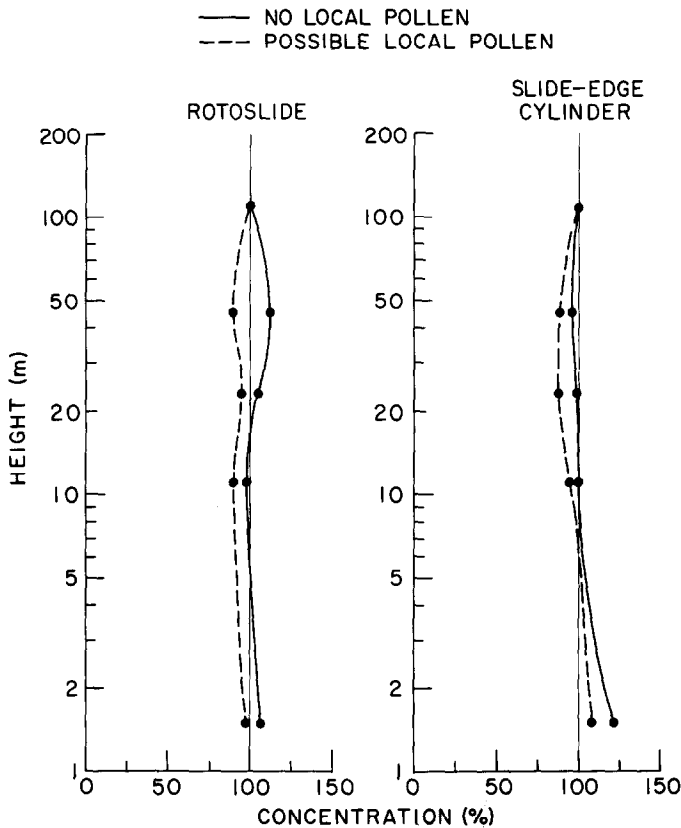


FIG. 2. Average vertical profiles of ragweed pollen concentration measured with rotoslide and slide-edge cylinder samplers over 24 hour periods. Cases with and without possible local pollen are shown separately as percentages of the 108 M. concentrations.

source such as ragweed. This pattern was found in many individual cases but was not evident in the averages.

Twenty-four hour samples with local pollen

Fewer cases were available with winds blowing from the local sources, but no significant difference in vertical profile was found. This could result from either or both of two possibilities. The amount of pollen reaching the tower may be small in comparison to that from more distant sources, or it may become well mixed vertically before reaching the tower. Earlier studies⁷ suggest that local contributions are relatively small at this distance, but vertical mixing probably also contributes to the patterns found. For comparison with results from cases with no local pollen, the average of all cases in this group is also shown in Fig. 2.

Shorter-period samples with no local pollen

All tests in 1969 and 1971 and tests with nonwesterly winds in 1966 to 1968 are included here. Despite the more uniform meteorological conditions dur-

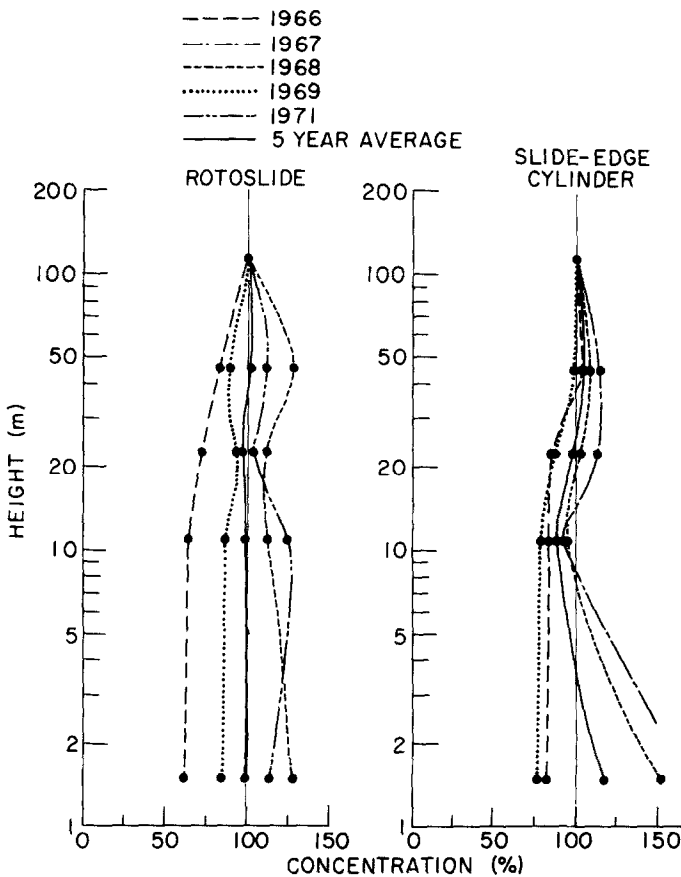


FIG. 3. Vertical profiles of ragweed pollen concentration measured with the rotoslide and slide-edge cylinder samplers over shorter time intervals. Averages are shown for each year and for the 5 year period as percentages of the 108 M. concentrations.

ing each test period, results are similar to those of the 24 hour experiments. Much variation in profile was found from one test to another, as shown in Table II. Both maximum and minimum concentrations occurred at all levels on different days. When averaged over a season, variation with height was usually less than a factor of 2 between 1.5 and 108 M., but average profiles differed from year to year. In 1966 and 1969, average concentrations generally increased with height, while in the other 3 years they showed a general decrease (Fig. 3). No specific reasons could be found for these differences. The overnight cases in 1966 did not differ appreciably from those taken during the day, but many of them included the early portion of the morning emission period and may not be representative of solely nocturnal conditions.

The data were also examined to determine if any of the variability observed could be related to meteorological factors. Cases were classified by wind direction and speed, gustiness,⁶ and cloudiness, but no consistent relationships were discovered.

TABLE II. Concentration data from 1968 roto-slide samples on days with no contributions from local sources

Test No.	Concentration (grains/M. ³) at height (M.)				
	1.5	11.3	22.8	45.7	108.2
4	5	10	10	12	7
6	13	6	12	7	11
7	11	15	—	11	11
10	28	26	17	41	20
12	92	85	73	72	60
13	58	31	45	58	26
14	71	67	69	63	57
15	83	92	82	85	58
16	65	79	61	69	49
17	302	208	200	176	154
19	42	44	34	49	85
20	100	74	88	67	93
21	125	77	97	104	84
22	98	98	—	110	97
Mean	78	65	66	66	58
S. D.	72	50	49	43	41

Shorter-period samples with local pollen

Cases with westerly winds in 1966 to 1968 are included in this category. As with the 24 hour data, profiles did not differ systematically from those found with other wind directions. However, variation between levels averaged greater, indicating that tower measurements sometimes included significant amounts of pollen from the local sources. Since most of these test periods included the time of peak emission, this was not unexpected. However, it appears that local pollen increased counts at different levels on different days.

DISCUSSION AND CONCLUSIONS

The results of this study indicate that ragweed pollen concentrations averaged over the length of the pollen season do not change appreciably from 1.5 to 108 M., although profiles measured over periods of a day or less show great variability. It appears that the diversity in size, distance, and location of ragweed sources and in timing, duration, and magnitude of pollen emission, plus the variability in meteorological conditions between source and sampling locations, form such a complex set of possible variables that variation with height over short periods cannot be related to parameters measurable at the sampling site. However, when averaged over longer periods of time, these variables tend to counteract each other so that a smoothed profile results.

Thus, ragweed pollen in the lower atmosphere appears to be poorly mixed vertically over short periods, but the variability largely disappears over longer periods. Patient exposure at high levels could be either greater or less than ground level exposure on any given day, but little difference would be expected over the course of a pollen season. These conclusions would not apply, of course, close to a local source where low-level concentrations would be much

greater than those at higher elevations and may not apply in cities or other dissimilar locations where vertical mixing and removal patterns may differ from those at Brookhaven.

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