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Original Articles

STUDIES ON FACTORS INFLUENCING RAGWEED POLLEN COUNTS IN THE NEW YORK METROPOLITAN DISTRICT

I. POLLEN STUDIES ON AMBROSE LIGHTSHIP IN NEW YORK HARBOR*

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SINCE 1936, the Allergy Division of the Jewish Hospital of Brooklyn has been making daily estimates of the ragweed pollen content of the air in and about New York City. During the first ten years, the air was sampled by the exposure of greased slides in a crude shelter on the roof of the hospital. The adoption, in 1946, of the Durham Shelter as a standard instrument of exposure and the standardization of counting techniques by the Pollen Committee of the Research Council of the American Academy of Allergy^{1, 2} made more intensive studies^{3, 4, 5} of New York City's pollen problems feasible.

Since 1946, surveys have been made during the ragweed pollinating seasons for one or more years in about 20 localities in the city and its environs. In some years, as many as 17 stations in the Metropolitan District† were studied. At the same time, meteorologic data from weather stations in these areas were analyzed in an attempt to correlate weather factors with pollen counts.

Almost coincidentally with the start of these surveys, the New York City Department of Health initiated a program of ragweed plant eradication within the city. This prompted considerable speculation as to the extent to which such an intramural campaign would influence pollen counts in the city and benefit its hay fever sufferers. It was common knowledge that ragweed pollen was wind-borne and could be carried from distant regions of heavy pollination into areas where ragweed growth was scant or absent. Durham, more than two decades ago, had suggested that New York City was probably receiving much of its pollen from the large ragweed beds in New Jersey.⁶ However, concrete data on these questions were lacking, a circumstance which prompted the writers to enter upon more extensive studies of these problems as soon as the standard technique became available.

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†The New York City Metropolitan District encompasses the area within a 50-mile radius of Columbus Circle at Broadway and 59th St., New York City.

In 1947, the second year of surveys of the Metropolitan District, a study was made of ragweed pollen conditions at Fire Island, N. Y.⁴ (Fig. 1, Station K). Because this island was relatively free of ragweed plants and was situated in the Atlantic Ocean several miles south of Long Island, it was frequently mentioned by the laity as a haven for hay fever patients sensitive to ragweed. Our studies revealed that while Fire Island tended to show daily ragweed pollen counts somewhat lower than the daily average for Greater New York, there were several days early in September, 1947, when readings on the island exceeded the city averages. Although the seasonal total* of 298 at Fire Island was relatively low, it exceeded the seasonal total of 271 for the borough of Brooklyn (Fig. 1, Station B) in New York City for that year and was approximately 70 per cent of the average total* of 423 for New York City.

The study of this problem was continued in 1948 and 1949 by a survey⁵ of ragweed pollen conditions at Sandy Hook, N. J. (Fig. 1, Station J). This area presented unusual characteristics in that it was a narrow peninsula, not more than a few hundred yards wide, extending several miles into the ocean with only a scant growth of ragweed plants. Despite these features which would be expected to produce low counts, the seasonal total for Sandy Hook in 1948 was 563, as compared to an average total of 530 for New York City. In 1949, the seasonal totals for Sandy Hook and New York City (average) were 494 and 550, respectively.

The data obtained in the Fire Island and Sandy Hook surveys clearly indicated that the peak counts in these areas of scant ragweed growth occurred on those days during the active pollinating period when winds blew briskly from the west. In this direction, according to previous surveys, were located the areas of densest ragweed growth in and around the New York metropolitan area.

The study of wind as a factor in New York's pollen problem continued under more ideal experimental conditions during the summers of 1949 and 1950 when pollen counts were made at Ambrose Lightship, anchored far out in the bay at the entrance to New York Harbor (Fig. 1, Station A). Here the absence of ragweed plants was complete and all pollen granules appearing on the exposed slides were incontrovertibly wind-borne from neighboring land areas.

The cooperation of the Aids to Navigation Division of the United States Coast Guard was enlisted to effect the surveys on Ambrose Lightship. The daily counts obtained on the ship were correlated with those obtained at the land stations (Table I) in the New York Metropolitan District during the same seasons.

These surveys yielded striking evidence that wind direction and velocity were the most significant meteorologic factors influencing the city's daily ragweed pollen counts. An analysis of the data obtained in annual surveys from

*The seasonal total for a station is computed by totaling its daily counts from August 1 through September 30 in terms of pollen granules per square centimeter of exposed slide per twenty-four hours. The average total for New York City represents the average of the seasonal totals of the five city boroughs.

1936 to 1946, with the counting technique employed before standard procedures were established, substantiated these conclusions. A detailed analysis of the evidence provided by these earlier studies will be the subject of another communication in this series.

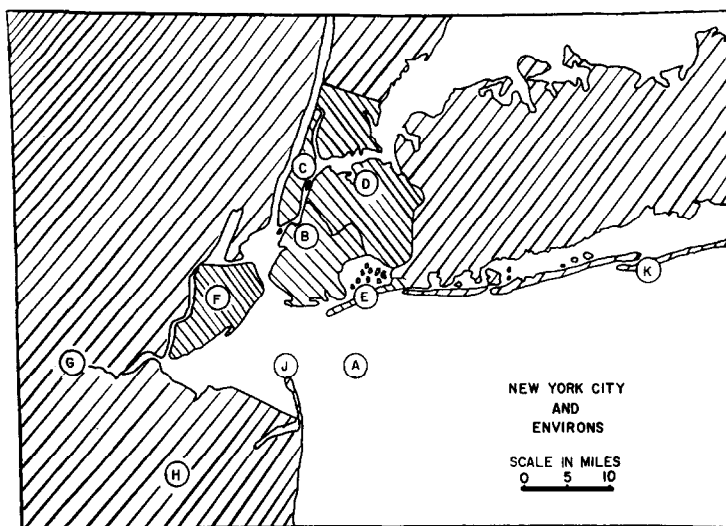


Fig. 1.—Localities surveyed in and around New York City. The locations of the stations, indicated by the encircled letters, are listed in Table I.

Location of Ambrose Lightship.—Ambrose Lightship (Station A) is anchored at the entrance to New York Harbor. Its approximate location and land relationships are illustrated in Fig. 1. The nearest land to the north of the Lightship is the Rockaway Peninsula (Station E) in New York at a distance of 8 or 9 miles. Equidistant to the west lies Sandy Hook, New Jersey (Station J). The Atlantic Ocean stretches to the south and east, so that from these directions, representing about one-third of its circumference, the ship can receive no pollen. To the west and southwest lies New Jersey, represented in the survey by the counting stations at New Brunswick (Station G) and Marlboro (Station H). In previous surveys, the pollen counts in this section of New Jersey had been found to be the highest in the New York Metropolitan District. West and slightly north of the Lightship lies Staten Island (Station F) with moderately high pollen counts, and northern New Jersey, with counts approximating the average for New York City. To the north and slightly west are Brooklyn (Station B) and Manhattan (Station C), with unimpressive counts. Due north lies the borough of Queens (Stations D and E) and, east of it, western Long Island, parts of which had been surveyed in previous years. With the exception of Rockaway (Station E), no stations on any part of Long Island had shown unusually high counts at any time during these surveys.

Techniques.—The technique employed conformed with the recommendations of the Pollen Survey Committee of the Research Council of the American

Academy of Allergy. Greased slides were exposed on a Durham Shelter fastened to the railing on the upper deck of the Lightship at a point as distant as possible from the smokestack. Slides were changed each day at 9 A.M. Daylight Saving Time (8 A.M. Eastern Standard Time) from August 1 through September 30.

A portion of the exposed greased slide was stained with Calberla's solution and a cover slip with an area of 3.6 sq. cm. was applied. After about ten minutes, the ragweed pollen grains under the cover slip were counted and recorded in terms of the number of granules collected on a square centimeter of slide in twenty-four hours. On rainy days, the counts, though incomplete, were recorded. They appear on the graphs as points enclosed in circles.

Daily data on wind velocity and prevailing wind direction, as recorded at the Battery in New York City and at Trenton, N. J., were obtained from the United States Department of Commerce Weather Bureau. Readings were also obtained from other weather stations in the Metropolitan area located at Central Park, Manhattan, at LaGuardia and Idlewild Airports in Queens, at Sandy Hook and Newark Airport in New Jersey, and at Ambrose Lightship. These readings corresponded so closely with those obtained at the Battery that it was decided, for the sake of uniformity and convenience, to use only the data obtained at the latter station.

TABLE I. SEASONAL TOTALS* OF RAGWEED POLLEN

STATION	LOCATION	1949	1950
A.	Ambrose Lightship	256	249
B.	Jewish Hospital of Brooklyn	395	224
C.	United States Weather Bureau, Central Park, Manhattan	481	227
D.	Chamber of Commerce Building, Flushing, Queens	560	500
E.	Rockaway Beach Hospital, Queens	990	638
F.	Sea View Hospital, Staten Island	714	458
	NEW YORK CITY AVERAGE	550	420
G.	St. Peter's General Hospital, New Brunswick, N. J.	1,313	957
H.	New Jersey State Hospital, Marlboro, N. J.	937	—
J.	United States Coast Guard Weather Station, Sandy Hook, N. J.	494	—
K.	United States Coast Guard Weather Station, Fire Island, N. Y. (surveyed in 1947)		

*Seasonal totals for each station are obtained by adding all its daily counts which are in terms of pollen granules per square centimeter of slide, exposed for twenty-four hours.

The daily readings for average wind velocity and prevailing wind direction, which are published by the Weather Bureau, are based on the averages of twenty-four hourly readings starting at midnight. The pollen slides, however, were exposed for twenty-four hours starting at 9 A.M. In order to correlate the pollen count and weather data for each day, it became necessary to recompute from the hourly readings, the daily average wind velocity and prevailing wind direction so that the twenty-four hour period covered corresponded to that of the pollen slide exposures. It was also necessary at times to analyze the hourly readings for wind velocity and wind direction in order to account for unusual pollen counts on the Lightship which could not be explained on the basis of the reported *average* wind readings for that day.

Results of Studies During the 1949 Ragweed Season.—The seasonal totals for ragweed obtained at the representative stations surveyed in 1949 are listed in Table I. It will be noted that the lowest seasonal total in the survey was 256 which was obtained at the Ambrose Lightship. This figure was approximately 46 per cent of the average of the seasonal totals of all the New York City stations (550). As in previous years, the highest seasonal totals in the Metropolitan area were those of Marlboro and New Brunswick, representing that part of New Jersey which lies west and southwest of the Lightship. Rockaway, with a seasonal total of 990, was the only station in New York City with pollen counts comparable in intensity to those found in this section of New Jersey.

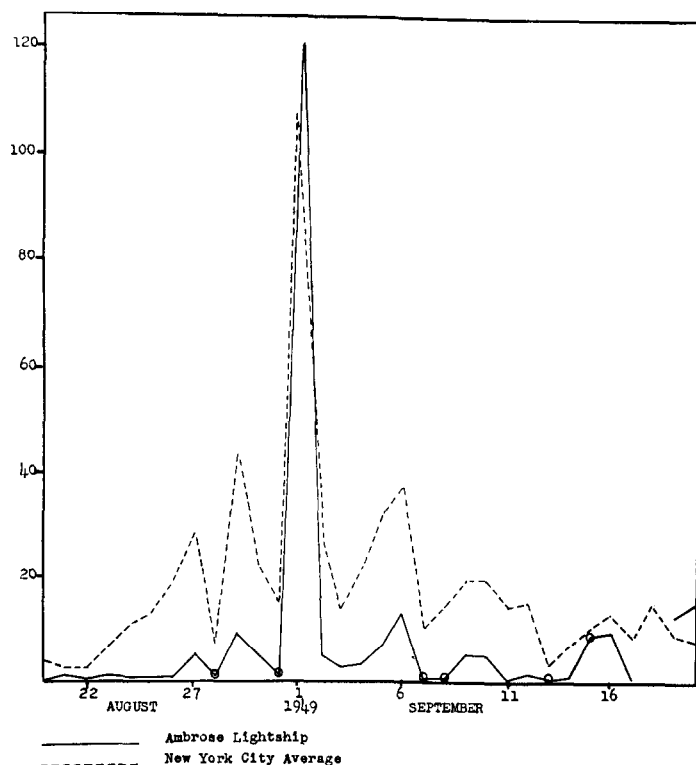


Fig. 2.—Graphs represent daily pollen counts at the Ambrose Lightship and the daily averages for New York City during the 1949 ragweed season. Circles indicate incomplete counts because of rain.

The daily ragweed pollen counts during the 1949 season at Ambrose Lightship and the stations around it are graphically presented in Figs. 2 and 3. The highest count of the year was recorded at every station, *including the Lightship*, on September 1. This was the only day *during the height of ragweed pollination* when the prevailing wind blew briskly from the west. The wind velocity on that day averaged 19 miles and reached a maximum of 34 miles per hour. These wind conditions were ideal for the transfer of pollen from the districts of high concentration in New Jersey, as represented by counts on that day of 182 at New Brunswick (Fig. 3, *A*) and 142 at Marlboro (Fig. 3, *B*) to the pollen-free

or pollen-poor areas to the east. It was thus possible to account for the imposing readings of 122 and 146 obtained respectively at the Lightship (Fig. 2) and Sandy Hook (Fig. 3, *E*) on that date. Significant is the fact that the count on the Lightship that day exceeded those of all the land stations in New York City with the sole exception of Rockaway (Fig. 3, *F*).

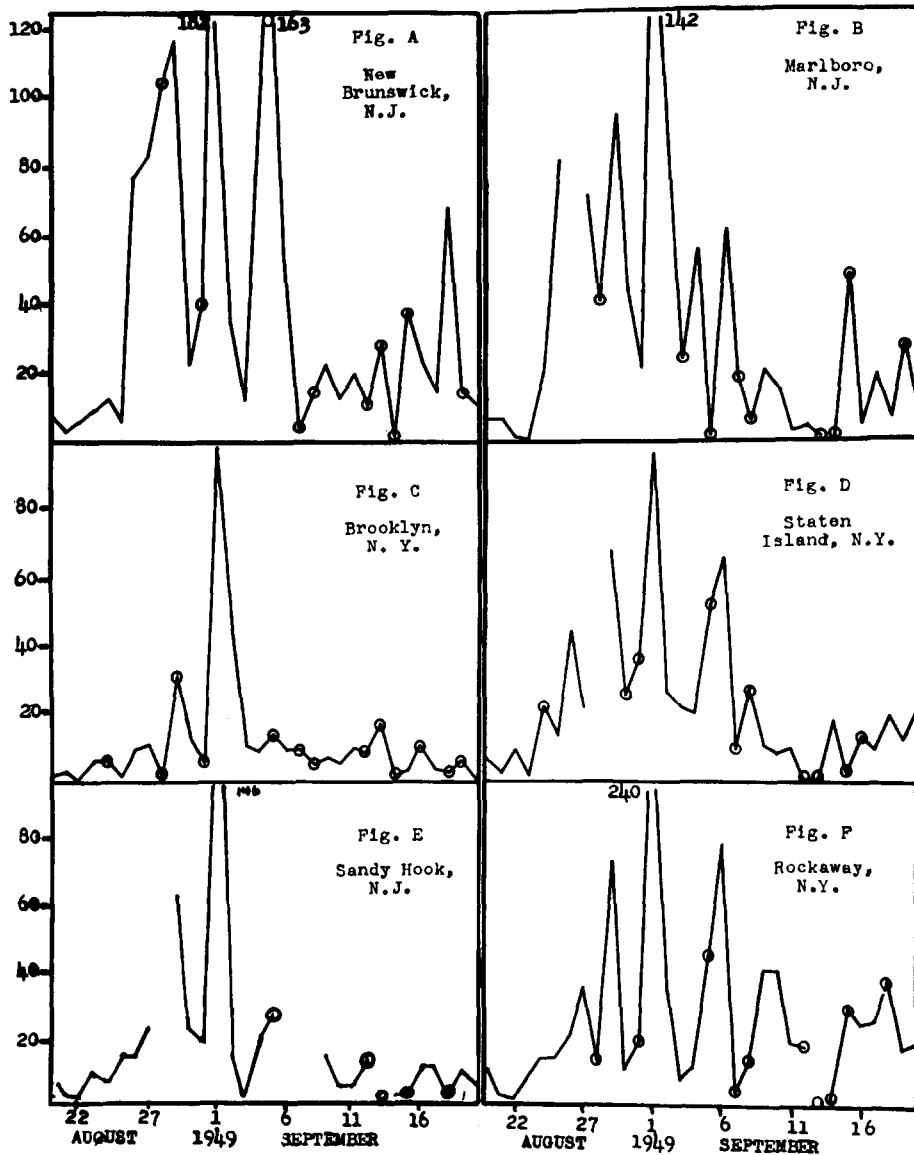


Fig. 3.—Graphs represent daily pollen counts at stations surrounding the Ambrose Lightship during the 1949 ragweed season. The gaps in *B*, *D*, *E*, and *F* denote a lack of data.

On September 2, 3, and 4, the prevailing winds in New York City again blew from the southwest. However, the winds were gentle and never exceeded 11 miles per hour. Under these circumstances Ambrose Lightship received only

small amounts of pollen and registered counts of 4, 3, and 4, respectively, on these dates. Although moderately high counts of 104 and 42 were obtained on August 28 at New Brunswick and Marlboro, respectively, the counts on the Lightship that day remained at zero because of a south wind which blew steadily from the ocean. On August 29 and September 6, winds blew with average velocities of 16 to 20 miles per hour toward the Lightship from the northwest, i.e., from the direction of Staten Island. Counts of 68 and 65, respectively, were obtained at Staten Island (Fig. 3, *D*) on these two days. Hence, on the basis of the prevailing wind condition, the counts at the Lightship of 10 and 14 on these two days were readily accounted for.

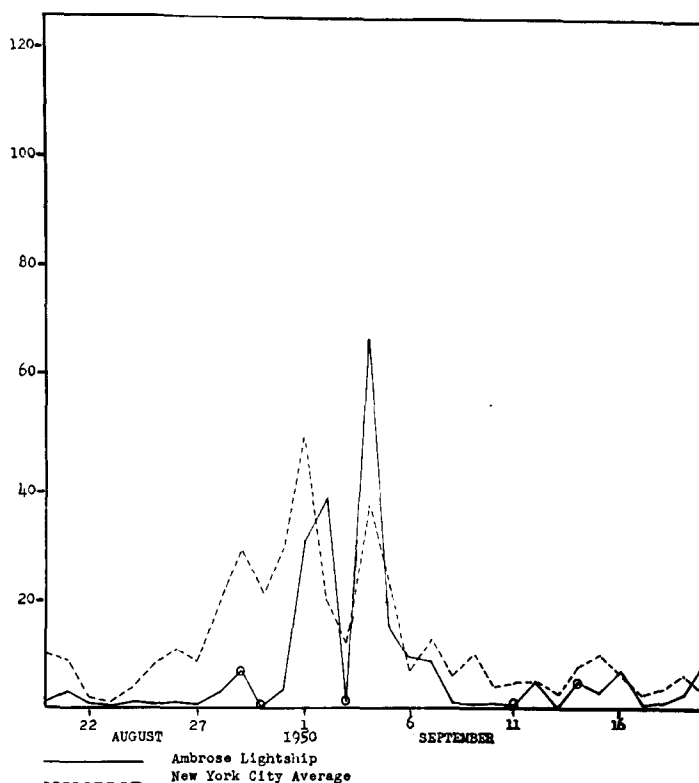


Fig. 4.—Graphs represent daily pollen counts at the Ambrose Lightship and the daily averages for New York City during the 1950 ragweed season.

Results of Studies During the 1950 Ragweed Season.—The ragweed pollen counts at the various stations surveyed in 1950 (Table I) are presented graphically in Figs. 4 and 5. The findings further establish the relationship of wind direction and velocity to the pollen counts on Ambrose Lightship as noted in 1949.

The three peak counts on the Lightship in 1950 occurred on September 1, 2, and 4 (Fig. 4). On September 1 the count at the Lightship was 31. The prevailing wind that day was from the southwest, with an average velocity of 13.8 miles per hour. The reading at New Brunswick that day was 74 (Fig. 5, *A*). The second peak count occurred on September 2 when the average wind

velocity was recorded as 7.8 miles per hour from the northeast. These wind conditions could not account for the high reading on the Lightship, but analysis of the hourly wind figures revealed that from 11 A.M. to 3 P.M. on September 2 there were northern winds ranging up to 13 miles per hour. On this day, the stations to the north of the Lightship, Flushing and Rockaway (Fig. 5, *B*), showed the highest counts in New York City. It thus seems likely that the pollen found on the Lightship slide on September 2 came from the land areas to the north of this station.

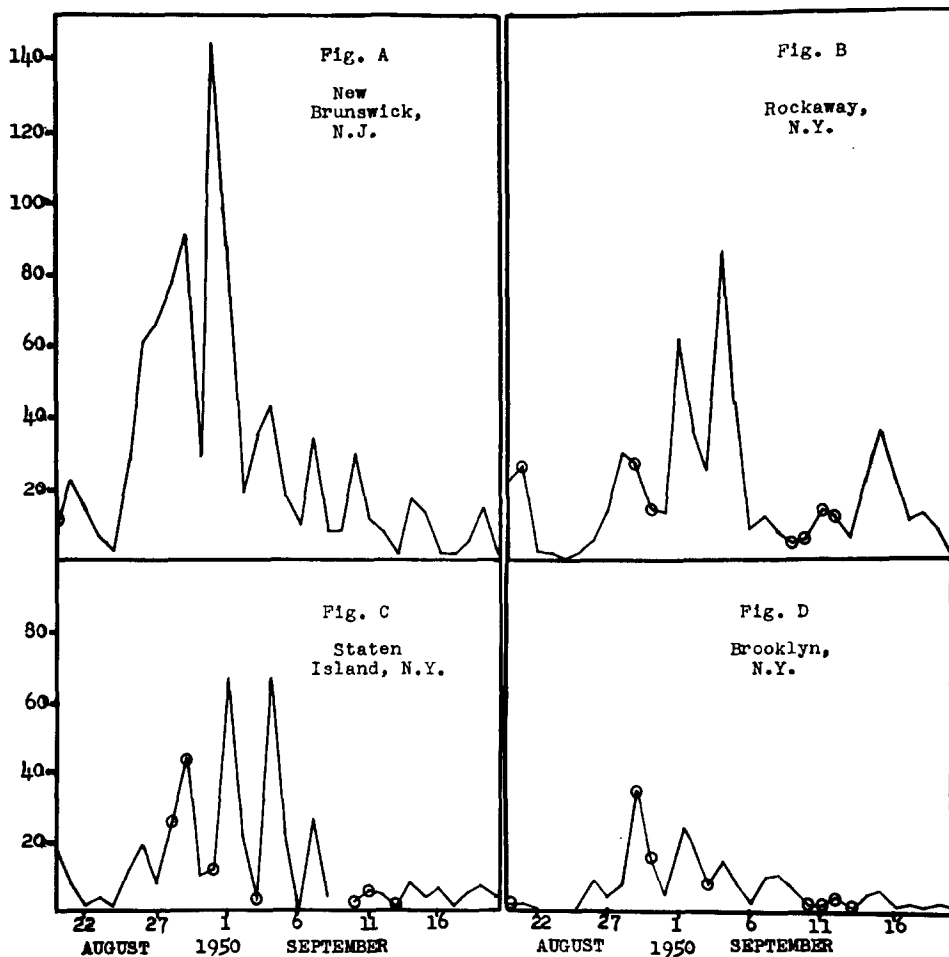


Fig. 5.—Graphs represent daily pollen counts at various localities surrounding the Ambrose Lightship during the 1950 ragweed season.

The highest count at the Lightship in 1950 was the reading of 67 on September 4 (Fig. 4). On that day, the wind was blowing at an average of 19 miles per hour from the northwest, i.e., from the direction of Staten Island, which also registered one of its peak days (Fig. 5, *C*) on this day. Despite high counts at New Brunswick (Fig. 5, *A*) from August 25 to August 31, the counts at the Lightship were low. On these days, the winds were southern most of the time and the occasional land breeze was gentle.

During the 1950 ragweed season, the seasonal total for Ambrose Lightship was 249, which was about 60 per cent of the average seasonal total of 420 for New York City. The seasonal total on the Lightship that year actually exceeded the totals for Brooklyn and for Central Park in Manhattan, which were 224 and 227, respectively (Table I).

DISCUSSION

Ample evidence of the importance of wind-borne pollen as a factor in the pollen problem in the New York City Metropolitan area has been presented. This fact had become evident in our studies on Fire Island in 1947 and on Sandy Hook in 1948 and 1949. Both of these areas have relatively few indigenous ragweed plants. The high readings which were found at these locations usually occurred on days when the winds blew briskly from the west. Though Fire Island is at least 60 miles from New Jersey, the evidence seemed to point to winds blowing from this direction as the bearers of most of the ragweed pollen found on the Island. The capacity of wind to transport ragweed pollen for distances up to 200 miles has been demonstrated by Sack¹⁰ in his controlled studies of slides exposed on planes and ships traversing the Atlantic Ocean.

The data collected in 1949 and 1950 at Ambrose Lightship, which is within the New York Metropolitan District and yet is completely ragweed-free, afforded even more convincing proof of the importance of wind-borne pollen as a factor influencing the city's pollen counts. The Lightship study demonstrated how an area totally free of ragweed plants could, under suitable conditions of wind direction and velocity, become grossly contaminated with large amounts of ragweed pollen. The day most illustrative of this point was Sept. 1, 1949, when the highest count (122) during the two years of the Lightship studies was obtained. On that day, western winds averaging 19 miles per hour brought in considerable amounts of ragweed pollen. It is significant that on this day, on which peak counts were obtained at all New York City stations, the reading at the Lightship actually exceeded some of those in the city boroughs which were producing their own ragweed pollen, but were less affected by the wind currents than the Lightship.

The data obtained in the Ambrose Lightship studies shed considerable light on the benefits which may be anticipated from local ragweed eradication programs such as the one being carried on by the New York City Health Department and by health and civic organizations in other communities. During 1949 and 1950 there were fifteen days during the ragweed seasons when the ragweed pollen count on the Ambrose Lightship was 8 or more granules per square centimeter of exposed slide. Such pollen concentration in the air would be likely to cause symptoms in most untreated ragweed-sensitive patients. Aside from the peak days previously noted, the counts at Ambrose Lightship tended to be lower than the New York City average counts for the same days (Figs. 2 and 4). It is apparent, therefore, that if ragweed plants were completely eradicated from New York City the patients would only be benefited on those days when there were no strong winds with a western component or when winds blew from the south or east.

Since the Lightship is about 9 miles from the nearest land and, in most directions, is at least 13 miles from shore, it may be considered to be situated at the center of an area which is completely free of ragweed plants and, by the most conservative estimate, covers at least 250 square miles.

The results obtained at the Lightship station may serve as an index of what may be expected in any neighboring land area of similar size undergoing ragweed extermination when it is surrounded by areas of heavy ragweed growth. Allowances are to be made for the fact that the Lightship area is exposed to land breezes on only two-thirds of its circumference. If this ragweed-free point were surrounded by land on all sides it is reasonable to assume that its seasonal totals would be considerably higher than those which were recorded. In 1949 and 1950 the seasonal ragweed totals at the Lightship were 46 and 60 per cent, respectively, of the average city totals for the same period. One may therefore speculate that in seasons such as New York City experienced in 1949 and 1950, total eradication of ragweed in a similar 250 square mile area in the city might diminish the seasonal total for the center of that area by about one-half, with diminishing effectiveness as the distance from the center increased. Increases in the number of days with western winds during the height of the pollen season would increase the contamination of the treated area and diminish the benefits of the ragweed elimination campaigns.

It is obvious that any attempt at ragweed extermination which concentrates only upon the elimination of the endogenous ragweed crop in New York City is bound to meet with only limited success. It would appear that ragweed extermination campaigns waged within the limits of New York City hold little promise for pronounced relief to hay fever sufferers unless a thorough and continuous eradication program can be waged for a few hundred miles in every land direction surrounding the city, with particular attention paid to districts west of the city.

The conclusions drawn from these studies support the recommendations of others who have investigated this problem.¹¹ While the study at the Lightship has dealt with ragweed, the conclusions may be applied to other eradication programs directed against elimination of plants generating wind-borne pollen. The effectiveness of ragweed elimination campaigns will be the subject of more detailed discussion in a subsequent communication in this series.

CONCLUSIONS

1. Ragweed pollen in considerable amounts was found on slides exposed at Ambrose Lightship in New York Harbor at a point at least 9 miles from the nearest land.

2. Wind direction and wind velocity were the most important determinants of the atmospheric concentration of ragweed pollen on the Lightship, a point entirely free of ragweed plants.

3. In 1949 and 1950 ragweed seasons, during which there were only two or three days at the height of ragweed pollination each season when strong

western winds prevailed, the seasonal totals at the Lightship were respectively 46 and 60 per cent of the average totals for New York City. In years with more western winds, higher totals at the Lightship may be expected.

4. On the basis of the Lightship studies it may be estimated that in the course of an average ragweed season, New York City probably receives as much wind-borne ragweed pollen as it raises within its own city borders.

5. An elimination program designed to free the city of ragweed pollen will only be completely successful when ragweed plants are completely and permanently eradicated from wide areas in every direction from which winds may carry pollen into the city. In New York City's planning, ragweed areas to the west of the city are its greatest problem.

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