

THE ACCURACY OF THE REPORTED RAGWEED POLLEN COUNT AS A MEASURE OF THE ACTUAL POLLEN EXPOSURE OF INDIVIDUALS IN THAT COMMUNITY

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THE atmospheric incidence of ragweed pollen is reported at the present time in terms of a single gravity sampler located on an "unobstructed roof of a tall, flat top building near the geographic center of a given community."¹ The practicability of utilizing a single sampling station in such reports has been questioned. In a preliminary study,² it was found that in sampling by a standard sampler at a residential site on a certain day, the pollen catch was 4 times greater than that reported at the central standard sampler located approximately 2 miles away.

In an attempt at control of the source, either by cutting or by suitable spraying of ragweed plants, a similar question arises. Can a single sampling station be used to measure accurately the expected decrease in atmospheric pollen by local control measures? These and similar questions cannot be answered at the present time due to insufficient study of the degree to which ragweed pollen is actually air-borne over long distances and to what extent the dosage is determined by local dispersion of pollen from plants in the immediate vicinity of the patient. It was hoped that this study would provide a partial answer to the above questions.

This investigation was concerned with the following closely related problems:

- (1) A study of meteorological conditions influencing aerial and local dispersion of ragweed pollen,
- (2) a field survey to determine the location and density of ragweed pollen plants within the city limits of a community located in a known high incidence area, and
- (3) the accuracy of the reported ragweed pollen count as a measure of the actual pollen exposure of individuals in that community.

PROCEDURE

A field survey which consisted of a block-by-block canvass of the residential areas was made during the months of June and July. The density of ragweed growth was noted and the location was carefully marked on a suitable work map. The results were then transferred to a larger map (1 inch equal to 691 feet) and, by the use of a planimeter, the approximate acreage of ragweed was determined.

Ten sampling sites throughout the residential area were then selected to determine the local ground level dispersion of ragweed pollen. At each sampling

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station a standard gravity sampler was erected with the top of each sampler exactly 6 feet above, and with the sampler plane horizontal to the ground as determined by a suitable level.

These were in addition to the central standard sampler which has been used for many years in reporting the pollen counts for this particular city. It is located on the topmost ledge of a tower on the Medical Laboratory Building, approximately 75 feet above the ground, well above the nearby trees, having no obstruction to air currents from any direction, and is approximately 300 yards from any known source of ragweed pollen. For the sake of clarity, this station will be referred to hereafter as the "central station" or "central sampler."

Vaseline-coated slides were collected from these samplers daily from August tenth through September nineteenth. In an attempt to decrease the sampling error, a total area of 5.42 square centimeters was counted for each slide. The total count was finally converted to pollen grains per cubic yard of air by using 3.6 as the conversion factor.¹

Pertinent meteorological data* were secured from the Weather Bureau Station at the close of the ragweed pollen season. It was hoped that these meteorological data when correlated with the pollen catch per each sampler would add useful information as to the factors involved in the local dispersion of pollen and that a comparison of the pollen count from these ten samplers with those at an ideally located central sampler would explain to what extent a single sampling station represents the true pollen exposure of individuals in this community.

DISCUSSION AND RESULTS

Meteorological Factors in Pollen Distribution and Prevalence.—

Wind velocity.—One factor in determining the local as well as the aerial distribution of pollen is wind velocity. Not only does the wind velocity determine in part the dispersion of ragweed pollen from the plant but the wind velocity is also important in that it does definitely affect the amount of pollen collected by the standard gravity sampler.

The extreme buoyancy of ragweed pollen in terms of wind velocity is perhaps not generally appreciated. In a study by Crawford³ on the specific gravity of ragweed pollen (*Ambrosia elatior*), it was found that the minimum velocity of dry air required to maintain pollen grains in an air-borne condition was 1.58 cm. per second. In arriving at this figure experimentally, there was a short lift given the pollen. Disregarding air turbulence, a horizontal air flow of 1.58 cm. per second would be sufficient to overcome the force of gravity and produce air-borne pollen. This means that a horizontal air velocity of only 186 feet (0.035 miles per hour) is sufficient to maintain, as air-borne, much of the pollen liberated into the air from a local source. This does not mean, however, that such an air velocity would be sufficient to pick up in appreciable amounts pollen granules after they had settled upon the ground, on vegetation or other objects.

Turbulence.—It would be rare indeed to have a horizontal air stream without turbulence. The earth's surface as it is warmed by the sun is very un-

*Supplied through courtesy of Professor Joseph W. Howe, Department of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa.

equally heated. This results in upward and downward convection currents of air between ground areas that have been heated to different degrees of temperature. Any obstructions on the earth's surface such as buildings, trees and even the pollen plants themselves would serve to create additional turbulence. Longstreth⁴ in his discussion of turbulence states that "below an altitude of 600 feet the wind proceeds in an unpicturable turmoil. Friction with field and wood and hill forms an irregular drag upon its undermost layer. The over layers stub their toes, stumble forward, fall down, turn somersaults, make mill-wheels, make spinners, fluctuate in velocity, rush and crowd and pick themselves up and go on." Because of the low wind velocity necessary to maintain ragweed pollen in the air, it is believed that the dosage in the near vicinity of ragweed plants is dependent to a greater degree on air turbulence than on wind velocity.

However, the actual pollen report in terms of the standard sampler is dependent in large part upon air velocity. This has been pointed out by Durham⁵ as well as by others.^{6, 7} Durham⁵ states that "the proportionate catch of pollen on the gravity slides, as compared with that measured by the volumetric instruments, varied directly with the wind velocity." He concluded⁵ that in "strong winds there are upward as well as downward currents, and that wind impingement can, under such conditions be responsible for most of the 'gravity' catch." Present slide counts in terms of the standard gravity sampler would be made a great deal more meaningful, if through additional experimentation a correction factor for wind velocity were available for the more common pollens and spores.

In spite of the sampling error of the standard sampler with a varying wind velocity, it is a well-established fact that in most patients the severity of the symptoms correlate roughly with the reported pollen count. With an increase in the reported count, there is an increase in symptoms and many patients have their most severe symptoms during days with a high wind velocity.

The inhalation rate of the patient being unchanged, one would not expect there to be any appreciable increase in the number of granules inhaled on windy days unless the plants discharged excessive amounts of pollen on such days. In our observations there is no evidence that this is true. There could be larger numbers impinged upon the conjunctiva on windy days just as there is upon vaselined slides because of the larger volume of air striking the conjunctiva. This raises the question as to what extent the conjunctiva may serve as a portal of entry.

Sunshine and pollen production.—It has been demonstrated⁸ that ragweed plants do not release pollen into the surrounding air at a constant rate. A large amount of sunshine with a sufficient wind velocity in the morning would provide for maximum release of pollen from the plant at this time of day. In an attempt to determine still further the effect of sunshine on the local dispersion of pollen, 7 days were selected during which there was little or no sun. The pollen catch at each sampling site during these 7 days was compared with the pollen catch on seven days during which there was 90 per cent to 100 per cent sun. It was possible to control the effect of wind direction from local pollen plants and the wind velocity by proper selection of days during which

these two factors would be approximately the same. The 14 days studied were equally distributed throughout the actual pollen season from August fifteenth to September fourth.

The average pollen count was 104 per cubic yard of air higher at each sampling station on those days having 90 per cent to 100 per cent sun than on days with no or little sunshine.

Humidity and the pollen count.—Markow and Spain⁹ report that “a comparison of the humidity curve with the symptom curve shows that they were inversely proportional. The three peaks in the severity of symptoms occurred upon days when there was the greatest drop in relative humidity.”

An experimental approach to this problem indicates that this increase in symptoms with a decrease in humidity may be due to the fact that with a high relative humidity there is apt to be a marked decrease in the incidence of air-borne pollen.

Samples (0.03 Gm.) of commercially collected ragweed pollen (*Ambrosia trifida*) were weighed out into clean Petri dishes. The pollen was discharged from the Petri dish into the air of an experimental chamber by a sudden jet of compressed air. A circular fan was used for 60 seconds to provide for a homogenous mixture of the pollen with the air. Immediately after the fan was turned off a suitable instrument¹⁰ was used to sample one cubic foot of air. A series of readings was taken at a relative humidity of 35 per cent. A second series of readings was taken at a relative humidity of 81 per cent. The mean dosage of ragweed pollen collected with the relative humidity at 35 per cent was 236 pollen grains per cubic foot of sampled air while with the relative humidity at 81 per cent a mean dosage of only 82 pollen grains was recovered.

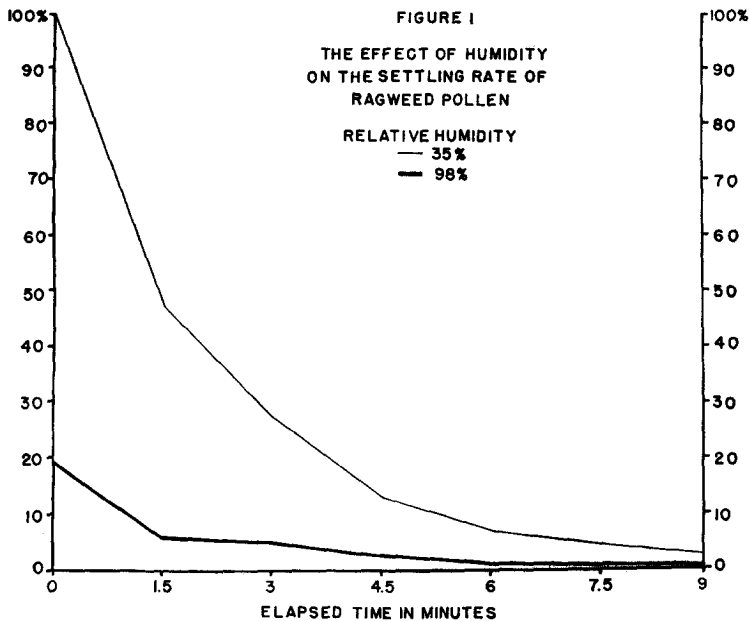
In these readings and the readings that follow the “funnel device”¹⁰ was used as the sampling instrument. With a slight modification of this device, sampling can be carried out by electrostatic precipitation with impingement or by simple impingement alone. As with an increase in humidity there is a breakdown in efficiency in sampling by electrostatic precipitation all air samples were taken by simple impingement in the belief that humidity would have little or no effect on the sampling efficiency of this method.

The effect of relative humidity on the rate of ragweed pollen fall is further indicated in Fig. 1. In these readings the portable humidifier was placed within the experimental chamber such that it was possible to raise the humidity of this chamber to 98 per cent.

The pollen was released into the air of the experimental chamber as in the former readings. A circular fan turned on for 60 seconds again provided for a thorough mixing of the pollen with the air of the chamber. Air samples were then taken at 7 time intervals. The sampling time of each air sample was exactly one minute, with the rate of air flow maintained at 0.5 cubic foot per minute. Thirty seconds were allowed between readings to change the vaseline coated slide used in the sampling instrument. The mean dosages of ten air samples taken at each of the seven time intervals were compared as shown in Fig. 1.

When pollen was introduced in this manner into an atmosphere with a low relative humidity of 35 per cent, 100 per cent. was used to indicate the pollen collected by the first air sample which was taken immediately after the circular fan was turned off or at 0 in elapsed time in minutes (Fig. 1) after turning off the circular fan. The first air sample, however, was actually taken one minute after the pollen was released into the experimental chamber as the circular fan was kept on for one minute. The second air sample was started one minute and thirty seconds after turning off the circular fan but again actually represents two minutes and thirty seconds after releasing the pollen into the experimental chamber.

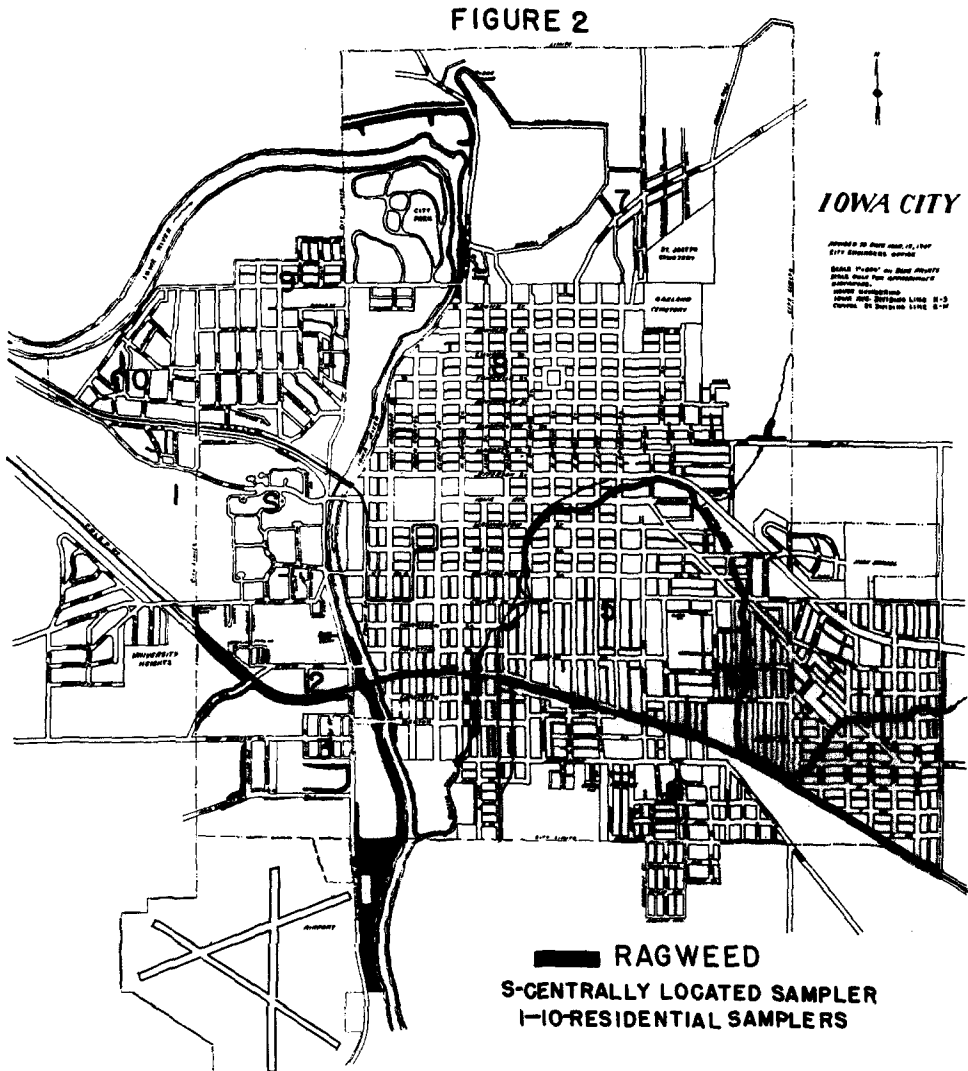
When pollen was introduced into an atmosphere with a relative humidity of 98 per cent only 19 per cent as much pollen was collected by the first air sample as was collected at a relative humidity of 35 per cent. Again it might be pointed out that although this first air sample was started as is indicated



in Fig. 1 at 0 in elapsed time in minutes after turning off the circular fan, it represents one minute in time after introduction of the pollen into the air of the experimental chamber. In spite of air turbulence created by the circular fan a marked settling did occur. That this marked increase in settling rate with an increase in humidity was not due to clumping was indicated during slide examination and counting. Very little clumping occurred on the vaseline coated slides used in the air sampler either at a low or high humidity.

With a low relative humidity of 35 per cent, the air samples at the end of 10 minutes showed that only 2.9 per cent of it remained air-borne, i.e., 97.1 per cent must have settled out. By contrast, where introduced into an atmosphere with the high relative humidity of 98 per cent practically all the pollen had fallen from the air (only 0.5 per cent remained therein).

These experimental readings suggest that under natural conditions, with a low wind velocity during the night, with less air turbulence than would be present during the day and with an increase in the humidity which is not uncommon, one should expect a rather rapid fall in the atmospheric ragweed pollen.



The factors discussed above suggest the limitations of air filtering units, vacuum cleaners, etc., in completely removing ragweed pollen from homes in which it has had time to settle. Such pollen settles on furniture, drapes, bed spreads, walls, etc. where it cannot be reached by the devices mentioned above. During sweeping and dusting operations, bed making, etc., air currents may make such pollen air-borne for a transitory period, after which it rapidly settles again. It is very difficult indeed to remove pollen from a house once it has settled therein.

The Field Survey.—The Iowa River traversing the city together with Ralston Creek provide for an excellent source of ragweed plants due partially to periodic floods and silting of bottom lands and banks. These two streams accounted for 55 per cent of the total ragweed acreage (Table I). The fact that ragweed seeds will germinate after being buried in sand for 40 years¹¹ and that the fibrous coat of the seed is penetrated very slowly by water permitting it to be carried great distances by rivers and streams¹² may also be responsible for these areas ranking first in a consideration of suitable local control procedures.

The railroad right-of-way together with sidings was responsible for 30 per cent of the total ragweed acreage. Several deep cuts were necessary in the construction of the railroad within the city limits. The bare denuded soil, together with the constant erosion year by year has provided for an excellent annual stand of ragweed.

TABLE I. THE RAGWEED ACREAGE OF IOWA CITY, IOWA, 1950*

	NO. OF ACRES	PER CENT
1. Railroad right-of-way and sidings	44	30
2. Iowa River	41	28
3. Ralston Creek	39	27
4. Residential area	22	15
Total ragweed area	146 acres	

*Iowa City—total acreage within city limits—3,315 acres.

Third in importance was the residential area accounting for only 15 per cent of the total ragweed acreage. It is of interest to note that the indicated growth of ragweed on the spot map (Fig. 2), especially along the river, creek and railroad consists almost entirely of giant ragweed (*Ambrosia trifida*). These plants with thick, woody stems were 6 to 8 feet tall. A few short ragweed plants (*Ambrosia elatior*) were found in the residential areas, on an occasional empty lot or along a small home garden but even here the giant ragweed plant was predominant.

It is obvious that control of ragweed plants within the city is not so much a problem of the individual property owner as it is a joint responsibility of the proper officials of the railroad and city.

Control procedures as by cutting or spraying of ragweed plants along the river and creek would have to be carried out annually to be of most value due to the possibility that in these areas the seeds are in part water-borne.

The total ragweed plant acreage within the city limits of Iowa City was found to constitute 146 acres. The ragweed production involves 4.4 per cent of the total area of the city (3,315 acres). With an estimated 60 pounds per acre⁵ this would amount to 8,760 pounds of ragweed pollen produced by plants within the city.

It is important to point out that the city studied is surrounded by rolling farm land. No survey was carried out to measure the ragweed acreage in this area, but within a radius of five miles in any direction the pollen production is undoubtedly very high.

The Accuracy of the Reported Ragweed Count.—The results obtained in a comparison of the pollen catch per each of the 10 standard samplers located in the residential areas (Fig. 2) at ground level with a single standard sampler indicated in Fig. 2 by *S* would depend in part upon the location of the central standard sampler. As has been stated the sampling site used for a number of years in the reporting of ragweed pollen in this city, is the topmost ledge of a tower on the Medical Laboratories Building. The sampling station is 75 feet above the ground, is well above the tops of nearby trees, and has no obstruction to air currents from any direction.

This sampling station is not centrally located from the standpoint of the city proper. It is however rather centrally located from any growth of ragweed plants. To the north, south and east from the centrally located sampler, ragweed growth is indicated in Fig. 2. To the west from the sampler, no ragweed is indicated as this area lies outside of the city limits. It is known however that some ragweed growth does occur to the west along the railroad right-of-way. The centrally located sampler *S* is therefore quite equidistant from any known ragweed source.

It was believed in making this comparison that the 10 samplers located in the residential areas would more nearly reflect the local ground level dispersion of pollen. Especially would this be true of those samplers intentionally located near a known source of ragweed and on those days with the wind from this source toward the sampler. The centrally located sampler used for the routine reporting of ragweed pollen on the other hand would indicate to a larger degree the over-all incidence of air-borne pollen for the area as a whole.

Seasonal comparisons.—A seasonal comparison was first made by utilizing Durham's¹³ method of calculating the pollen index. The results of this comparison along with the apex dates are indicated in Table II.

A wide variation in the calculated pollen index was found ranging from a low of 69 at sampling station No. 1 to a high of 114 at sampling station No. 3. The results reflect the proximity of ragweed in that station No. 1 is about as far from a known source as any of the stations and station No. 3 as near as any to a ragweed source.

It is of interest to note, however, that the central standard sampler with an index of 99 is actually higher than most of the calculated pollen indices for the samplers located in the residential areas. The pollen index for sampling stations known to be located near a ragweed source but with the prevailing winds in other directions than from the source and with air turbulence resulting from buildings and trees is actually lower in many instances than the pollen index calculated for the centrally located standard sampler. The reported incidence at the latter therefore does not always indicate the minimum exposure of a patient in the community but may represent the maximum possible seasonal exposure. This being so, obviously on a seasonal basis, little would be accomplished in this city by a city-wide attack upon ragweeds. To reduce the reading at the central sampler evidently a much wider area of control would have to be included.

TABLE II. THE CALCULATED POLLEN INDEX DATE OF TEN STANDARD SAMPLERS LOCATED IN THE RESIDENTIAL AREAS AS COMPARED WITH A STANDARD SAMPLER CENTRALLY LOCATED IN THE SAME CITY, IOWA CITY, IOWA, 1950

SAMPLER LOCATION BY NUMBER	AVERAGE NUMBER OF HAY FEVER DAYS PER SEASON	MAXIMUM POLLEN COUNT ON ANY ONE DAY	POLLEN GRAINS SEASONAL TOTAL	RAGWEED POLLEN INDEX	APEX DATE
Standard*	36	832	10,893	99	9/1
1	33	575	6,048	69	9/1
2	36	738	7,955	83	8/24
3	34	2450	11,110	114	8/22
4	38	1100	11,149	105	8/26
5	34	474	6,333	70	9/1
6	38	1230	10,025	100	8/24
7	37	620	8,070	84	8/24
8	32	739	7,997	79	8/24
9	34	599	7,214	76	9/1
10	36	682	8,227	84	8/25

*Standard—centrally located standard sampler, see Figure 2 for location of additional sampler.

The mean pollen index of the 10 sampling sites located in the residential areas was found to be 86. A single centrally located standard sampler with a calculated pollen index of 99 does indicate the practicability of making seasonal comparisons of the ragweed pollen incidence of communities in terms of a single properly located sampler.

It would also seem probable from these results that a single sampler, again properly located, will serve to measure the adequacy or inadequacy of plant control or eradication procedures in this community when these procedures are carried out on a broader basis than on a local level.

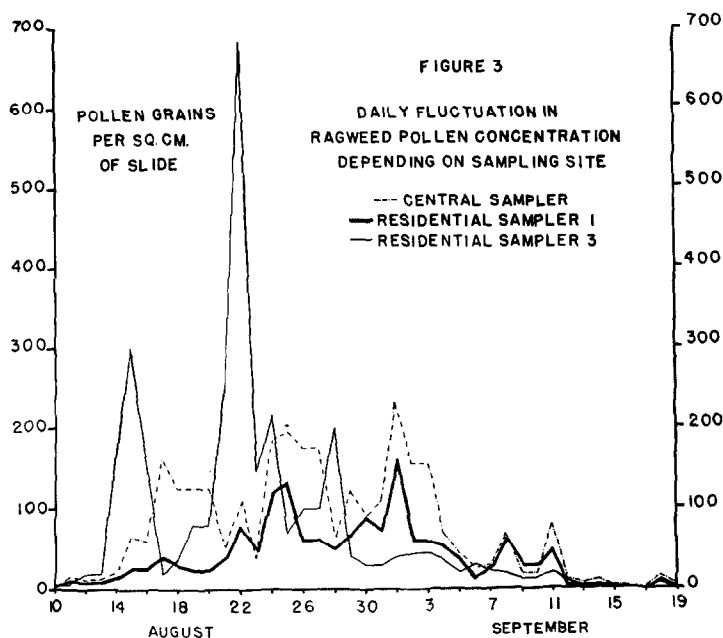
Daily pollen fluctuations:—A single centrally located standard sampler, however, does not indicate the marked daily fluctuations in exposure to ragweed pollen of the individual patient. This fact is indicated in Fig. 3. In this graph a comparison is made between the sampling site having the highest pollen index (No. 3), the site with the lowest index (No. 1) with the pollen concentration reported from the centrally located standard sampler.

On August fifteenth a patient living at site No. 3 would have about 6 times the exposure as compared with the reported dosage at the standard location or 12 times the exposure to ragweed pollen as compared with a patient living near sampling site No. 1. Similarly on August twenty-second the patient living at site No. 3 would have about 7 times the exposure to ragweed pollen as compared to the reported dosage at the standard sampler and about 9 times the exposure to ragweed pollen as compared with a patient living near sampling site No. 1.

The physician can rely on the reported pollen index computed on the basis of a single standard sampler in determining the ease or difficulty in treatment on a seasonal basis. The physician cannot, however, with any degree of certainty rely on the reported daily reports in terms of a single sampler in determining the dosages necessary for successful desensitization.

Local control measures would then be of some benefit on a daily basis to the individual patient living near a ragweed source and on those days when the prevailing winds are from this source. However, Table II indicates that in only

3 instances was the maximum or peak concentration higher in the residential areas as compared with the maximum pollen concentration reported at the standard sampling site. Comparatively few patients then, depending on proximity of ragweed and prevailing winds, would be benefited by city-wide ragweed control measures.



Marked variations were found in the apex date or day at which the ragweed pollen concentrations exceeded all other days for that particular location (Table II). This may represent an actual difference in the maturing of ragweed plants. It would seem more probable, however, that these results indicate still further the daily variations in pollen concentrations that may be expected in sampling at ground level.

SUMMARY

A field survey to determine the location and density of ragweed growth was made in a city located in a known high ragweed pollen area. Ten standard samplers were located in certain residential areas. Slides exposed for 24 hours at each of these sampling sites were compared with the pollen catch reported in terms of a centrally located standard sampler. It was believed the 10 samplers located in the residential areas would determine the ground level dispersion of ragweed pollen, while the centrally located standard sampler would more nearly approximate the aerial transmission of ragweed pollen.

1. This comparison indicates that on a seasonal basis, little would be accomplished by local ragweed control measures, if such were restricted to the city grown ragweed.

2. The ragweed pollen index in terms of a centrally located standard sampler is of value to the physician on a seasonal basis in that it does indicate to him rather accurately the ease or difficulty in treatment of patients living in the area. However, the daily reports in terms of a centrally located standard sampler do not indicate accurately the marked daily variations in pollen dosages to which the individual patient is exposed.

3. Certain meteorological conditions, such as wind velocity, air turbulence, sunshine, and humidity influencing the local and aerial transmission of ragweed pollen are discussed.

4. This study also appears to show that a centrally located standard sampler in this community will have value in measuring the effectiveness of plant eradication programs when such programs are carried out on a broader basis than on a local level.

REFERENCES

1. Durham, Oren C.: Volumetric Incidence of Atmospheric Allergens; A Proposed Standard Method of Gravity Sampling, Counting and Volumetric Interpolation of Results, *J. ALLERGY* 17: 79, 1946.
2. Barnes, Milford E., and Rooks, Roland: Ragweed Pollinosis; Some Practical Considerations, *J. Iowa State Med. Soc.* 40: 287, 1950.
3. Crawford, James H.: Determination of the Specific Gravity of Ragweed Pollen (*Ambrosia elatior*) and Conversion of Gravity Sample Counts to Volumetric Incidence, *Pub. Health Rep.* 64: 1195, 1949.
4. Longstreth, T. Morris: *Knowing the Weather*, New York, 1943, The Macmillan Company.
5. Vaughn, Warren T., and Black, J. Harvey: *Practice of Allergy*, St. Louis, 1948, The C. V. Mosby Company.
6. Fletcher, Alfred H., and Velz, C. J.: Pollens-Sampling and Control, *Indust. Med. and Surg.* 19: 129, 1950.
7. Balyast, Ray M.: Factors Which Determine the Pollen Content of the Air, *J. Lab. and Clin. Med.* 12: 1151, 1927.
8. Durham, Oren C.: The Volumetric Incidence of Atmospheric Allergens. V. Spot Testing in the Evaluation of Species, *J. ALLERGY* 18: 231, 1947.
9. Markow, Harry, and Spain, W. C.: Ragweed Hay Fever, Its Diagnosis and Treatment, *J. ALLERGY* 1: 414, 1930.
10. Rooks, Roland: A Device for the Electrostatic Precipitation of Pollen and Fungus Spores Upon a Counting Slide, *J. ALLERGY* 19: 206, 1948.
11. Darling, H. T.: The Sixty-Year Period for Dr. Beals Seed Viability Experiment, *Am. J. Botany* 28: 271, 1941.
12. Foerste, A. F.: Notes on *Ambrosia Trifida*, *Botanical Gazette* 7: 40, 1882.
13. Durham, Oren C.: Our National Parks as Ragweed Hay Fever Refuges, *J. A. M. A.* 138: 126, 1948.