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INTRODUCTION

Data on pollen and spores are of importance in studies pertaining to recent and past floras and alterations in these floras, or as expressed more generally, the history and prehistory of vegetation. In such projects, particularly in their interpretive aspects, it is of importance to have some measure of the degree of relationship which exists between records of the pollen-spore content of the air and similar data on pollen and spores found in moss-mats (Erdtman 1943, Carroll 1943, Hansen 1949) and lake sediments (Faegri and Iversen 1950). It seems of particular importance that such correlated analyses should be taken during the same period in topographically connected regions.

The data to be presented represent a survey of air-borne pollen and spores collected at Itasca State Park, Minnesota during the summer of 1954.

In addition to the present enumeration of the air-borne pollen and spores of Itasca State Park, correlative samples have been obtained in a nearby Sphagnum bog (Figure 1, Site 3) and in Lake Itasca itself (Figure 1, Site 2). Eventually it is intended that the pollen record from the air-sampling, herein reported, will be compared with records to be obtained from analyses of samples of moss polsters and lake sediments taken from locations in close alliance with the stations established for the atmospheric sampling.

METHODS

For five weeks during the summer of 1954 two pollen-spore collection stations were maintained at selected sites on the Lake Itasca Forestry and Biological Station Campus of the University of Minnesota. The Biological Station and Lake Itasca are located in Clearwater County. A map of the Biological Station Campus showing the locations of the pollen-spore shelters is represented by Figure 1. One shelter was placed five feet above the ground in an open field (Figure 1, Site 1a) while the second shelter was placed twelve inches above the ground in a thickly wooded site (Figure 1, Site 1b).

[1] The writer wishes to express his sincere thanks to Professor A. Orville Dahl for his assistance and guidance during the course of this investigation and in the preparation of this paper.

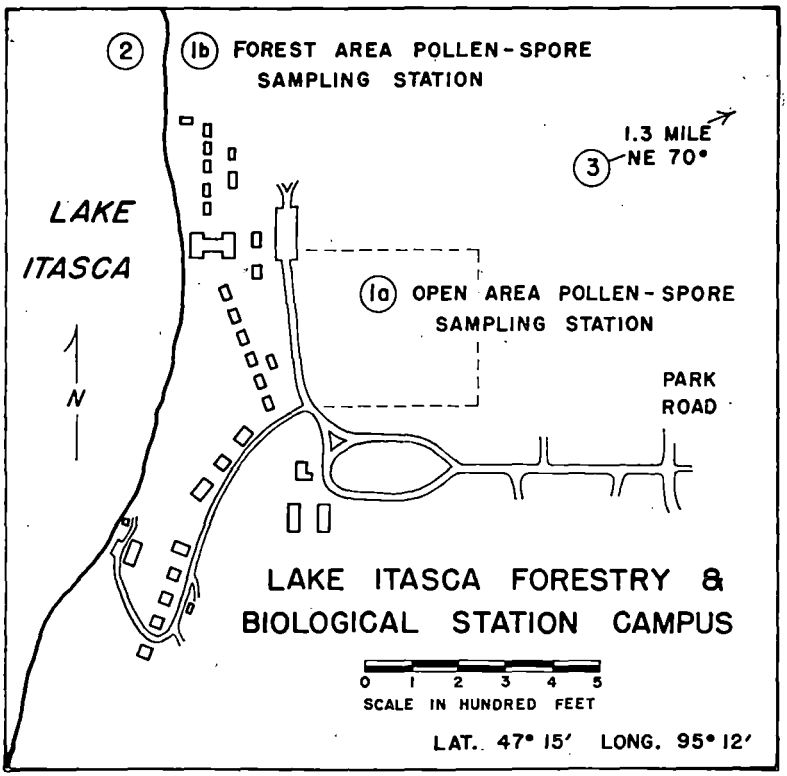

Fig. 1. Sketch map indicating the locations of: 1a. and b., air-borne pollen and spore collection stations; 2., recent lake sediment sampling site; and 3, a Sphagnum bog in which moss-mat collections have been made.

The pollen-slide shelter consists of two disks each nine inches in diameter which are oriented horizontally and held parallel, three inches apart, by three equally spaced struts. A platform for holding an ordinary 2.5 cm. by 7.5 cm. microscope slide is located between these two disks, one inch above the lower disk. The whole apparatus is supported on a vertical standard consisting of ¼-inch pipe. To hold the pollen-slide shelter in position the standard was simply driven into the ground.

This pollen-spore gravity sampling device was described by Durham (1946) and has been adopted as the "standard" approved by the Committee on National Pollen Survey of the American Academy of Allergy (Durham *et al.* 1946).

The microscope slides used to sample air-borne pollen and spores were coated with a thin film of the oil preparation used in earlier atmospheric studies in Minneapolis (Rosendahl *et al.* 1940, Dahl and Ellis 1942). This oil mixture consists of:

1. 2 parts — melted white petrolatum,
2. 1 part — paraffin (mineral) oil,
3. 1 part — *n*-butyl alcohol,
4. 1 part — xylene.

The mixture is filtered while warm and kept free from contamination in a stoppered container.

Slides were marked appropriately with a diamond tipped pencil. The slides were then coated with the oil coating in a culture chamber, providing maximum protection against contamination, and kept before and after exposure in a slide box protected at the seams with masking tape. Each microscope slide was exposed to the atmosphere for twenty-four hours.

A compound microscope was used for examination of the oil-coated slides. The pollen grains and spores appearing in a predetermined number of fields totalling one square centimeter were recorded. With the Leitz Ortholux microscope used for these determinations 204 fields, using a 12X objective and a 12X ocular, are equal to an area of 1.0 square centimeter. The 204 fields were systematically distributed over the surface of the exposed slide along four equally spaced longitudinal transects.

OBSERVATIONS

The daily record of pollen and spore incidence for each of the two stations is broadly summarized in Figure 2. Pollen grains have been placed in groups whose taxonomic specificity is dependent upon the morphological distinctness of the pollen. The encountered spores have been assigned to the most specific taxonomic position conveniently attainable.

The value of field observation and a pollen reference collection was eminently demonstrated with the Mountain Maple (*Acer spicatum* Lam.) pollen recorded on the 17th of June. In this case the air-borne pollen collections were more sensitive to the onset of the flowering period than were my field observations. Mountain Maple was first observed in flower on the day following the pollen slide collection. This information on the local flowering time coupled with examination of known Mountain Maple pollen, collected at Lake Itasca for reference purposes, definitely established the identity of these pollen grains.

The high atmospheric concentration of pine pollen between June 16th and 20th corresponds to the flowering period of Norway (Red) Pine (*Pinus resinosa* Ait.). The pine pollen peak between June 24th and July 2nd similarly agrees with the observed White Pine (*Pinus Strobus* L.) pollen shedding period. Pine pollen caught before June 16th, the first date that Norway Pine was observed to shed pollen, may be that of Jack Pine (*Pinus Banksiana* Lamb.). Jack Pine had shed its pollen before observations were begun but a few individuals, particularly broken or dying trees, were found with male cones containing quantities of pollen and, in any case, a lingering atmospheric concentration would be expected. Size frequencies substantiate this interpretation. Red Pine and White Pine pollen are similar in size (with modes of 58μ and 59μ respectively between the points of insertion of the bladders, Cain 1940) but Jack Pine is considerably smaller (45μ) and may be distinguished from the other two pines of northern Minnesota with some reliability.

Grass pollen was observed on the slides almost every day during this mid-summer period. It is interesting in this respect that about an equal number of grass pollen grains were recorded at the two collection sites, even though one was located in a grassy field (which was, however, kept partially mowed) and the other on the forest floor where grasses were not locally abundant. A total of 34 grains was recorded in the open area and 37 on the forest floor. The daily frequency of grass pollen is also similar at each of these two stations.

In a region with such an abundance of lakes and bog areas as Itasca State Park it might be expected that the atmospheric concentration of Cat-tail (*Typha latifolia* L. and *T. angustifolia* L.) pollen would exceed the numbers actually recorded. Cat-tail pollen reached its highest peak on the 16th and 17th of July, the last two days on which collections were made. The trend beyond these dates cannot be determined but field observations indicate that the highest concentration had not been reached.

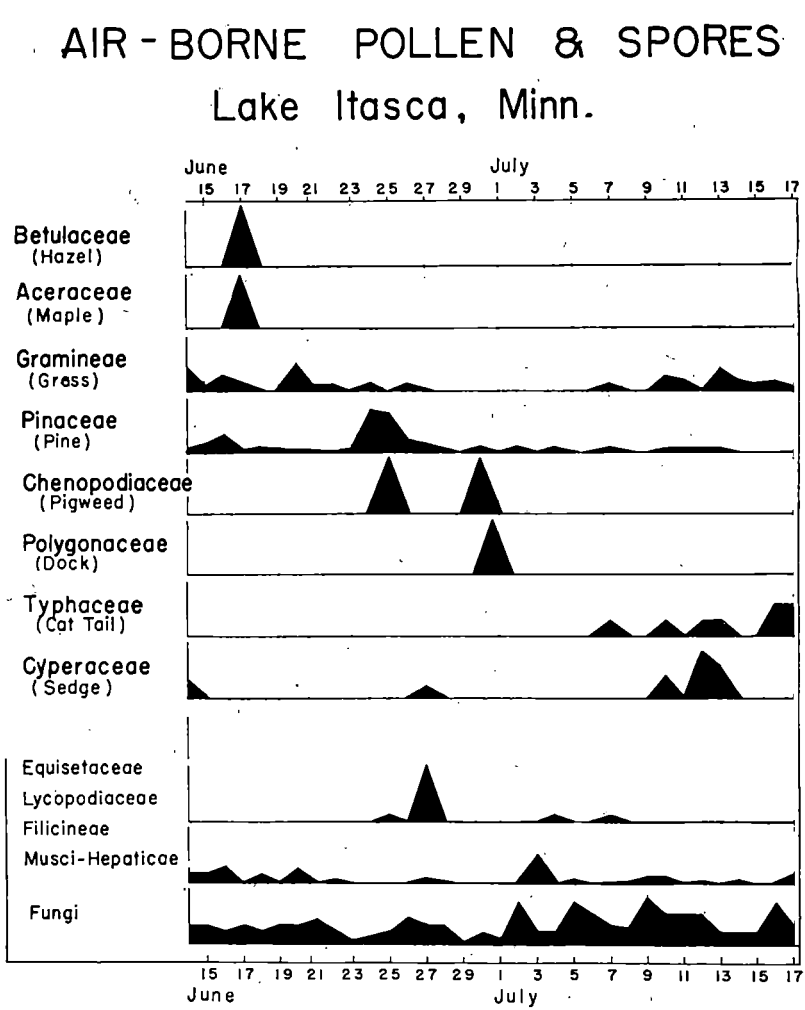

Fig. 2. A graphic summary indicating the relative daily pollen and spore records during the summer of 1954.

A graphic summary of the relative pollen and spore daily records is shown in Figure 2. It will be noted that this method of representation does not permit quantitative comparisons between groups. Rather the peaks indicate the percent of each pollen and spore type that was caught per day based upon the total number of pollen grains or spores of that type recorded over the five week period. A more detailed and extended account of air-borne pollen and spores will be prepared with reference to later correlated analyses of pollen and spore deposits in moss polsters and lake sediments.

DISCUSSION

The total number of pollen grains and spores recorded at each of the two pollen-spore sampling sites is in close agreement. This agreement suggests that the location of the pollen-spore shelter, within the limits of this study, is not of paramount importance.

The specific data are as follows:

	Pollen-spore Collection Stations	
Pollen-spore Type (s)	Open Field	Forest Floor
Grass	34	37
Pine	218	294
Total Non-Grass,-pine	29	27
Total Pollen	281	358
Fungi Spores	1,614	1,672
Fern and Fern Ally Spores	31	72
Total Spores	1,645	1,744
Total Pollen and Spores	1,926	2,102

The records for the pollen of pine and the spores of the ferns and fern allies may be possible exceptions to the close quantitative agreement between the data for the two stations. In the case of pine there were 23% more pollen grains recorded from the slides exposed near the forest floor. Two prime reasons for this discrepancy present themselves. First the forest about the University of Minnesota Biological Station has a high conifer composition with both Norway Pine and White Pine well represented. Much of the pine pollen collected on the slides exposed near the forest floor may have been derived from trees almost immediately above the shelter. Buell (1947) in a study of the mass dissemination of pine pollen determined that the quantity of pollen that falls to the ground in the forest is very much greater than that which is carried even a short distance beyond the forest margin. At a distance of one-quarter of a mile from the forest, in non-mountainous country, Buell obtained a 90% reduction of pine pollen.

The second factor which may be of importance in the observed difference in the total numbers of pine pollen grains at the two stations is, in part, directly connected with the first. Effici-

ency of the horizontally orientated adhesive coated microscope slide is in part dependent upon wind velocity. The study of Gregory and Stedman (1953), with the spores of *Lycopodium*, indicate that the percentage of spores deposited on a microscope slide orientated as above is dependent upon wind velocity. The deposit of spores is reduced as the wind velocity is increased due to edge shadow caused by the buffeting of air against the edge of the slide and slide holder. Spores and presumably other particles of similar shape and speed of fall are carried over the slide or a portion of the adhesive area of the slide for a distance which is directly proportional to the wind velocity. Beyond a certain wind velocity, the critical velocity being dependent again on the size and shape of the particle and its speed of fall, it is interesting to note that turbulence increases the deposit on the sampling area.

The difference in the total number of spores recorded at the two sites is only 6%. The station on the forest floor received 99 more spores than the open area station, a difference which could easily be due to the discharge of a single fungus in close proximity to this station. The similarity rather than the difference between these two records deserves comment. This agreement again suggests that the gravity slide method of air-borne pollen-spore sampling, whatever its many faults, does give a reproducible record. The record demonstrates some independence of the exposure location.

When the spore records are examined with respect to its fern and fern ally components there are greater differences as noted above. A total of 72 fern and fern ally spores were recorded on the slides from the forest floor site, while 31 such spores were found on the slides exposed in the open area. The greater number of fern and fern ally spores recorded from the sampling station near the forest floor may be a product of the same two factors considered in the case of pine. The proximity of pines, ferns, and fern allies to this collection site is, however, the simplest and most acceptable tentative explanation for the greater representation of their pollen and spores.

Examination of the total number of spores recorded for each group within the ferns and fern allies indicates that approximately the same relative numbers were recorded at each station, with the exception of *Lycopodium*. The *Lycopodium* total is higher for the open area station due to a clump of 16 spores on the 8th of July.

Of incidental interest is a comparison of the total number of pollen grains and spores which were recorded each day during this period at Lake Itasca and in Minneapolis.* Methods of collection and examination were the same in both cases.

*I am indebted to Miss Agnes Hansen of the University of Minnesota Botany Department for the Minneapolis pollen-spore records.

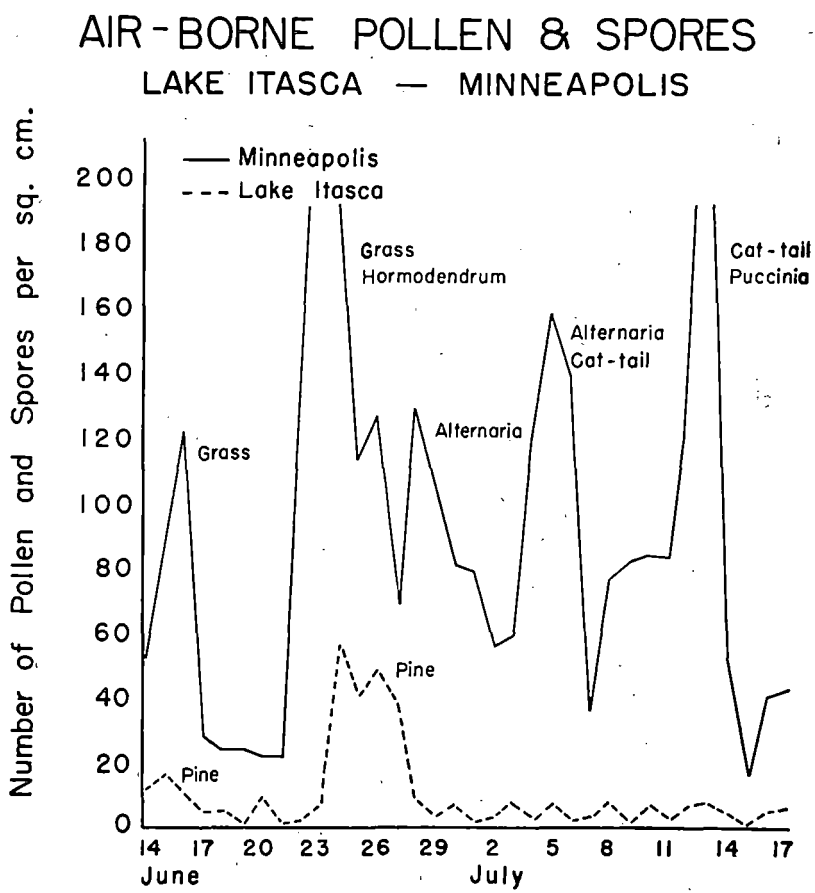

Fig. 3. A comparison of the total number of pollen grains and spores which were recorded each day in Minneapolis and Lake Itasca during the period of this survey.

Two points are evident from the graphic comparison of these two sets of data (Figure 3. Only the names of the dominant types are indicated on this figure). Quantitatively a larger number of pollen grains and spores was collected from the atmosphere in Minneapolis than at Lake Itasca. The records for these two sites also differ qualitatively, demonstrating regional differences in the air-borne pollen-spore content. The differences reflect dissimilar floras or flowering periods or the interaction of both of these factors between these two locations.

At Lake Itasca, Norway Pine and White Pine account for the dominant peaks in the pollen-spore record, while the Minneapolis records show a dominance of grass and Cat-tail pollen. In terms of absolute numbers fungal spores account for the high peaks in the Minneapolis record during this mid-summer period.

Plotting in a similar manner the pollen grains recorded at Lake Itasca and Minneapolis without the fungal contribution (Figure 4), quantitative differences are reduced but the qualitative variation is emphasized. The concentration of pollen in the air, as measured by this method, is consistently higher in Minneapolis with the exception of the two periods of peak pine pollen concentration at Lake Itasca.

Pine pollen was present only in insignificant numbers in the Minneapolis record. However, pollen of pine is usually most abundant around May 20th in Minneapolis (Rosendahl *et al* 1940). Grass and Cat-tail pollen represent the major constituents of the mid-summer Minneapolis collections. The period of greatest Cat-tail pollen concentration in Minneapolis was recorded between July 5th and 13th, while, as mentioned below the Cat-tail pollen peak was not reached, based on field observations, until sometime following the 17th of July at Lake Itasca.

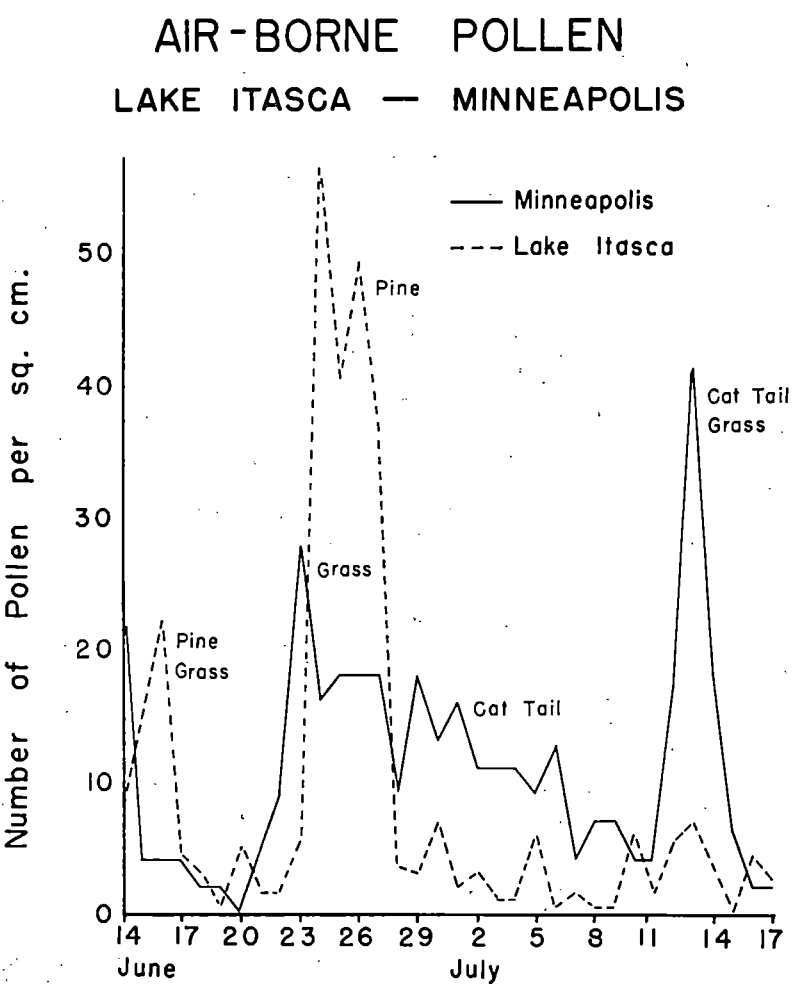

Fig. 4. A comparison of the Minneapolis and Lake Itasca pollen records.

SUMMARY

Two pollen-spore collection stations (gravity sampling method) were maintained from June 14th to July 17th, 1954 on the University of Minnesota Lake Itasca Forestry and Biological Station, Minnesota. The number of pollen grains and spores per square centimeter of surface on adhesive coated microscope slides was determined directly by microscopic examination. The pollen grains and spores recorded each day are enumerated directly and summarized in graphical form.

The two pollen-spore sampling stations give remarkably similar results, even though one station was located in an open field and the other in a densely forested area. The corresponding records obtained indicate that the gravity pollen-spore sampling method exhibits some independence of the exposure location, providing there is free access to the atmosphere.

A comparison of the total number of pollen grains and spores recorded per day at Lake Itasca and in Minneapolis show both qualitative and quantitative differences.

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