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Palynologie : état des connaissances

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Résumé de l'article

Depuis l'introduction en Amérique du Nord des études palynologiques par P. B. Sears, il y a 50 ans, ce domaine de recherches demeure encore peu rigoureux. Les améliorations importantes apportées aux méthodes d'échantillonage et d'analyse sont encore limitées par une compréhension très partielle des problèmes de production différentielle, de dispersion, de ballistique, de sédimentation et de préservation du pollen. Les données mêmes de stratigraphie pollinique, constituées principalement de microfossiles préservés dans les sédiments, ont encore une valeur supérieure à l'ensemble des renseignements que l'on peut en tirer. On a pu confirmer la concordance entre les diagrammes polliniques tardi- ou postglaciaires dans tous les cas où la méthode a été employée. Les méthodes quantitatives d'échantillonage, de préparation des échantillons et d'analyse, utilisées parallèlement aux multiples datations au radiocarbone, permettent de calculer le taux de sédimentation et l'apport absolu de pollen aux sédiments. Moins de 30 des 300 carottes de sédiments provenant du nord-est de l'Amérique du Nord comptent plus de trois déterminations et permettent de calculer avec justesse des courbes de régression pour déterminer les taux de sédimentation. L'analogie avec les différents milieux actuels, représentés par les spectres polliniques de surface, est limitée par un nombre insuffisant d'échantillons de même qualité aptes à caractériser une mosaïque de végétation couvrant 40 degrés de latitude (40-80°N) et de longitude (60-100°O). La banque de données polliniques compte maintenant 700 échantillons, de qualité inégale et mal distribués, permettant tout au plus une finesse de résolution de 10 000 km^2.

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POLLEN ANALYSIS: STATE OF THE ART

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ABSTRACT Although nearly 50 years have passed since P.B. Sears introduced pollen analysis to North America, it remains an occult art. Dramatic improvements in sampling and analytic techniques continue to be limited by intractable problems of differential production, dispersal, ballistics, sedimentation, and preservation. It is a basic tenet of pollen stratigraphy that the data set, consisting primarily of microfossils preserved in sediments, is better than anything we have yet been able to do with it. Basic agreement between late- and postglacial pollen records has been confirmed wherever the method has been applied. Quantitative sampling techniques, sample preparation, and analytic procedures, together with multiple radiocarbon dates, permits calculation of sedimentation rates and absolute pollen influx. Of approximately 300 sediment cores from northeastern North America, fewer than 30 have more than 3 radiocarbon determinations from which least squares power curve regressions can be reliably calculated in the determination of sedimentation rates. Analogy with modern environments represented by surface pollen spectra is limited by an insufficient number of samples of uniform quality to characterize a vegetational mosaic covering 40 degrees of latitude (40-80°N) and longitude (60-100°W). The present surface pollen data bank includes about 700 samples, unevenly spaced and of uneven quality, permitting a grid resolution of no better than 10,000 km².

RÉSUMÉ *Palynologie: état des connaissances.* Depuis l'introduction en Amérique du Nord des études palynologiques par P. B. Sears, il y a 50 ans, ce domaine de recherches demeure encore peu rigoureux. Les améliorations importantes apportées aux méthodes d'échantillonage et d'analyse sont encore limitées par une compréhension très partielle des problèmes de production différentielle, de dispersion, de balistique, de sédimentation et de préservation du pollen. Les données mêmes de stratigraphie pollinique, constituées principalement de microfossiles préservés dans les sédiments, ont encore une valeur supérieure à l'ensemble des renseignements que l'on peut en tirer. On a pu confirmer la concordance entre les diagrammes polliniques tardi- ou postglaciaires dans tous les cas où la méthode a été employée. Les méthodes quantitatives d'échantillonage, de préparation des échantillons et d'analyse, utilisées parallèlement aux multiples datations au radiocarbone, permettent de calculer le taux de sédimentation et l'apport absolu de pollen aux sédiments. Moins de 30 des 300 carottes de sédiments provenant du nord-est de l'Amérique du Nord comptent plus de trois déterminations et permettent de calculer avec justesse des courbes de régression pour déterminer les taux de sédimentation. L'analogie avec les différents milieux actuels, représentés par les spectres polliniques de surface, est limitée par un nombre insuffisant d'échantillons de même qualité aptes à caractériser une mosaïque de végétation couvrant 40 degrés de latitude (40-80°N) et de longitude (60-100°O). La banque de données polliniques compte maintenant 700 échantillons, de qualité inégale et mal distribués, permettant tout au plus une finesse de résolution de 10 000 km².

РЕЗЮМЕ СОСТОЯНИЕ ПЫЛЬЦЕВОГО АНАЛИЗА. Несмотря на то, что прошло уже почти 50 лет с тех пор, как П.Б. Сирс ввел пыльцевой анализ в Северной Америке, он все еще недостаточно развит. Резкие улучшения методов отбора образцов и их анализа до сих пор не достигнуты из-за трудностей в разрешении проблем касающихся добывания пыльцы различного происхождения, ее рассеивания, баллистики, осаждения и сохранения. Самое важное, что мы до сих пор смогли достичь с помощью пыльцевой стратиграфии, это получить сведения о различных микроскопических органических остатках сохранившихся в ледниковых осадках. Где бы не применялся этот метод, с его помощью удавалось подтвердить принципиальное сходство между пыльцевыми остатками поздне-ледникового и послеледникового периодов. Метод количественного отбора образцов, приготовление образцов и аналитические процедуры вместе с многочисленной радиоуглеродной датировкой, дают возможность подсчитывать скорости седиментации и абсолютные размеры притока пыльцы. Из примерно 300 проб (кернов) осадков взятых в северовосточной части Северной Америки, менее чем 30 содержали более трех радиоуглеродных детерминантов. Это позволило составить график регрессии пользуясь методом наименьших квадратов и установить скорость седиментации. Проведение аналогии с современной средой, представленной образцами пыльцы взятой с поверхности земли, затруднено из-за отсутствия достаточного числа проб одинакового качества взятых из осадков. Поэтому трудно провести сравнения и установить различия в вегетационной мозаике в пределах между 40 и 80 северными широтами и 60 и 100 западными долготами. У нас до сего времени собрано 700 образцов различной наземной пыльцы. Однако, собраны они неравномерно и качество их различное. Поэтому подобные образцы могут дать представление о растительности на общей площади не более чем в 10 тысяч квадратных км.

INTRODUCTION

In the 50 years that have passed since P.B. Sears introduced pollen analysis to North America, more than 300 sediment cores have been analyzed from northeastern North America. It has only been since 1950, however, that radiocarbon dating control of sediment sequences has permitted correlation of pollen-stratigraphic events on a chronologic base. The number of adequately dated pollen sequences is still disappointingly small, with less than 30 sequences containing 4 or more radiocarbon dates.

Quantitative sample preparation techniques, spearheaded largely by DAVIS and her co-workers (1965, 1967a, 1967b, 1968, 1973) have permitted calibration of absolute pollen influx (pollen grains/cm^2/yr). Simpler techniques outlined by STOCKMARR (1971), make the method attractive and feasible in most laboratories. These techniques have a principal advantage in removing the "closed universe" constraint of populations based on ratios. It is to be emphasized that the validity of these approaches depend upon determination of absolute sedimentation rates, based on a sufficient number of radiocarbon determinations from each sequence.

Dramatic increases both in statistical tools, and large computers capable of handling massive data sets have provided the pollen analyst with tools of spectacular power. These advances, however, as pointed out by OGDEN (1976), place an increasing responsibility upon the investigator to be sensitive to distributional problems associated with data sets of uneven quality, *e.g.*, with or without non-arboreal pollen, moss polsters vs lake sediments or bogs, absolute or relative pollen counts, and counting to fixed or variable pollen sums. Preliminary efforts to reconcile pollen and vegetational records by DAVIS and GOODLETT (1960), and OGDEN (1969) are being refined by DAVIS and WEBB (1975) and are the subject of active research by a number of investigators : ANDERSEN (1970), JANSSEN (1966, 1967, 1970, 1973), and LICHTI-FEDEROVITCH and RITCHIE (1968). Among the many distributional problems that beset pollen analysis, some of the intractable problems under active investigation are pollen production (WRIGHT, 1952), pollen dispersion, filtration, and deposition (TAUBER, 1965, 1967; OGDEN *et al.*, 1964; RAYNOR *et al.*, 1965; JANSSEN, 1966) resuspension and redistribution of pollen in lakes (DAVIS, 1968), and statistical treatment of pollen data (MOSIMANN, 1962, 1965; MOSIMANN and GREENSTREET, 1971; YARRANTON and RITCHIE, 1972).

Increasing interest in paleoclimatology is recognized by LAMB *et al.* (1966, 1970) and BRYSON *et al.* (1967, 1970). Use of powerful multivariate statistical tools to generate transfer functions have enabled WEBB and BRYSON (1972) to contrast pollen records and vegetation with climatic shifts of weather-generating air masses since deglaciation. Among the exciting possibilities of this research is the recognition of changes in the length of the growing season, as well as other important climatic variables of plant growth and distribution.

Difficult problems of appropriate statistical treatments are considered by MOSIMANN (1962, 1965) and MOSIMANN and GREENSTREET (1971). A number of useful statistical methods for handling pollen data are described, but critical tests of between and within group variances have yet to be performed. Imaginative application of principal component analysis permitted WEBB (1974) to reconstruct pollen floristic and vegetational changes in lower Michigan. DAVIS and WEBB (1975), and BERNABO and WEBB (in press) have constructed isopollen maps showing patterns of plant migrations during the postglacial.

NORTHEASTERN NORTH AMERICA SURFACE POLLEN DATA

The primary tool available to the pollen analyst interested in the reconstruction of environmental change in the region remains the pollen record of contemporary environments recorded in surficial sediments of lakes, bogs, and moss polsters. Figure 1 shows the location of surface pollen samples (*ca.* 700) on file in the Dalhousie computer. Samples include those reported in DAVIS and WEBB (1975), OGDEN (1969), RICHARD (1976) and made available by other investigators. The dots in the figure are at a scale indicating approximately 100 km^2. Based on TAUBER (1967), more than 50% of the pollen in a sample can be expected to be derived within the area covered by the dot. The uneven distribution of the records indicates that a great many environments have yet to be sampled to provide adequate coverage for the region. As presently constituted, the data set includes 23 pollen types (*Abies, Larix, Picea, Pinus, Tsuga, Acer, Betula, Carpinus/Ostrya, Carya, Fagus, Fraxinus, Juglans, Populus, Quercus, Tilia, Ulmus, Alnus, Corylus, Salix,* Ericaceae, Compositae, Cyperaceae, and Gramineae). This data set collectively accounts for more than 80% of all pollen types recorded in sediment sequences throughout the region covered in Figure 1. Comparison with the DAVIS and WEBB (1975) data set covering 406 samples shows that the Dalhousie data set includes more than 92% of the pollen sums, and more than 80% of the pollen types recorded in the Davis and Webb set, where the number of pollen types recorded is 40.

Statistical package programs include Pearson and Spearman correlation coefficients, time series and principal component programs utilized by GREEN

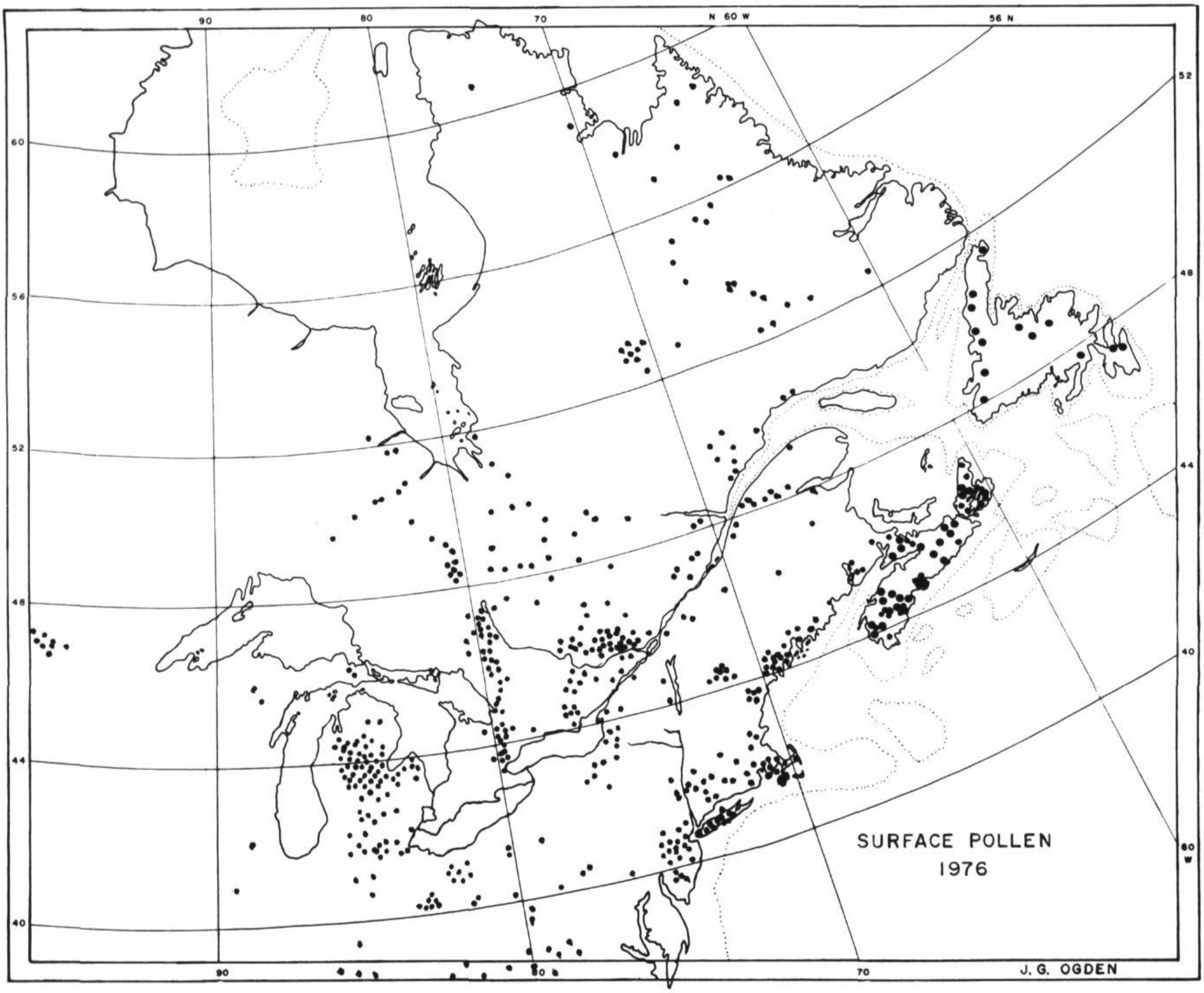

FIGURE 1. Surface pollen records from Northeastern North America, on file in Dalhousie University Computer (*ca.* 700).

Données polliniques de surface pour le nord-est de l'Amérique du Nord, incorporées à la banque de l'ordinateur de l'université de Dalhousie (environ 700).

(1976) in his study of the role of fire in southwestern Nova Scotian forest history.

There is as yet little agreement upon appropriate correlation techniques for pollen analysis. MOSIMANN (1965) provided a method for calculating approximate 95% confidence intervals for proportions:

$$p = \frac{\hat{p} + (3.84/2N) \pm 1.96\ ((\hat{p}(1-\hat{p})/N) + (3.84/4N^2)^{.5}}{1 + (3.84/N)}$$

where $\hat{p}$ = proportion of particular pollen type
N = Number of pollen grains in sample.

While this approach provides estimates of the significance of differences with a pollen sequence, it does not assist in defining similarities or differences between pollen spectra. YARRANTON and RITCHIE (1972) provided a useful objective technique for determining pollen zone boundaries by use of sequential Pearson product-moment correlations. A difficulty with the use of Pearson product-moment statistics is that the resultant correlations are heavily weighted by large numbers, while zero cells have little or no effect. An alternative to this difficulty is to use the distribution free Spearman Rank Correlation, which has the potential disadvantage of assigning equal weight to zero cells and large number cells alike. An example of these differences is shown in Table I, which compares Glenholme Lake (45°23'N, 63°33'W) in the Windsor-Truro district of Nova Scotia with an unnamed lake (47°25.5'N, 53°19.8'W) in the Avalon section of Newfoundland.

TABLE I

Surface pollen spectra comparison: Nova Scotia and Newfoundland (RAILTON, 1972).

Comparaison des spectres polliniques de surface: Nouvelle-Écosse et Terre-Neuve (RAILTON, 1972).

Pollen type	Nova Scotia NS-14 (45°23'N, 64°33'W)	Newfoundland N-2 (47°25.5'N, 53°19.8'W)
Abies	0	10
Larix	0	0
Picea	9	10
Pinus	6	1
Tsuga	9	0
Acer	2	0
Betula	50	53
Carpinus/Ostrya	0	0
Carya	0	0
Fagus	12	0
Fraxinus	0	0
Juglans	0	0
Populus	0	0
Quercus	1	0
Tilia	0	0
Ulmus	0	0
Alnus	2	2
Corylus	0	1
Salix	0	0
Ericaceae	1	6
Compositae	0	1
Cyperaceae	0	1
Gramineae	1	2
Sum Pollen	93	89
No. non-zero data	10	10
Pearson product-moment r =	.926	
Spearman r_s =	.358	

The Pearson Product Moment correlation between these two samples is .926, implying no significant difference between the samples. The Spearman Rank correlation is .358, which is significant at the 95% level for rejecting similarity.

It may be argued that the Spearman technique sacrifices the quantitative characteristics of the data set, by reducing the numbers of pollen grains counted in each category to their rank order. On the other hand, a number of simple tests, such as partitioning a large data set into sequential rankings, provides convincing evidence that the rank order of pollen data sets is a property of the system, and not of the statistic. In other words, where N (Number of pollen grains counted per sample) is reasonably high, *e.g., ca.*300 or more pollen grains, changes in rank order drop to less than 5%, as counting incremental totals increase. The reader is invited to convince himself by applying the process to their own data sets. A simple experiment is to take any sample known to have *ca.*30-50 pollen grains per traverse, and record sequential traverses separately. When 10 or 15 traverses have been completed, simply rank the first traverse, then add the second traverse and rank the sums. Continue until the full data set is ranked and plot the number of rank order changes against successive pollen sums. When N=500 pollen grains, and the number of items being ranked is 23, the percent change with incremental pollen sums drops well below 5%.

If the above argument is reviewed, it follows that a major problem with existing surface pollen data sets is unevenness of pollen sums. DAVIS and WEBB (1975) have provided a data set covering 40 pollen types in an attempt to describe eastern North American pollen types from 25°-65° N Lat, and 50°-100° W Long. The

TABLE II

Relative information content of subsets based on (DAVIS and WEBB (1975) pollen sets.

Contenu relatif de l'information d'une partie des données de DAVIS et WEBB (1975).

Latitude	N	No. of Pollen types 40	% No. of pollen types 23	18	Pollen Sums % Pollen sums 40	23	18
55-62	13	10.08	.86	.61	1284	.98	.96
52-54	16	9.00	.91	.73	1106	.99	.96
50-51	23	12.70	.89	.72	1130	.98	.95
48-49	32	9.00	.88	.77	1040	.99	.98
46-47	59	11.17	.91	.84	1103	.97	.95
44-45	82	18.43	.80	.69	1244	.94	.92
42-43	81	19.37	.76	.64	1409	.92	.91
40-41	64	12.94	.82	.70	1540	.82	.82
27-39	36	15.25	.73	.60	1340	.86	.84
Averages		13.10 ± 3.86	(.84)	(.70)	1244 ± 165	(.93)	(.92)

* Pollen sums shown as per mil (‰), based on original DAVIS and WEBB data set

data set includes 406 pollen spectra, the information content of which is summarized in Table II by latitudinal increments. The average number of pollen types in the full (N = 40) data set is 13.10 ± 3.86. OGDEN's (1969) data set extracted from the Davis and Webb set includes 10.82 ± 2.52 pollen types. Similarly, if the data set used by GREEN (1976) is extracted from the original (Davis and Webb) data set (N = 18), the average number of pollen types is 9.06 ± 2.34.

It therefore follows that the Davis and Webb pollen set includes an average of about 27 zero cells in each pollen spectrum, whereas the N = 23 data set has about 12 zero cells and the Green set has about 9 (for N = 18).

The situation with respect to pollen sums explains, at least in part, why Pearson product-moment correlations sometimes provide spuriously high correlations. Both the Ogden (N = 23) and Green (N = 18) data sets show pollen sums that average greater than 92% of the full (N = 40) data set of Davis and Webb. Extraction of major components from the latitudinal set summarized in Table II shows that more than 80% of the pollen sums in each latitudinal set are accounted for by 4 or fewer pollen types. This characteristic biases Pearson product moment correlation statistics in favor of the moments produced by a few large cells in each spectrum.

TABLE III

Location of Maritime surface pollen samples (RAILTON, 1972).

Localisation des échantillons polliniques de surface dans les Maritimes (RAILTON, 1972).

Lake Code	Name	Latitude & Longitude	District or Section
NOVA SCOTIA			
NS — 1	Croft L.	44° 33.75′ N. 64° 19.00′W.	Mersey River
NS — 2	....	43° 52.50′ N. 66° 05.00′W.	Cape Sable
NS — 3	Upper Doucette L.	44° 06.50′ N. 66° 04.00′W.	Wentworth Lake
NS — 4	Bower L.	44° 05.50′ N. 65° 46.50′W.	Clyde River
NS — 5	Young L.	44° 49.00′ N. 65° 27.00′W.	North Mountain
NS — 6	Church. L.	44° 43.00′ N. 65° 18.50′W.	Annapolis
NS — 7	Zwicker L.	44° 44.00′ N. 65° 02.00′W.	Fisher Lake-Halifax
NS — 8	Lohnes L.	44° 29.00′ N. 64° 47.50′W.	La Have
NS — 9	Bluff L.	44° 33.00′ N. 63° 40.00′W.	Fisher Lake-Halifax
NS — 10	....	44° 28.50′ N. 63° 33.50′W.	Eastern Shore
NS — 11	Rock Elm L.	45° 56.00′ N. 60° 19.00′W.	Eastern Shore
NS — 12	Quillan L.	44° 54.75′ N. 62° 32.25′W.	Sheet Harbour
NS — 13	Moore L.	45° 06.50′ N. 62° 53.00′W.	Musquodobit Harbour
NS — 14	Glenholme L.	45° 23.00′ N. 63° 33.00′W.	Windsor-Truro
NS — 15	Taylor L.	45° 22.00′ N. 62° 26.25′W.	St. Mary's River
NS — 16	McLeod L.	45° 48.00′ N. 63° 40.00′W.	Oxford
NS — 17	Poison L.	45° 33.00′ N. 63° 56.00′W.	Cobequid Mountain
NS — 18	....	45° 23.50′ N. 64° 27.50′W.	Chignecto
NS — 19	....	45° 40.25′ N. 62° 36.75′W.	Northumberland Shore
NS — 20	....	45° 37.00′ N. 61° 50.00′W.	East River-Antigonish
NS — 21	Cameron Lakes	45° 33.50′ N. 62° 08.00′W.	Pictou Uplands
NS — 22	....	45° 51.50′ N. 61° 06.50′W.	Guysborough-Bras d'Or
NS — 23	....	46° 09.75′ N. 60° 55.00′W.	Cape Breton Hills
NS — 24	Loch Gorm	46° 16.00′ N. 60° 57.50′W.	Cape Breton Hills
NS — 25	Mariana L.	46° 22.50′ N. 60° 40.50′W.	Cape Breton Highland
NEWFOUNDLAND			
N — 1	....	47° 21.00′ N. 53° 02.00′W.	Avalon Section
N — 2	....	47° 25.50′ N. 53° 19.75′W.	Avalon Section
N — 3	....	47° 44.00′ N. 53° 56.00′W.	Avalon Section
N — 4	....	47° 55.00′ N. 54° 19.50′W.	Avalon Section
N — 5	....	48° 57.00′ N. 55° 42.00′W.	Grand Falls Section
N — 6	....	49° 02.00′ N. 54° 58.00′W.	Grand Falls Section
N — 7	....	49° 09.25′ N. 56° 05.00′W.	Grand Falls Section
N — 8	Jack's Pond	49° 22.50′ N. 57° 35.00′W.	Northern Peninsula Sct.
N — 9	....	49° 55.75′ N. 57° 46.25′W.	Northern Peninsula Sct.
N — 10	....	50° 12.50′ N. 57° 36.25′W.	Northern Peninsula Sct.
N — 11	....	50° 43.75′ N. 57° 16.25′W.	Northern Peninsula Sct.
N — 12	....	51° 19.50′ N. 55° 37.75′W.	Tundra Section
N — 13	....	48° 40.00′ N. 58° 11.00′W.	Corner Brook Section
N — 14	....	48° 20.00′ N. 58° 33.00′W.	Corner Brook Section

The data summarized in Table II show that for latitudinal increments as shown, the use of 23 pollen types account for more than 84% of the pollen types and 93% of the pollen sums, whereas the use of 18 pollen types accounts for 70% of the pollen types and 92% of the pollen sum.

RELATIONS BETWEEN ATLANTIC CANADA POLLEN SAMPLES

RAILTON (1972) collected and analyzed 25 surface pollen samples from Nova Scotia and 14 from Newfoundland. Names and locations of sample sites are shown in Table III, and illustrated in Figure 2. Data were punched on cards (Number of pollen types = 23) and were run serially for both Pearson product-moment correlations and Spearman rank correlations. A sample of the results is shown in Table IV, for all values of r_s greater than -1.000. Included are values of z for the Pearson product r, and of t for the Spearman r_s. The last column is the ratio of Spearman r_s to Pearson product r, and is designed only to «flag» large departures from unity. Where both values are similar, the ratio is close to 1.0, and the investigator has increased confidence in the values of the coefficients, since unity implies that neither statistic is being unduly weighted by either large cell moments, or a large number of 0 cells. Where, however, r_s/r values are either greater than 1.75, or less than .500, the investigator is justified in surveying the actual count data to determine the cause of the disparity.

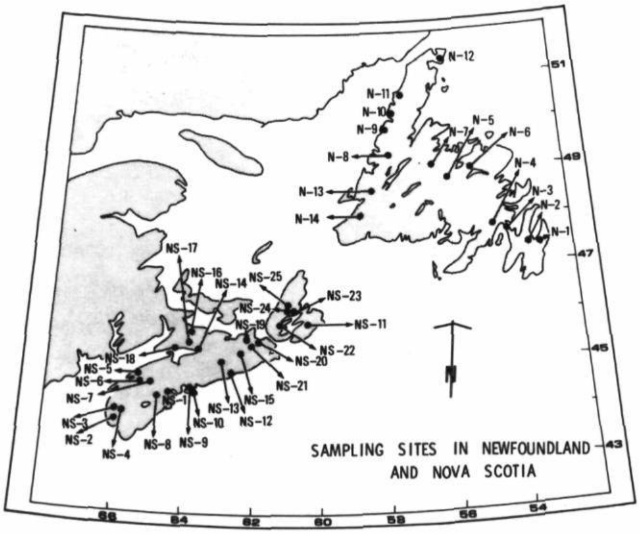

FIGURE 2. Location of Nova Scotia and Newfoundland surface pollen samples (RAILTON, 1972).
Localisation des échantillons de surface de la Nouvelle-Écosse et de Terre-Neuve (RAILTON, 1972).

Spearman Rank correlation coefficients for the Railton data set from Nova Scotia and Newfoundland are shown in Table V. It can be seen that there are no «misclassifications» between Nova Scotia and Newfoundland at $r_s = .900$, and only 5 (1%) at $r_s = .800$. Broadening the correlation to .700 results in 10% of the Nova Scotian samples falling in with the Newfoundland samples. Within Nova Scotia, it can be observed that samples NS-1 through NS-8, which are located in the

TABLE IV

Sample correlation matrix of Maritime surface pollen spectra.
Matrice de corrélation des spectres polliniques de surface des Maritimes.

Level of correlation greater than — 1.000
N 1 0
Correlation on

Lake	Depth	Product R	Z	Spearman Rm	T	RS/R
N 2	0	.578	.659	.914	10.352	1.582
N 3	0	.980	2.309	.868	8.018	.886
N 4	0	.902	1.485	.606	3.492	.672
N 5	0	.527	.586	.544	2.974	1.033
N 6	0	.562	.635	.658	4.006	1.172
N 7	0	.540	.604	.674	4.184	1.249
N 8	0	.643	.763	.637	3.787	.991
N 9	0	.939	1.729	.839	7.054	.893
N 10	0	.678	.826	.689	4.361	1.016
N 11	0	.605	.701	.476	2.478	.787
N 12	0	.900	1.470	.676	4.205	.752
N 13	0	.627	.736	.650	3.925	1.038
N 14	0	.662	.796	.748	5.167	1.130
NS 1	0	.797	1.090	.475	2.471	.595
NS 2	0	.745	.962	.632	3.733	.847
NS 3	0	.643	.763	.500	2.648	.778
NS 4	0	.608	.706	.447	2.287	.735
NS 5	0	.633	.747	.490	2.575	.774
NS 6	0	.607	.704	.366	1.802	.603
NS 7	0	.536	.598	.593	3.378	1.107
NS 8	0	.524	.582	.323	1.566	.617
NS 9	0	.660	.793	.271	1.288	.410
NS10	0	.829	1.185	.454	2.335	.548
NS11	0	.588	.675	.385	1.912	.654
NS12	0	.800	1.098	.619	3.611	.774
NS13	0	.536	.598	.369	1.821	.689
NS14	0	.525	.584	.303	1.455	.576
NS15	0	.590	.678	.450	2.312	.763
NS16	0	.661	.795	.470	2.439	.711
NS17	0	.578	.660	.372	1.835	.643
NS18	0	.550	.618	.206	.963	.374
NS19	0	.491	.538	.322	1.558	.655
NS20	0	.550	.618	.375	1.851	.682
NS21	0	.400	.424	.201	.938	.502
NS22	0	.494	.541	.220	1.032	.445
NS23	0	.679	.827	.456	2.347	.672
NS24	0	.611	.711	.573	3.200	.936
NS25	0	.600	.693	.337	1.643	.562

N 1 O TESTED AGAINST 38 samples

TABLE V

Spearman Rank correlations between Nova Scotia and Newfoundland.
Corrélation de Spearman entre les échantillons de la Nouvelle-Écosse et de Terre-Neuve.

	N 1	N 2	N 3	N 4	N 5	N 6	N 7	N 8	N 9	N 10	N 11	N 12	N 13	N 14	NS 1	NS 2	NS 3	NS 4	NS 5	NS 6	NS 7	NS 8	NS 9	NS 10	NS 11	NS 12	NS 13	NS 14	NS 15	NS 16	NS 17	NS 18	NS 19	NS 20	NS 21	NS 22	NS 23	NS 24	NS 25
N1		X	0						0					+																									
N2			0		+	+	0	+	+	+		+	+	0																									
N3				0		+	0	+	X	+		+		0																									
N4					+	0	0	0	+	0	+			+																									
N5						+	0	X		+	0	+	+	+																									
N6							+	0	+	+	+	+		+																			+						+
N7								X	0	0	0	0	+	0																									
N8									+	0	+	0	0	0																								+	
N9										0		0		0																									
N10											X	0	+	0										+		+				+				+			+	+	
N11												+		+	+					+			0	+								+	+		+	+		+	
N12													0	+																			+	+			+	0	
N13														0	+		+	+								+	+			+				+			+	0	+
N14															+									+		0				+						+	0		
NS1																0	X	X	X	0	0	0	+	0	0	0	+	+	0	0	0	+	0	0	0	0	0	0	0
NS2																	0	+	0	+	+	+			+	+		+	0	0			+	+	+		+	0	+
NS3																		X	X	0	X	0		+	X	+	+		0	+	+	+	+	+	+	+		+	+
NS4																			0	0	X	X	+		X	+	+		+		+		+		+	0			0
NS5																				0	0	0	+	0	0	0	+	+	0	0	0	+	0	0	0	0	+	+	0
NS6																					+	0	0	0	0	+	+	0	+	+		+	0	0	0	0	+	+	0
NS7																						0			0	+			0	+	+		+			+			+
NS8																							0		0	+	+		+	+	+	+	0	+	0	+			0
NS9																								0			+	0		+	+	+	+	+	+	0			0
S10																										0	+	0	0	0	0	+	0	0	0	+	+	+	+
NS11																											+		+	+		0	0	+	+	0		+	+
NS12																											0	+	0	0	0		+	+	+	+	0	+	0
NS13																												0	0	0	0		0	0	+	+	+	+	0
NS14																													0	0	0	0	0	0	0	0			0
NS15																														0	0	+	0	+	+	0			+
NS16																															0	+	X	X	0	+	0	0	+
NS17																																	0	+	+	+		+	+
NS18																																	0	0	X	0	+	+	0
NS19																																		X	X	0	0	0	0
NS20																																			X	0	0	0	+
NS21																																				0	0	+	0
NS22																																							X
NS23																																						0	+
NS24																																							
NS25																																							

N = NEWFOUNDLAND

NS = NOVA SCOTIA

X = $r_s > .900$

0 = $r_s > .800$

\+ = $r_s > .700$

N = 23 Pollen types

southern half of the province (Fig. 2), are distinct at r_s greater than .900 from the rest of Nova Scotia and Newfoundland.

CONCLUSIONS

Despite impressive advances in sample recovery and preparation, data manipulation and statistical treatment of pollen, there is no substitute for the interpretive experience of the skilled investigator. The area included in northeastern North America is about 4×10^6 km^2. Although surface pollen samples now number well over 700 from within this region, spacing and sample quality are uneven. Even at a sample grid spacing of 10^3 km^2, more than 55 samples are required for Nova Scotia, New Brunswick would require more than 60 samples, Newfoundland about 100, and Québec would require nearly 1,500 surface pollen samples. More than 5,000 samples would be needed to include Ontario and northeastern United States. It is a remarkable testimony to the coherence of the pollen record that geographic integrity of pollen samples is as convincing as described in the literature.

It is apparent that refinement of palaeogeography will require intensive sampling for modern pollen records of different environments. Such a data set must include moss polsters, surficial lake and bog sediments, marsh (both fresh and saline), fen, and swamp forest environments. Coding to recognize environmental type is essential, as is increasing attention to basin type if palynologists are to take advantage of the tools now available. The concept of a distinctive «pollen signature» characteristic of mappable vegetational units underlies many of the studies referred to in this paper. The ability of large computers to «see» patterns in multivariate data sets is probably the strongest justification for their application to paleoecological problems.

It is a major contention of this discussion that the data set is capable of far greater resolution than has yet been realized. Because the paleoecologist is in a unique position to recognize the effects of previous environmental influences, it follows that there is an implicit responsibility to define these effects and contribute to understanding of potential effects of proposed land use alterations.

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QUESTIONS AND COMMENTS

A. DREIMANIS:

«During the last (3rd) AMQUA meeting in Arizona, a week ago, a distinction was made between to two less cold environments, particularly in NW North America: the tundra and the cold steppe. While the former one has not been favoured by post-mammals and humans, the latter one appeared to be a very favourable environment for both of them. Is it possible to differentiate their late-Wisconsin and early-Holocene distribution also in eastern Canada.»

J. G. OGDEN:

«Recognition of cold steppe and tundra environments in NW North America is not yet recognized in the NE, and with a larger number of NE environments now available (DAVIS and WEBB, 1975), it may be possible to make a similar distinction in NE North America.»