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The *Butler University Botanical Studies* journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology. The papers contain valuable historical studies, especially floristic surveys that document Indiana's vegetation in past decades. Authors were Butler faculty, current and former master's degree students and undergraduates, and other Indiana botanists. The journal was started by Stanley Cain, noted conservation biologist, and edited through most of its years of production by Ray C. Friesner, Butler's first botanist and founder of the department in 1919. The journal was distributed to learned societies and libraries through exchange.

During the years of the journal's publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor's degrees and 75 master's degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner , included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master's students who made active contributions to the fields of botany and ecology include Dwight. W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daudenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

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POLLEN FROM MOSS POLSTERS ON THE MAT OF LAC SHAW BOG, QUEBEC, CORRELATED WITH A FOREST SURVEY

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Pollen analysts have always been haunted by the uncertainty of pollen representation proportionate to the forest complex they were to represent, and comparatively little work has been done on this important problem. Caroll (3) investigated the problem in the Great Smoky Mountain area, Hansen (4) in a western forest region, and Cain (1) in 1953 began an extensive piece of work covering a wide geographical area. His plan was to associate moss polster pollen representation with basal area of trees in 1/10 to two acre plots. The present writers felt that such an approach does not well harmonize with the modus operandi in nature, when pollen settles out on the open surface of a lake or on a bog mat. They further felt that most of the plots (1/10 acre) were too small a unit on which to base the composite pollen rain of a given region, especially when the aim is to determine the over- and under-representation of certain genera. So it was planned to select a natural situation, i.e., an open bog mat and a more extensive analysis of the bordering forest, and to associate with such quadrat study pollen percentages obtained from moss polsters. The small Lac Shaw bog, one and a half miles south of the Mont Tremblant Biological Station, seemed ideally suited to such a study (Fig. 1), especially since Potzger and Courtemanche (7) had already presented a pollen profile from this bog.

The surrounding forest is a typical spruce-fir *(Picea-Abies)* forest of a lowland habitat which was in late secondary succession after selective cutting. The association consists primarily of coniferous species, but a prominent rocky upland a half mile north and northwest of the bog is covered with a dense broadleaved forest primarily paper birch *(Betula papyrifera)*, yellow birch

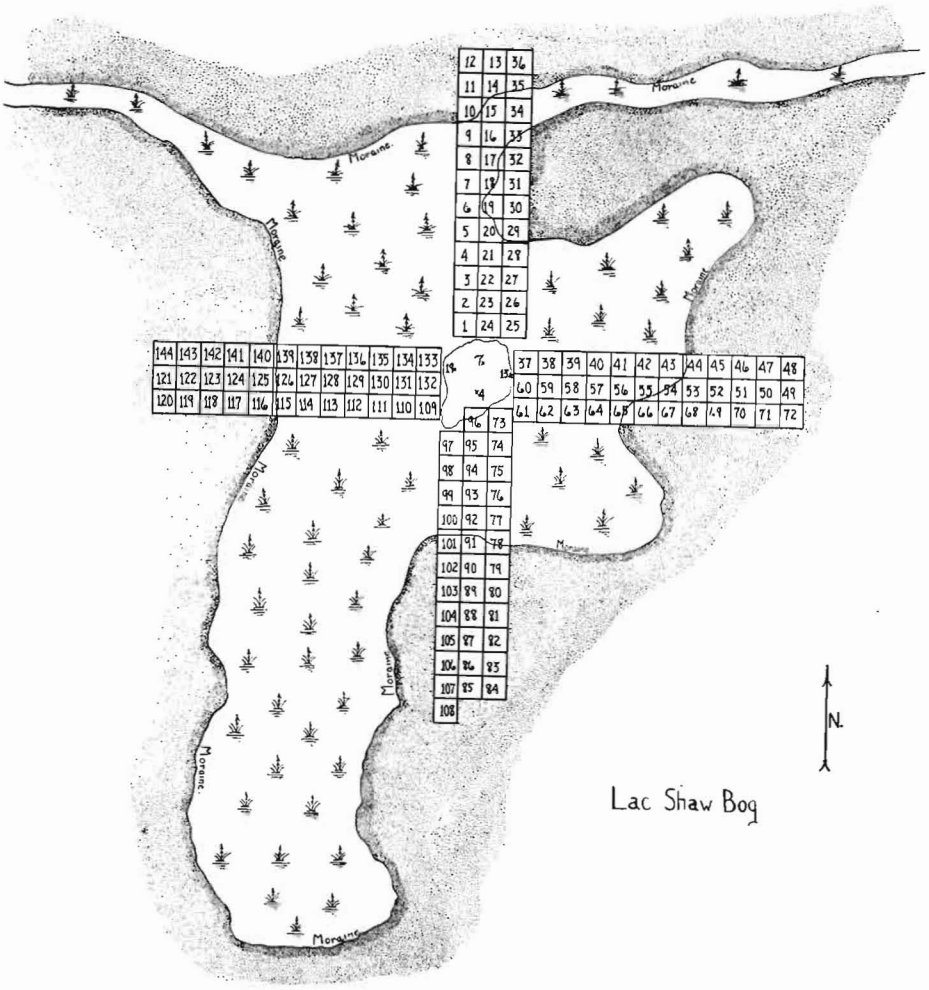

FIGURE 1

Map of the Lac Shaw Bog and surrounding territory, showing the location of moss polster samples on the open mat at the center, and the 144 forest quadrats in the adjacent area.

(Betula lutea) and sugar maple *(Acer saccharum)*. The lowland forest is "belted," determined in this characteristic by a low surrounding moraine (Fig. 1), and the completely closed former bog mat, which is covered by a dense coniferous forest except for the 200 x 200 foot open central area. The whole mat is still quite wet.

METHODS

In order to obtain a record of the sociology of the border forest, the quadrat method was used to obtain data on per cent F. I. (frequency index), density, size classes and reproduction. The unit was a 10 x 10 meter quadrat. Four lines of quadrats were laid out as three rows of 12 quadrats each (Fig. 1) radiating from the bog's open central area along the four main directions (N, E, S, W). The 144 quadrats total approximately 3.6 acres. Lines were run by compass direction. In order to facilitate both laying out of quadrats as well as tabulating, stakes were driven at each corner of the quadrats and the areas were then delimited by white string. This system also made possible the numbering of each quadrat (Fig. 1) and associating moss polster collections with definitely numbered quadrats. The diameter at breast height (D. B. H.) of trees was measured with wooden calipers. All stems below one inch D. B. H. but at least three feet in height were tabulated to record established reproduction of the various associates. Moss polsters were taken at a number of points on the mat (Fig. 1) and in quadrats of the forest survey. Shrubs were listed only for presence in a quadrat. Basal area was calculated for the various tree species.

In the laboratory, patts of the moss polsters were stirred vigorously in hot 95% alcohol, strained through cheesecloth to remove coarse particles, and the finer particles, constituting the sediment in the beaker, were stained with gentian violet. Glycerine jelly served as mounting medium. Tabulation followed customary procedures in pollen analysis. While pollen rain associated with bordering forest was the main aim of the study, detailed sociological analysis of a Quebec spruce-fir forest in secondary succession is included in the work. Cain (2) has pointed out that red spruce *(Picea rubens)* is frequently an important element in the Mont Tremblant Park forests, but since it is not easy to differentiate between black *(Picea mariana)* and red spruce in the field, especially when trees are young, and since pollens of red spruce closely resemble those of white spruce *(Picea glauca)*, no differentiation was attempted in the pollen counts between white and red spruce.

Comparisons of pollen percentages are correlated with stems 6-inches or above in diameter (Fig. 2) because such stem-size individuals would very likely participate in pollen production.

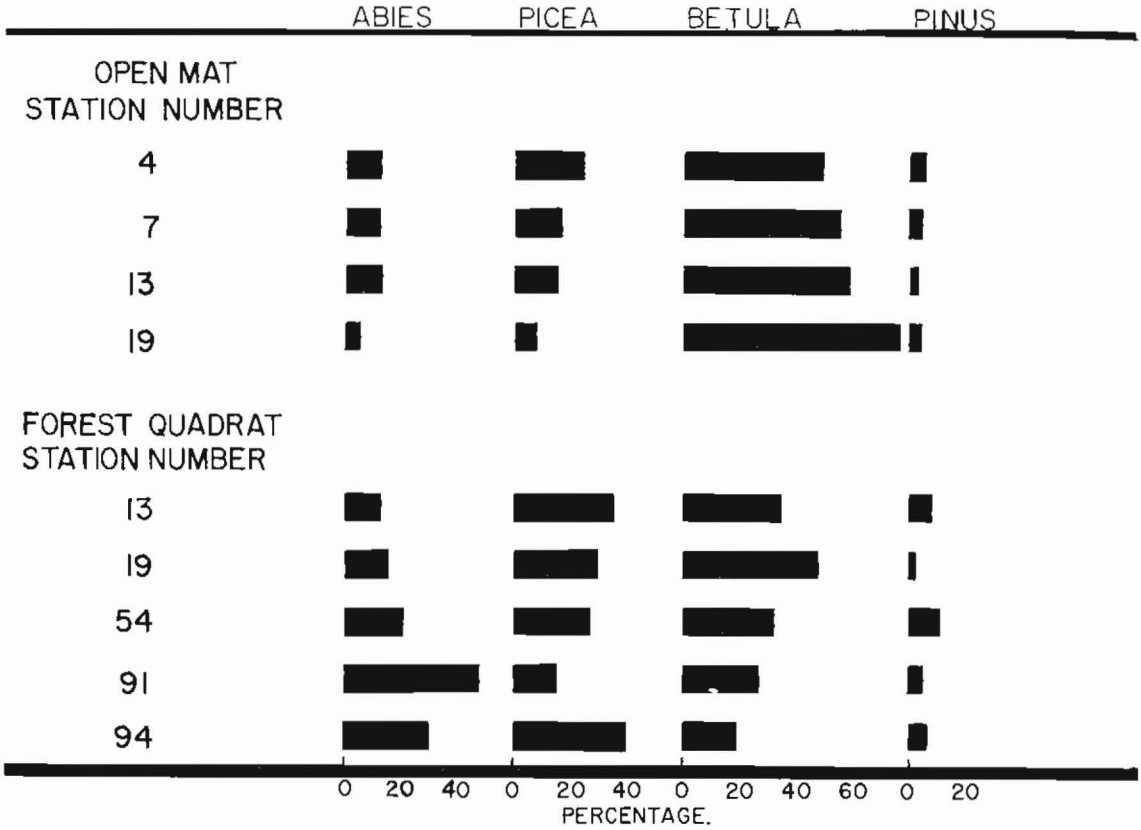

FIGURE 2

Pollen frequencies of four genera from four moss polster samples obtained from the open mat, in comparison with pollen frequencies from moss polsters from five selected stations in the adjacent forest. See figure 1 for locations of stations.

RESULTS

Forest Survey

Table 1 presents the results of the quadrat study in summary form. From the per cenr F. I. and density (abundance) we may classify the forest as spruce-fir in which birch and arbor vitae *(Thuja)* play an important role. Arbor vitae is limited chiefly to the west and north sectors. Birch is limited to the low morainic borders. Fir *(Abies)* surpasses all species in reproduction, and since foresters are very much interested in reproduction ratios between spruce and fir, it may be noted that at this station the ratio is about 3:1 in favor of fir. Thuja displays a vigorous reproduction but *Larix* shows no aggressive participation in the reproduction nor in the crown control, not a single stem above 1-inch D. B. H. appearing in the survey. *Acer saccharum* (sugar maple) is limited to the moraines in its invasion, but at present it promises no aggressive competition. Of the tall shrubs or small trees, *Pyrus americana* (Mountain ash) and *Acer spicatum* (Mountain maple) are most abundant, the latter usually growing in dense clumps as result of root sprouting. Abundance is high but per cent F. I. is only 48%.

Stems of all species which are 3 inches in diameter or above total 1982, or 550 stems per acre. Such great abundance is indicative of successional status, in this case secondary succession. Basal area in sq. ft. per acre listed in order of decreasing amounts for most important species is as follows:

Thuja	34.060
Abies	29.844
Picea mariana	25.695
Betula lutea	11.640
Picea rubens	3.747
Betula papyrifera	1.876
Picea glauca	.891
Acer rubrum	.353

Of the shrubs only *Nemopanthus mucronata* has a wide distribution (F. I. 56) and of the small trees *Acer spicatum* (F. I. 48). Total number of shrub species is high (19).

MOSS POLSTER STUDY

Summary results are shown in figure 2, and abundance of stems used for comparison with pollen percentages are shown in tables 1 and 2. Outstanding, easily recognizable differences in the pollen percentages are extreme under-representation of *Thuja, Larix, Acer* and all shrubs, including such common mat species as *Chamaedaphne* (Leatherleaf) and *Kalmia,* as well as the widely

TABLE 1

Size classes in inches D. B. H. and Basal Area, and percent Frequency Index, of trees and shrubs in a total of 144 quadrats, each 100 square meters in size. See figure 1 for location of quadrats.

Species	Below 1 in.	1	2	3-5	6-9	10-15	16-20	Above 20	Total	% F. I.	Basal area sq. ft. per acre
Abies balsamea	964	631	611	746	160	4	—	—	3116	90.0	29.844
Acer rubrum	45	4	2	2	5	—	—	—	58	24.0	0.353
A. saccharum	10	—	1	—	—	—	—	—	11	4.0	—
Betula lutea	13	20	22	45	29	13	1	2	145	42.0	11.640
B. papyrifera	8	17	38	46	7	1	—	—	117	34.0	1.876
Fraxinus nigra	—	—	—	1	—	—	—	—	1	0.7	0.024
Larix laricina	97	5	—	—	—	—	—	—	102	9.0	0.006
Picea glauca	—	—	3	4	6	—	—	—	13	5.5	0.891
P. mariana	392	245	215	377	173	10	—	—	1412	78.0	25.695
P. rubens	2	—	—	6	8	6	—	—	22	7.0	3.747
Pinus strobus	—	—	—	1	—	—	—	—	1	0.7	0.014
Prunus pennsylvanica	21	2	2	1	—	—	—	—	26	13.0	—
P. serotina	—	1	1	5	—	—	—	—	7	2.7	—
Salix	4	—	—	—	—	—	—	—	4	0.7	—
Thuja occidentalis	278	94	61	110	73	37	3	1	657	29.8	34.060
SMALL TREES AND SHRUBS											
Acer spicatum	1037	21	—	—	—	—	—	—	1058	48.0	—
Pyrus americana	102	2	—	—	—	—	—	—	104	28.0	0.086
Alnus rugosa	—	—	—	—	—	—	—	—	—	26.0	—
Amelanchier	—	—	—	—	—	—	—	—	—	2.7	—
Chamaedaphne	—	—	—	—	—	—	—	—	—	5.5	—
Corylus cornuta	—	—	—	—	—	—	—	—	—	13.0	—
Diervilla lonicera	—	—	—	—	—	—	—	—	—	6.2	—
Kalmia	—	—	—	—	—	—	—	—	—	25.7	—
Ledum groenlandicum	—	—	—	—	—	—	—	—	—	1.4	—
Lonicera	—	—	—	—	—	—	—	—	—	2.7	—
Myrica gale	—	—	—	—	—	—	—	—	—	7.5	—
Nemopanthus mucronata	—	—	—	—	—	—	—	—	—	56.0	—
Ribes	—	—	—	—	—	—	—	—	—	2.0	—
Rubus	—	—	—	—	—	—	—	—	—	2.7	—
Sambucus	—	—	—	—	—	—	—	—	—	5.5	—
Spiraea latifolia	—	—	—	—	—	—	—	—	—	2.7	—
Vaccinium	—	—	—	—	—	—	—	—	—	33.3	—
Viburnum alnifolia	—	—	—	—	—	—	—	—	—	31.8	—
Viburnum cassinoides	—	—	—	—	—	—	—	—	—	31.9	—

TABLE 2

Percentages of pollen in moss polster samples from both open mat and selected forest stations. See figure 1 for locations of stations.

Species	Open Mat Stations					Forest Quadrat Stations					
	4	7	12	19	Average of 4 Stations	13	19	54	91	94	Average of 5 Stations
Abies	12.0	12.0	12.5	5.0	10.5	0.5	—	0.5	—	—	0.2
Larix	0.5	—	2.0	0.5	1.0	16.0	4.5	6.0	1.5	12.5	8.1
Picea glauca	5.0	5.0	6.0	4.0	5.0	19.5	25.5	21.0	14.0	27.5	21.5
Picea mariana	19.5	11.5	9.0	3.5	10.5	5.5	1.5	4.5	2.5	2.5	3.3
Pinus banksiana	1.5	1.5	1.0	2.0	1.5	2.5	0.5	6.0	2.5	4.0	3.1
Pinus strobus	4.0	3.0	2.0	2.0	3.0	0.5	0.5	0.5	—	—	0.3
Pine (intermediate)	—	—	—	—	—	0.5	0.5	1.5	—	1.0	0.7
Tsuga	1.0	1.5	1.0	1.0	1.0	—	—	—	—	—	—
Thuja	1.5	1.5	—	0.5	1.0	1.0	—	—	1.0	—	0.4
Acer	1.5	2.0	0.5	2.0	1.5	11.0	12.0	14.5	10.0	5.5	10.6
Betula papyrifera	15.0	27.0	22.5	28.5	23.3	24.0	36.0	18.0	17.0	13.5	21.7
Betula lutea	34.5	28.5	36.5	48.0	37.0	0.5	—	—	—	—	0.1
Fagus	—	—	1.0	—	—	—	—	—	—	—	—
Fraxinus	—	0.5	—	—	—	—	—	—	—	—	—
Populus	—	—	1.0	—	—	—	0.5	0.5	0.5	0.5	0.4
Quercus	1.0	1.0	0.5	0.5	1.0	—	—	—	—	—	—
Salix	—	—	—	0.5	—	0.5	0.5	1.0	1.0	—	0.6
Ulmus	0.5	1.5	0.5	0.5	1.0	1.0	4.0	3.0	—	—	1.6
Alnus	—	1.0	1.0	3.0	—	—	—	—	2.0	—	0.4
Betula pumila	—	—	—	1.0	—	—	—	7.0	1.0	4.0	2.4
Corylus	—	1.0	—	—	—	8.0	—	—	—	—	1.6
Ericaceae	—	—	—	—	—	2.0	5.0	4.0	3.0	1.0	3.0
Myrica	22.0	8.0	—	12.0	—	6.0	1.0	18.0	1.0	1.0	5.4
Gramineae	10.0	2.0	9.0	6.0	—	—	—	1.0	—	—	0.2
Carex	—	—	—	—	—	—	—	2.0	—	—	0.4
Chenopods	1.0	—	2.0	—	—	8.0	9.0	14.0	3.0	4.0	7.6
Compositae	10.0	9.0	12.0	8.0	—	1.0	—	—	—	—	0.2
Typha	—	—	—	—	—	—	—	—	—	—	—
Lycopodium	2.0	1.0	—	1.0	—	5.0	2.5	4.5	1.5	3.0	3.3
Unknown	2.5	3.5	4.0	1.5	3.0	13.0	15.5	21.0	48.0	30.0	25.5

distributed *Nemopanthus*. It is very likely that *Nemopanthus, Alnus, Corylus* and *Spiraea* produce none or very few flowers in the shade of the forest where most of them were observed. The most over-represented genus in polsters from the bog mat is *Betula*. Apparently over-represented to a lesser degree is pine, while fir is under-represented. Closest correlation between pollen and forest representation is in spruce *(Picea)*.

It is quite obvious that moss polsters taken in quads located in a forest stand show the influence of pollen rain of trees within that area, and so will not represent a regional forest condition. It is also apparent that a wide area participates in the pollen rain falling on an open area, such as a lake or a bog mat. The high percentage of birch pollen from polsters on the mat suggests that the birch forest a half mile north and west of the bog contributes much of the birch pollen settling out on the mat. Pine has a very sparse representation in the border forest but shows a five percent representation in the pollen record. This too points to longer distance transfer. The nearest station for jack pine *(Pinus banksiana)* is perhaps 15 miles to the northwest.

Tree genera not present in the forest survey but appearing in the pollen record of the moss polsters (Table 2), and known as minor elements in nearby forests are: *Ulmus, Tsuga, Acer, Fagus, Fraxinus, Populus*. Trees appearing in the pollen record (Table 2) which have not been reported from nearby areas, but are known to be present in forest stands 5 to 15 miles distant are *Quercus* and *Pinus banksiana*.

DISCUSSION

Forest Survey

The forest of the Mont Tremblant Park area is difficult to fit into a definite pattern because of the unusual characteristics in the distribution of the various species. At times one wonders if there is any pattern involved. Frequently there is also a baffling association of species. Tops of mountains may be covered by spruce-fir or yellow birch, or sugar maple, beech and yellow birch with intrusion of hemlock. Elsewhere spruce-fir may form dense stands in valleys. While white pine is at present a relic in spruce-fir as well as in broadleaved forests, it may at times appear in considerable abundance, as on the slopes above Lac des Femmes (adjacent to the Biological Station).

The border forest around Lac Shaw bog is more definitely a spruce-fir type in which arbor vitae and birch play a considerable part. At the Lac Savanne bog in the same general region, which we may use for comparison, the forest is nearly all spruce-fir. If one were to estimate from general observation the species which have greatest abundance in the Lac Monroe area (which includes the Lac Shaw bog station) one would say without hesitation yellow birch

(formerly no doubt white birch in addition to yellow birch). The Lac Shaw forest as presented in Table 1 leaves no doubt of its classification as spruce-fir type. In spite of former cutting we find in the 3.6 acre survey 203 stems (chiefly black spruce) and 164 stems of fir 6 inches or above in diameter. Reproduction is high, on an average 271 small trees up to three inches D.B.H., plus 175 saplings of 1-inch D.B.H. per acre.

Foresters are of course interested in the spruce-fir ratio. Here as in many or most other localities of the region, fir is reproducing more abundantly than spruce. At Lac Shaw bog one finds abundant decaying logs, so that the difference in reproduction is not, as sometimes assumed, due to lack of organic material to favor reproduction of spruce. Since fit is also more shade tolerant than spruce, the end of succession in the Lac Shaw bog forest may, indeed, give fir importance in the forest cover.

It is very interesting to note how similar the dominants in the Laurentian Shield stand are with respect to density, frequency, reproduction and even in associated species to spruce-fir stands elsewhere—those in Great Smokies as reported by Oosting and Billings (5) and especially to stands in the White Mountains of New Hampshire as reported by the same authors. The dominant genera spruce and fir also show great similarity in their sociology to the spruce fir forest of the Medicine Mountains, Wyoming, as described by Oosting and Reed (6).

The Canadian stand differs from the other spruce-fir stands referred to in that three species of spruce enter into the forest complex. Greatest similarity is to the New Hampshire stands. This would be expected because of the greater similarity in geographical location. However the Laurentian stand has double the number of associated tree species and a larger number of shrubs associated with it. This may be due to the greater number of quadrats included in the Canadian study, or to habitat differences, or also to successional influences. For more comparable results one should no doubt select an upland rather than a lowland spruce-fir stand in the Mont Tremblant region.

As refererd to previously, the dominants are strikingly similar in their phytosociological expression in all the spruce-fir stands mentioned. The greater abundance of *Abies* may be due to climatic control, for at latitudes north of Mont Tremblant Park spruce surpasses fir in abundance.

Moss Polsters

It seems quite cerrain that moss polster studies will hardly be a solution to the problems involved in absolute correlation of pollen percentages and abundance of genera and species constituting the forest composition. The present study emphasizes, however, that among the factors which enter into the prob-

lem of pollen representation are local and regional parricipation in the pollen rain and inrerferences with the settling out process as such. The results of this study strongly indicare that a coniferous forest interferes with deposition of pollen in moss polsters beneath its crown. We should point out some confidence-inspiting features of tbis moss polster study. Field workers in the Mont Tremblant Park forests would be much disappointed if such infrequent genera as *Ulmus, Tsuga, Fagus, Fraxinus* and *Acer* did not appear in a moss polster pollen record in the park. They are rare elements in these forests but one need not necessarily search for them. Their appearance in the pollen records makes the forest community read into a pollen profile more real.

If one does not expect to find an absolute mathematical correlation between numbers of stems and pollen percentages, the over-all characteristics of the forest are fairly well pictured, but we must not assume that the pollen profile represents only a limited bordering area. After several years of field work in this region one would be disappointed if *Quercus* and jack pine had not appeared in the pollen record. If the pollen rain settles out on a body of water, over-representation of a bordeting forest is also modified. This is indicated by the pollen profile of upper inches from the sediments in Lac aux Atocas as shown by Potzger and Courtemanche (7).

It is no doubt necessary to assume a regional participation in the pollen rain, especially in an open location such as a lake or an open bog mat. Even on a bog mat the central position (See 4, 7 on Table 2) appears to record more uniformly the same percentages for the various genera. One should, therefore, use more tban one moss polster sample and average the percentages. There is no doubt that moss polsters taken beneath the forest canopy reflect to some extent vety narrow local influences. This is especially emphasized by quadrat 91 where *Abies* has an unusual high pollen representation (Fig. 2) and also a high total abundance of stems. *Betula* as a whole has a much lower representation in stations located within the forest. This may be due to interception of the pollen rain by the dense crowns of the conifers. If one disregards *Thuja,* the pollen percentages emphasize the three most important components of the forest, provided one does not delimit the area to be represented too much.

The inadequate representation of such sbtubs as *Nemopanthus, Alnus, Kalmia, Chamaedaphne* and other Ericads is perhaps not a serious problem in forested regions, but it is a disconcerting defect in tundra areas where shtubs become diagnostic and constitute the tallest vegetation.

SUMMARY AND CONCLUSIONS

1. The study presents a 3.6 acre quadrat survey (144 ten by ten meter quadrats) of a spruce-fit forest adjacent to Lac Shaw bog in Mont Tremblant

Park. Associated with the forest survey was a pollen representation in moss polsters to determine reliability of pollen percentages to indicate forest composition.

2. The forest is predominantly spruce-fir with strong participation of arbor vitae and birch in the forest community. While both birch and black spruce have abundant reproduction, fir dominates spruce by three to one.

3. In the pollen records arbor vitae, tamarack, *Acer spicatum* and all shrubs are poorly represented.

4. Pine and birch are over-represented, especially on the bog mat, if only the bordering forest is considered. High representation of birch probably reflects the dense birch forest on uplands a half mile west and north of the bog.

5. Collections of polsters under the forest cover show great variation in pollen representation of the various genera. This is attributed to the influence of nearby trees.

6. Pollen percentages from moss polsters taken on the mat do not reflect the forest of the first thirty meters encircling the bog. This rules out the assumption that pollen rain over a lake or a bog is contributed chiefly by trees nearest the basin.

7. Dense crown cover of a coniferous forest seems to interfere with settling out of birch pollen from outside areas.

8. From a superficial evaluation of the forest composition of the whole region the pollen record from the bog mat polsters presents a more representative picture than any of the collections made under forest cover.

9. Results of the study will not permit assigning "values" to a given genus on the basis of which to estimate over- and under-representation of the associates which appear in a pollen profile, especially if polster collections are made under the forest cover. Even a 3.6 acre survey of a forest adjacent to a bog is inadequate as a basis upon which to correlate mathematically the abundance of certain genera and species with their representation in a pollen rain.

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