January, 1966

REPORT TO: Robert J Salzer

FROM: J. Schoenwetter

TITLE: Archaeological Pollen Analyses from North-Central Wisconsin

INTRODUCTION

This program of palynological research was designed as an experimental and exploratory program. It's objectives were recognized as simplistic, and it was basically an attempt to recover as many kinds of information per dollar expended as possible. None of the conclusions drawn in this report can be said to be well-evidenced. The function of this research was never to establish truths, only to verify that truths could be established.

POLLEN RECOVERY

Forty-one samples of sediments from cultural contexts were submitted and processed to concentrate and extract their pollen. The average sediment sample involved a volume of about 100-150 cc's. The samples were sieved and given HF, acetolysis and KOH treatments but no flotation step was used. Fourteen of the archaeological samples did not yield sufficient pollen for analysis, though four of these might be analyzable with further laboratory work. One sample was not analyzed because of lack of time. Nine samples yielded counts of less than 100 grains per slide, so are statistically suspect. Of the 41 samples submitted, 18 fulfilled the objective of recovery of sufficient pollen for analysis. The percentage of recovery, about 44%, could have been improved with further lab work but this was considered unnecessary at the present time. An additional 32 samples of surface sediments were submitted and processed. 30 of these yielded sufficient pollen; the other two need further lab work to reduce the amount of organic matrix.

It is clear that with a relatively minor increase in the amount of laboratory time, well over 65 percent of the subsurface pollen samples submitted could be analyzed. It would be wise in the future, however, to collect at least 250 cc's volume of sediment per sample while in the field, to insure that replicate lab runs could be made if necessary.

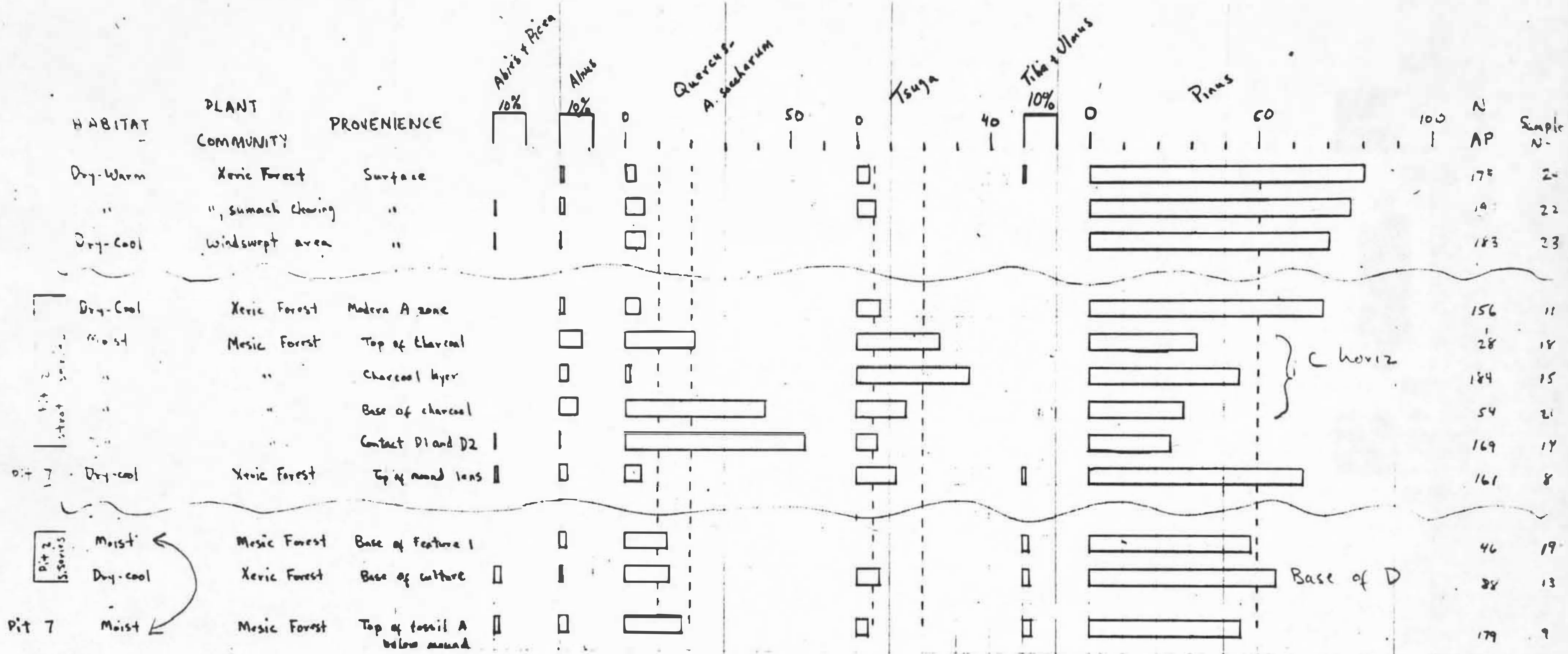

FIGURE 2. Pollen Frequencies of Robinson Site Analyses

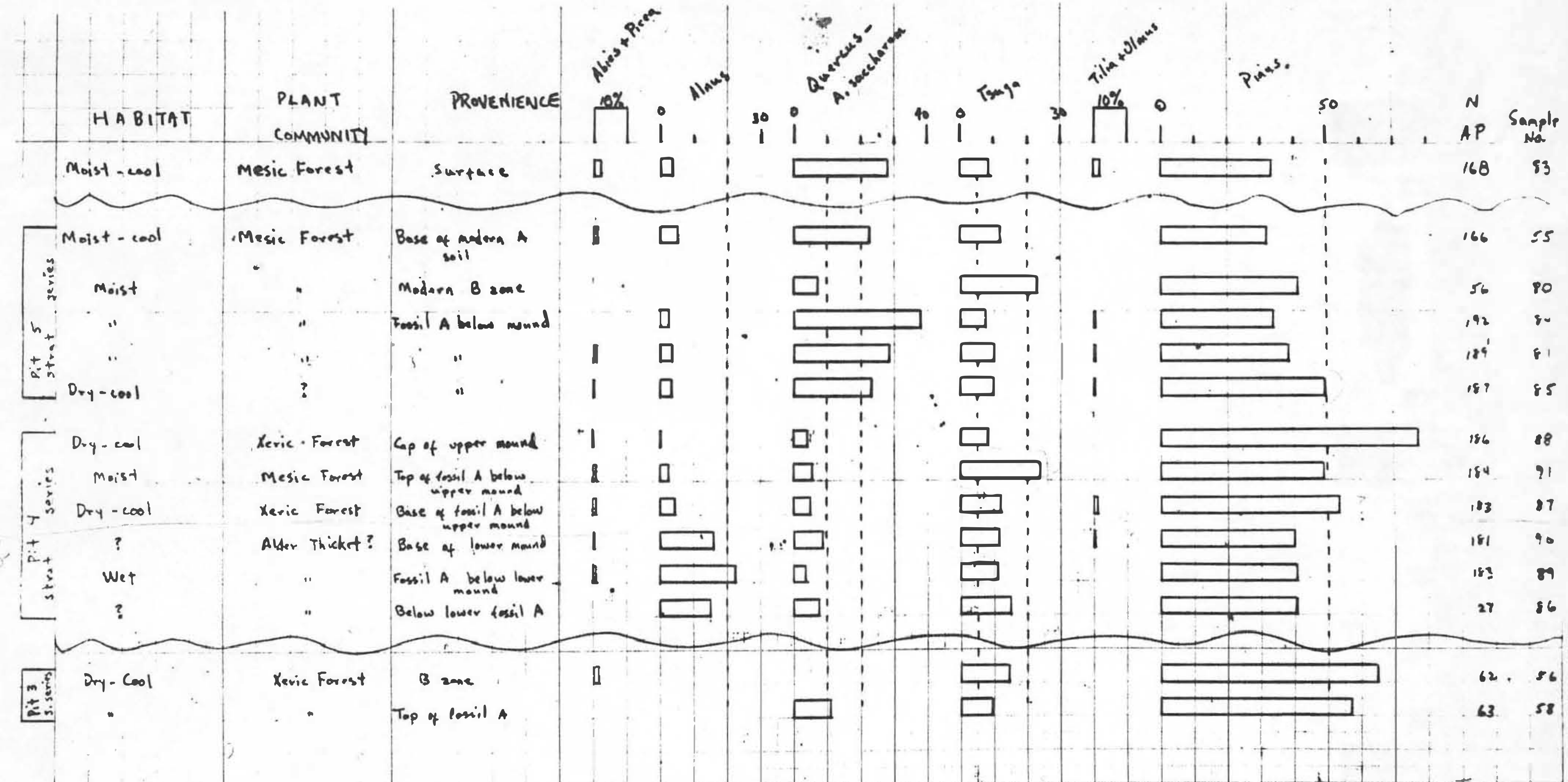

FIGURE 1. Critical Pollen Frequencies of Shannon Site Analyses

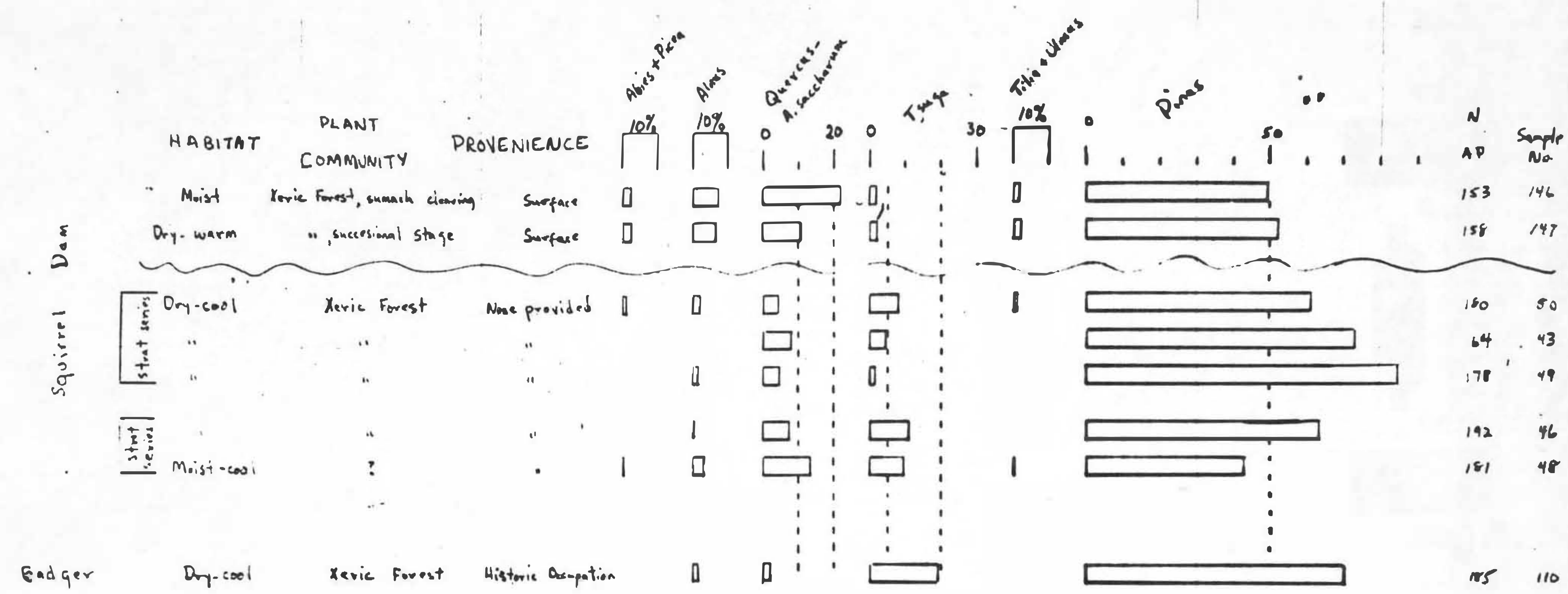

FIGURE 3. Squirrel Dam and Badger Pollen Frequencies

It was necessary to set an arbitrary standard as an "acceptable" pollen count, since no work has previously been done on sediments of this type from the region. Counts of 200 grains, exclusive of spores, were taken as the standard on both surface and subsurface samples and this seems to have been a respectably accurate guess.

ECOLOGY AND PALEOECOLOGY

It was hoped that the ecological meaning of the subsurface pollen spectra could be evaluated by reference to a set of surface sample pollen spectra collected under known conditions. To this end 25 surface samples were collected by D. Snarski of the Department of Biology, Wisconsin State University, with descriptions of the dominants, sub-dominants, understory, litter depth and sediment type at the sampling station. An additional eight samples were collected from the surfaces of archaeological sites with somewhat less information on local conditions.

What surface yields a representative surface sample? In this forested region one could sample the top, middle, or base of the leaf litter, or the middle or base of the A horizon, and give cogent argument why any might be considered as representing the modern pollen rain. After much consideration, it was decided that the base of the leaf litter, at the point that mineralization of the humus began to occur, should be the favored sampling station. This location, of all those possible, was that which most clearly approximated the pre-existing "surfaces" which the archaeologists would be uncovering and sampling for pollen analysis. Because it was unlikely that the archaeologist would be uncovering surfaces associated with the prehistoric sites which were once aquatic or semi-aquatic, modern swamp and lacustrine plant communities were not sampled systematically, though a few samples from bog margins were recovered and analyzed to determine if they had any unusual palynological characteristics.

There was no prospect that a completely representative series of all the plant communities of the region could be obtained in the surface samples collected in 1965, and all the samples could not have been analyzed in the time available even if they had been obtained. The region is relatively well known ecologically, but only in rather broad terms. It is obvious to one who has visited the area that Curtis' (1959) excellent analysis only covers the broad major catagories of plant community variation which actually exist.

Curtis recognizes four categories of forest, one category of grassland, two categories of savanna, one category of tall shrub community, meadows and bogs in the non-aquatic environment of the area undergoing study. These are all major ecological categories and each must be refined for the recognition of all the types of habitats, or "ecological niches" available in the region.

There are three subcategories of Boreal Forest recognized by Curtis for Wisconsin, none of which he considers "true Boreal Forest" as recovered in Canada. Five of the six Boreal Forest samples collected are from one of Curtis' categories: Boreal Forest succession under aspen or white birch (65-131, 133, 137, 138, 139). The sixth (65-116) seems to fit in none of Curtis' categories but may represent "true" Boreal Forest.

Two samples (65-130, 144) are of the second subcategory of Curtis' Lowland Forest: White cedar-black spruce coniferous swamp.

Six samples (65-83, 117, 119, 122, 140, 142) are from Curtis' Mesic Forest Category, which he does not subdivide but which he recognizes as capable of subdivision.

In the Xeric Forest category, Curtis makes two subdivisions: Dry Mesic and Dry Northern Hardwoods. There are three samples of the former (65-120, 123, 129), and four samples of the latter (65-24, 118, 134, 136).

No samples were collected of the bracken-grassland subcategory of grasslands. One sample (65-143) was collected from the Alder Thicket subcategory of Tall Shrub Communities, and one sample (65-135) from the Pine Barren subcategory of Savanna Communities. Meadows, bogs and aquatic communities were not sampled.

In addition, three samples (65-22, 23, 146) are from open areas in Xeric Forest; two samples (65-121, 132) are from mixed plant communities at the edges of swamps; and one (65-147) is from a successional stage community in a Dry-Mesic Xeric Forest.

Table I shows the number of pollen grains observed of each taxon recognized for the 23 samples of plant communities recognized by Curtis. It is readily apparent that the raw pollen frequencies do not yield particularly diagnostic indications of the plant community involved.

Forest type	Sample	Abies	Picea	Tsuga	Pinus	Quercus-Acersaccharum	Acer	Tilia	Ulmus	Carya	Juglans	Alnus	Populus	Betulaceae	Salix	Fraxinus	Chenopodiaceae	
BOREAL FOREST	131	18	17	25	62	9	1					4		37			5	
	137	14	7	3	47	13		1	3			6	1	41			9	
	133	8	15	20	54	14	1		2	1		10	2	39			4	
	139	4	3	18	53	19	1		1		1	6	1	60			1	
	138	1	3	21	58	22			3			7	2	33			6	
	116		2	4	11	12	1		1			26	4	44	1		7	
ALDER THICKET	143		1	2	27	21		2				27		43			2	
LOWLAND FOREST	144	3	6	4	35	13			6			25	4	29			9	
	130	2	3	19	70	12	1					5	5	61			5	
MESIC FOREST	142	1	2	11	33	42			6			4		44	1		7	
	83		3	14	56	47	1		3	2	1	6	4	31			3	
	122	2	3	18	56	15			1		1	6		53			2	
	117		4	35	32	8		2	1	1		4	1	84			5	
	119		2	4	41	22	1	10	2			3	2	55			3	
	140	2	1	4	49	27		1	21	1		7		15		3	6	
XERIC FOREST	129	1		2	85	15	1					8	2	36	1		3	Dry
	123	1	1	8	103	4						1	1	42				Mesic
	120		2	15	153	6		1				2	1	15				
	134*	1	2	4	60	31				1		4	1	47			3	Dry
	136	1		14	136	3				2		4		23			1	N.
	24			6	144	5	1		2			2		19			5	Hard-
	118		4	3	170	3			1					6			1	woods
PINE-OAK BARREN	135	1		6	105	18			1			4		35			2	

* At this sample locality in the Xeric Forest, oak was the dominant species; at the other localities pine was dominant.

TABLE I
(p.1)

	Sample	Artemisia	Amb Ambrosieae	Tubuliflorae	Liguliflorae	Gramineae	Cyperaceae	Ericaceae	Other NAP	Unknowns	
B F	131	1	10	2		5			2	2	
O O	137	3	33	1		12			2	4	
R R	133	3	20			3	1		1	2	
E E	139	1	21	2	2	5				1	
A S	138		28	2		10	1			3	
L T	116	3	47	3		17	10		1	5	
ALDER THICKET	143	2	14	2	10	36	3			8	
LOWLAND FOREST	144	2	38	1	1	15	5			4	
	130	1	8			1				7	
M F	142		32	1		13	1			4	
E O	83	1	19			7			1	1	
S R	122		35	1		5r	1			1	
I E	117		13	3	2	3	1	1	1	5	
CIS	119	3	35	3	2	3		1		8	
T	140	4	17	5	4	20	1			12	
X F	129		41			1	1			3	Dry
E O	123		31			4	1		1	2	Mesic
R R	120		2	1					1	1	
I E	134*	1	32	2		7	1			3	
C S	136		7	1		2		2		4	Dry
T	24		12	1		11				2	N. Hardwoods
	118		7	1		2				2	
PINE-OAK BARREN	135		20	1	1		3			3	

* At this sample locality in the Xeric Forest, oak was the dominant species; at the other localities pine was dominant.

TABLE I
(p.2)

Part of the problem arises from certain difficulties in pollen identification. No reference materials were available for this perliminary work, and pollen grains deposited under these conditions of terrestial environment tend to be more often crushed and partly corroded than the pollen recovered from bog sediments, so much reliance cannot be placed upon shape and fine details of sculpturing, as is usually done. All pollen of the Betulaceae, with the exception of alder, was lumped together in one category. Some grains, the majority actually, were quite definitely Betula, others were quite definitely Corylus, and the Ostrya-Carpinus type no doubt occurs as well. Such distinctions will be made in future work, when reference specimens are available.

The pollen of Acer saccharum (sugar maple) and that of Quercus (oak) is similar in shape, size, aperture system and sculpturing. Working without the benefit of reference material, I made no attempt to systematically segregate pollen of the two taxa. By the end of the period of analysis, I felt that I could generally make an adequate distinction between the two pollen types, as I was more familiar with the range of variation of such pollen grains. The majority of the observed pollen of this type is undoubtedly Acer rather than Quercus.

Time commitments precluded size-frequency analysis of Pinus pollen, but it is likely that this will prove profitable in future work. Size distinctions in Betula and Tsuga pollen were noted which might also be profitable avenues for future work.

The analysis of the samples from subsurface associations with archaeological data illustrated that the modern surface samples are biased in the amount of non-arboreal pollen they contain. While the subsurface pollen spectra regularly contain more than 85% arboreal pollen, about two-thirds of the surface pollen spectra contain less than 85% arboreal pollen. It is not unlikely that this bias in the surface pollen records is a function of the extensive lumbering of the region over the past century, the greater human population of the area in recent times, and the maintenance of forest clearings for roads, houses, etc. However, if the surface pollen records were to be used as an index for interpretation of the fossil pollen spectra, this bias would have to be eliminated. This was accomplished by expressing pollen frequencies (percentages) wholly in terms of the arboreal pollen sum.

There are five arboreal pollen taxa--Alnus, Tsuga, Quercus-Acer saccharum, Pinus, and Betulaceae--which are almost universally present in the surface pollen spectra. Of the others, only Ulmus, Tilia, Picea and Abies yield significant amounts of pollen in any sample. Recognizing this, I tabulated the frequencies of the five most common arboreal taxa and the frequencies of two pairs of the other common arboreal taxa (Table II) as functions of the arboreal pollen sum.

From this tabulation it became evident that the Betula frequency is not informative for differentiating between floristic associations or habitat units, but the other categories are. Betula frequencies are relatively stable--between 20 and 35 percent--except in samples from the Xeric Forest, where the high values of Pinus force a constraint on the percentage values of all other taxa.

The highest values of Picea-Abies pollen are recovered from slope exposures and sandy soils where Picea or Abies are dominants or sub-dominants. These trees may be equally prevalent at moister sites, but in such cases their pollen does not reach a frequency value above 10%. It would appear, then, that high values of Picea-Abies pollen are indicative of dry-cold habitats. The highest frequencies of Alnus pollen are correlated with the most Mesic of the terrestrial environments sampled.. The difference between high Alnus frequencies and low ones is quite dramatic. If the habitat is quite wet, regardless of whether it is cold and covered with boreal forest trees, and regardless of the edaphic condition, as at the edge of the bog mat, Alnus pollen frequencies are approximately 20%.

Quercus-Acer saccharum values over 20% are directly correlated with the presence of either Quercus or Acer saccharum as dominant members of the flora. In future analyses, when Quercus and Acer saccharum are segregated, it should be possible to differentiate Mesic Forests from Dry Northern Hardwood Xeric forests by this variable. Highest frequencies of Tilia-Ulmus pollen are directly correlated with the presence of these genera in the local flora and are thus another good index to Mesic Forest communities. Tilia and Ulmus indicate a somewhat warmer habitat where they occur.

TABLE II

	Sample	Abies + Picea	Alnus	Betulaceae	Q-Acer saccharum	Tsuga	Ulmus + Tilia	Pinus	Remarks
BOREAL FOREST	131	20.2	2.3	21.4	5.2	14.5	0	35.8	slope above sample 130
	137	15.4	4.4	30.1	9.6	2.1	2.8	34.6	slope above alder thicket
	133	12.8	6.0	23.4	12.0	12.0	1.2	32.4	succession under Populus
	139	4.2	3.6	36.0	11.4	10.7	0.6	31.6	Betula subdominant
	138	2.7	4.7	22.0	14.7	14.0	2.0	42.5	Abies-Betula co-dominants
	116	1.9	24.3	41.1	11.2	3.7	0.9	10.3	adjacent to marshy creek bott
ALDER THICKET	143	0.8	22.0	35.0	17.0	1.6	1.6	22.0	complete Alnus coverage
LOWLAND FOREST	144	7.2	20.0	23.2	10.4	3.2	4.8	28.0	Thuja dominant, Abies-Picea subdominants, [illegible]
	130	2.4	2.8	34.3	6.7	10.7	0	39.4	Thuja-Fraxinus co-dominants
MESIC FOREST	142	2.1	2.8	31.0	29.6	7.8	4.2	22.2	A. saccharum-Tsuga [illegible]
	83	1.8	3.6	18.5	28.0	8.3	1.8	33.4	Populus-A. saccharum-Betula co-dominant
	122	3.2	3.9	33.1	9.7	11.6	0.6	36.1	Betula dominant, A. saccharum subdominant
	117	2.3	2.3	48.7	4.7	20.3	1.8	18.5	Tsuga dominant
	119	1.4	2.1	38.7	15.6	2.8	8.6	38.6	A. saccharum-Tilia co-dominan Ulmus subdominant
	----140	2.4	5.3	11.5	20.6	3.2	16.8	37.4	A. saccharum-Ulmus co-dominant
									Dry Mesic
XERIC FOREST	129	0.7	5.3	23.8	9.5	1.3	0	56.4	Pine dominant, Populus subdominant
	123	1.2	0.6	26.1	2.5	5.0	0	60.6	Pine dominant, Betula subdominant
	120	1.0	1.0	7.7	7.7	7.7	0.5	78.5	Pinus-Quercus-A. saccharum co-dominants
									Dry N. Hardwoods
	134	2.0	2.7	31.2	20.6	2.7	0	39.8	Quercus dominant, Pinus subdominant
	136	0.5	3.2	12.5	1.6	7.7	0	74.4	Pinus dominant, understory of Pranus and Corylus
	24	0	1.1	10.6	2.8	3.8	1.1	80.5	Nearly pure pine stand
	118	2.1	0	3.2	1.6	1.6	0.5	90.7	Nearly pure pine stand
PINE-OAK BARREN	L35	0.6	2.3	20.6	10.6	3.5	0.6	61.9	

Pinus values above 50% are correlated with the occurrence of pine as a dominant or co-dominant in the local flora. This is the characteristic which defines the majority of Xeric Forest associations [illegible] Quercus is dominant), so it is possible to recognize the Xeric Forest by its high frequency of Pinus pollen. However, Pine and Pine-Oak barrens cannot be distinguished from Xeric Forest since pine is also a dominant or co-dominant in these situations, the difference being the species and the distributions of the pine. If it becomes possible, by future research, to differentiate the Jack Pine from the Red and White Pine pollen, it should be possible to differentiate between Pine Barren and Xeric Forest communities.

Tsuga pollen frequencies are highest in the sample where Tsuga is the dominant in the local flora, but Tsuga frequencies between 5 and 20 percent occur in Boreal Forest, Lowland Forest, Mesic Forest and Xeric Forest samples. Such frequencies of Tsuga pollen appear to indicate a series of alternative habitats. If they are associated with high frequencies of Abies and Picea pollen they may indicate a somewhat moister condition than if low Tsuga frequencies are so associated. Where associated with high values of Quercus-Acer saccharum pollen they may indicate a somewhat cooler condition than where low Tsuga values are so associated, since low Tsuga values are associated with Mesic Forest samples only when Tilia-Ulmus values are high. Where associated with high values of Pinus, Tsuga values between 5 and 20 percent also seem indicative of a mesic influence, as they occur where Betula, Corylus or A. saccharum are important members of the flora. In addition to the samples tabulated there were two samples from openings in Xeric Forest stands (22,23) and two from ecotones between Lowland Forest and Mesic Forest (121,132) which yield Tsuga values between 5 and 20 percent.

In effect, Tsuga pollen frequencies between 5 and 20 percent seem to indicate a relatively intermediate value of effective moisture between the high values of Alnus pollen at wet sites and the high values of Pinus pollen at dry sites. Effective moisture is recognized as the moisture available for growth, which is conditioned by temperature. In dry locales a decrease in temperature increases effective moisture values so long as the freezing point is not reached; thus Tsuga values between 5 and 20 percent from Xeric Forest and Mesic Forest stations would indicate somewhat cooler conditions, but in Boreal Forest stations they would indicate somewhat wetter ones.

There are, then, a series of ecological conditions which it appears possible to determine from the pollen statistics of the surface samples:

1) dry-cold habitat: Abies-Picea > 10%, Tsuga < 5%

2) moist-cold habitat: Abies Picea > 10%, Tsuga > 5% < 20%

3) wet habitat: Alnus ca. 20%

4) moist-cool habitat: Tsuga > 5% < 20%, Acer > 10% < 20%, Abies-Picea < 10%

5) moist habitat: Acer > 20% or Tsuga > 20%, with other > 5% < 20%

6) moist-warm habitat: Acer > 10%, Tilia-Ulmus > 5%, Tsuga < 5%

7) dry-cool habitat: Tsuga > 5% < 20%, Pinus > 50%

8) dry-warm habitat: Pinus > 50%, Tsuga < 5%

It is also possible to relate the pollen statistics to the ecological units described by Curtis in a general way:

1) Xeric Forest cannot be differentiated from Pine or Pine-Oak Barren, but these two can be recognized from all the others as they have over 50% pine pollen or they have high frequencies of oak pollen.

2) Mesic Forest can be recognized by Tilia-Ulmus values greater than 5%, by Acer saccharum values greater than 20%, or by Tsuga values greater than 20%. However, some samples from Mesic Forest (e.g. 65-122) must be expected to exist which do not have distinguishing characteristics.

3) Some Boreal Forest samples can be recognized by Abies-Picea values greater than 10%, but others cannot.

4) Samples from Alder thickets, Lowland Forest, Boreal Forest, and Mesic Forest may have no distinguishing characteristics, but any sample which contains more than 20% Alnus pollen probably does not come from a Mesic Forest station.

These interpretive schemes are based on relatively few samples, and suffer from a lack of reference materials, so they must be recognized as highly tentative and very open to question. If this report were destined for publication they would not be presented at all, or would be couched in such conservative language as to be almost unrecognizable. But this research program was designed to explore the potentialities of palynological analysis in this area. Thus I have pushed the few bits of data to the extremes of interpretation logically possible and feel no need to apologize for it. The reader is cautioned, however, to expect these interpretations to be subject to rapid modification as more data becomes available.

As there is no evidence to the contrary, it is assumed that pollen statistics of subsurface samples which are like those of surface samples reflect the same conditions of floristics and habitat. There are some samples associated with archaeological features which yield pollen statistics unlike those of the surface samples. These cannot be interpreted at the present time. In my interpretations I have assumed that all pollen of the Quercus-Acer saccharum category is Acer rather than Quercus. Future research will no doubt qualify this, and thus modify the interpretations derived to the recognition of some drier habitats.

THE SHANNON SITE (Fig. 1)

Figure 1 illustrates the critical pollen statistics of samples from this site. The wavy horizontal lines denote known time breaks; the vertical broken lines are placed at critical statistical points. The stratigraphic series from Test Pit 4 and Test Pit 5 both relate to sediments associated with Late Woodland artifacts and construction features. The series from Test Pit 3 was collected from sediments which may be associated with an earlier, Archaic, occupation of the site area.

There are three samples from the fossil A soil horizon trapped below mound 2 at the site (Pit 5). The upper two of these seem to reflect moist conditions, while the lower one reflects dry-cool conditions. There are two samples from the fossil A soil trapped below the upper construction stage of mound 1 at the site. The upper sample seems to reflect moist conditions, while the lower sample reflects dry-cool conditions. While there is insufficient artifactual data to support correlations of these samples, their occurrence as stratigraphic components of a fossil A soil horizon relatively near the surface, but buried by Late Woodland mound construction, and the fact that Mounds 1 and 2 are separated by only a few tens of yards, seems adequate justification for considering them identical expressions of habitat conditions at one point in Late Woodland time.

Using this horizon for a marker, the stratigraphy of the two test pits would indicate the following relative sequence of samples and habitat conditions during Late Woodland occupation:

Sample	Habitat	Curtis' Unit
65-88	Dry-Cool	Xeric Forest
65-80, 84, 81, 91	Moist	Mesic Forest
65-87, 85	Dry-Cool	Xeric Forest
65-90	?	?
65-89	Wet	?
65-86	?	?

Dry-cool, Xeric Forest, conditions also occurred earlier in the site's history, if the samples from Pit 3 are Archaic in age.

ROBINSON SITE (Fig. 2)

There are two stratigraphic series from which pollen was recovered, and two cultural periods. The archaeological evidence would indicate that sample 15 is very late in Late Woodland time, while samples 21, 14 and 8 are earlier than the Late Woodland horizons recovered at Shannon. It is possible that Shannon is as early as or earlier than the Late Woodland represented by samples 21, 14 and 8 from Robinson, but not probable according to the artifact record.

It is not to be expected that the pollen statistics from the Late Woodland horizons at Shannon and Robinson would agree for any time period sampled at both. Today the sites support completely different plant communities, as is evident in the surface samples, and one must presume that they have been distinct because of their edaphic and elevational qualities throughout the last few millenia. Yet it might be expected that if climatic variations were occurring regionally during any time period, both localities would show some effect of the regional variation.

Testing operations at Robinson from which these samples were recovered were undertaken on the sandy ridge elevated above the waters of modern Lake Nikomis by about 35 feet. Modern Lake Nikomis is the product of a dam, but old Corps of Engineers maps indicate that the placement of this area of the site relative to the water table has not been significantly changed by the dam construction. On the other hand, the test pits from which pollen data was recovered at the Shannon site are only 10-15 feet above the local lake level, and the Shannon site is located some miles north of Robinson. One would expect from these data that a variation in climatic conditions which increased or decreased the height of the regional water table would be reflected more strongly at Shannon than at Robinson. An increase in moisture could flood Shannon long before it similarly affected Robinson, and a decrease could shift the balance from Mesic Forest to the regional climax Xeric Forest more rapidly.

Because of its more southerly location, variations in climatic conditions which affect temperature values might be expected to be more sensitively recorded at Robinson than at Shannon. A slight decrease in temperature could shift the balance from dry-warm conditions to dry-cool ones, as seems to be the situation in the windswept area at Robinson where surface sample 65-23 was taken. An increase in temperature could shift the balance from Mesic Forest to the climax Xeric Forest of the region.

It might therefore be presumed that the development of a wet habitat at Shannon might only be reflected at Robinson by the development of a moist habitat if regional moisture values increased. The development of a dry habitat could occur as moisture values decreased at Shannon, without critical limits to cause change being reached at Robinson. Also, a decrease in temperature values could be reflected at Robinson without being critical enough to be reflected at Shannon, and an increase in temperature values could be more critically reflected at Robinson if the change occurred while a Mesic Forest stand occupied the locality. It is recognized, of course, that temperature and precipitation values have interrelationships in this region. Colder average annual temperatures probably would result in increased precipitation, and warmer average annual temperatures probably would result in less precipitation. Seasonal changes in one variable which did not affect the annual average would also affect the other variable, possibly to the extent that its average annual figure might change. The effects of such variations would be recognizable in changes in habitat expressed in the pollen record. But for the moment, I shall proceed <u>as if</u> the variables of temperature and moisture could be considered independent of one another.

If all the variation in habitat expressed by the pollen record at Shannon was due to changes in temperature and moisture, the paleoclimatic record would appear like this:

Sample	Habitat	Moisture	Temperature
83 (modern)	Moist cool	standard	standard
88	Dry-Cool	reduced	standard
80,84,81,91	Moist	standard	increased somewhat
87,85	Dry-Cool	reduced	standard
90	?	?	?
89	Wet	increased	?
86	?	?	?

And at Robinson, the record for Late Woodland time would be:

Sample	Habitat	Moisture	Temperature
24 (modern)	Dry-Warm	standard	standard
18	Moist	increased	decreased somewhat
15	Moist	increased	decreased somewhat
21	Moist	increased	decreased somewhat
14	Moist	increased	decreased somewhat
8	Dry-Cool	standard	decreased

Shannon is the more sensitive site relative to moisture; any moisture variation that occurs at Robinson should also occur at Shannon. Similarily, since Robinson is the more temperature sensitive, any variation in temperature which occurs at Shannon should be very apparent at Robinson.

Robinson, which is the site less sensitive to moisture variation, shows increased moisture for most of the Late Woodland horizon it covers. One would expect that this would be reflected much more strongly at Shannon, as it would be likely that any regional change in moisture which could shift the less sensitive site from standard to increased moisture, would shift the more sensitive site beyond to very increased values. There is a change at Shannon which results in very increased moisture values, occurring between the deposition of samples 86 and 89. Thus there is also a reasonable possibility that the period of deposition elapsed between samples 86 and 90 at Shannon covers part or all of the time period elapsed between samples 14 and 18 at Robinson.

If the interpretation that the time elapsed between the deposition of samples 86 and 90 at Shannon is equivalent to part or all of the time elapsed at Robinson between the deposition of samples 14 and 18, the following picture of Late Woodland paleoclimatology emerges:

Samples	Moisture	Temperature
88	Drier	?
80,84,81,91	Like present	somewhat warmer
87,85	Drier	?
90,84,86,18	Wetter	somewhat cooler
15	Wetter	somewhat cooler
24,14	Wetter	somewhat cooler
8	?	cooler

The amount of absolute time incorporated by this relative chronology remains unknown at present, but soon should become known. Charcoal for radiocarbon analysis was collected in association with sample 87 and also with sample 15. This should give some perspective if the ranges of error of the two samples do not overlap. Also, if the C-14 dating is sensitive enough, this should resolve the question of relative chronologies of the two sites. If sample 15 is older than sample 87, then the suggested correlated site chronology is probably a close approximation to true conditions. If sample 15 is younger than sample 87, then correlation between sites on the basis of interpretations of pollen data like those attempted here is unreliable.

I have pointed out my intention to explore the implications of these pollen records beyond the realm of scientific conservatism to the ultimates of suggested interpretation. I am not adverse, then, to pointing out that there are some possible correlative paleoclimatological records from other areas to these of the Late Woodland horizon. In the American Bottoms area near St. Louis, palynological records indicate a change from drier to wetter conditions of effective moisture during the growing season, beginning between the middle of the 13th and the middle of the 14th century A.D. These wetter conditions may be correlative with those of samples 21, 14, 15, 90, 89, 86 and 18 in North-Central Wisconsin. A reduction in temperature values and an increase in annual moisture values is indicated in pollen spectra associated with the end of Upper Republican occupation in northeastern Colorado. This condition could also be correlative with the condition shown in these Late Woodland samples. In the American Southwest colder wetter conditions are evidenced in pollen spectra from well dated horizons at Picuris and Sapawe Pueblos during the years 1350 to 1425 A.D., followed by periods similar in climate to that of today, drier than that of today, and moister than that of today in the 16th, 17th and 18th centuries. By correlating these dated paleoclimatic conditions with those of the Late Woodland paleoclimatic chronology offered, I suggest that the earliest date of deposition for sample 14 might be between 1300 and 1350; that the youngest date of deposition of sample 18 might be 1525, though 1425 would be more probable; that samples 85 and 87 are likely to date between 1550 and 1600; and that sample 88 was deposited very recently--within the last 150 years.

I will venture to predict that the C-14 age estimations for samples 15 and 87 will probably not resolve the question of interest to us unless the standard deviation is less than 100 years. According to my speculations, the true date of sample 15 is between 1350 and 1425 A.D., while sample 87 dates between 1550 and 1600 A.D.

Three samples of pre-Late Woodland horizons at Robinson yielded palynological records. Because of the small number of associated artifacts, no cultural designation can be assigned to this horizon. The samples are from sediments superimposed on a Paleoindian horizon and are probably not Archaic horizon in age. It is entirely possible that they represent a horizon not far removed in absolute time from the Late Woodland material which is superimposed on them.

The meager artifactual data indicated that the sample of this horizon collected from Pit 7 (65-9) would be more or less time-equivalent to the sample collected from Pit 2 at the base of the culture-bearing deposit (65-13). This is not borne out by the pollen spectra of these samples, as the former indicates much moister conditions than the latter. However, the pollen spectrum of the sample from the base of Feature 1 in Pit 2 (65-19) is quite similar to that from Pit 7. I suggest that the artifacts associated with these samples be re-evaluated in light of the possibility that the top of the fossil A horizon in Pit 7 is time-equivalent to the base of Feature 1 in Pit 2.

It may also be noted that the sample recovered from the top of the mound lens in Pit 7 (65-8) yields a very similar pollen spectrum to that recovered at the base of the culture-bearing deposit at

Pit 2 (65-13). The former sampte has been attributed to the pre-Late Woodland horizon. While there is no reason why the habitat of a pre-Late Woodland horizon could not have been identical to that occurring somewhat later, the very close similarity between samples 8 and 13 leads me to suspect that an error may have been made in attributing the former sample to the late horizon.

SQUIRREL DAM SITE

There are both Archaic and Late Woodland occupations at this locality. The Archaic horizon was sampled stratigraphically in samples 65-50, 43, and 49. A sedimentary feature which was similar to that on which the Archaic artifacts were recovered was observed in another test pit but no Archaic artifacts were found. Samples 65-46 and 48 were collected below this sedimentary horizon, but may or may not relate to conditions existing somewhat before Archaic times.

The three samples known to relate to the Archaic period are equivalent in their pollen spectra. Sample 46 yields the same sort of pollen statistics and could well be related to the same paleoecological horizon. Sample 48 indicates a more mesic habitat, which apparently existed before the Archaic period.

The dry-cool, Mesic Forest environment indicated by these Archaic samples is replicated among the Archaic samples at the Shannon Site. Without more information it would be unwise to presume that this indicates that the two sites are time-equivalent in regard to their Archaic occupations, however. The Archaic period in this area might encompass a good amount of absolute time, during which there may have been a number of intervals of dry-cool environment at both sites. Yet there might be some indication here that peoples of the Archaic period were selecting the dry-cool habitat for camping. As we can observe that Late Woodland occupation occurs in a number of habitats (wet, moist and dry-cool), this may be a character by which Archaic sites can be differentiated.

BADGER SITE (Fig. 3)

A single sample was submitted from an historic association at this locality, and dated about 1900 A.D. The habitat indicated by the pollen record is dry-cool. As no surface sample was submitted, or records submitted on the nature of the existing vegetation pattern, I cannot determine the difference between this record and the conditions which exist today, if any.

NEGATIVE RECORDS

There are some advantages to the discussion of the nature and condition of pollen samples which yielded insufficient pollen for analysis. Such discussion serves as a guide for future work and allows us to benefit from errors already made. There were five samples submitted (65-16, 30, 31, 33 and 107) which were almost completely inorganic, and the acid treatments did their work of eliminating inorganic debris so well that no pollen-bearing matrix remained. The excavation records may show some specific characteristics by which the sediments involved are differentiated from ones which were successfully analyzed. If so, collection of samples from such sediments should be avoided or discouraged in future.

Samples 65-32, 36, 53, 101 and 100 produced an organic matrix at the end of the laboratory processing but this contained very little pollen. I believe that these samples could be processed in a different fashion (perhaps using a swirl technique followed by additional acetolysis and KOH treatments) to concentrate the pollen from larger volumes of samples. Samples 104 and 92 contained too much organic debris for analysis. This can be remedied easily in the laboratory if the pollen content of the original samples is reasonably high. This information points to the necessity of obtaining larger samples in the field.

It is very encouraging to report that of the 41 subsurface samples submitted only two (65-34 and 57) were unanalyzable because of excessive inorganic content. Laboratory procedures which are designed to extract pollen from highly inorganic sediments are unreliable, time consuming and costly. Apparently, future work in this area will not often encounter such sediments in archaeological contexts, and this will tend to increase the amount of valuable research accomplished per unit of time.

SUMMARY

This exploratory program set out to determine if palynological research could assist the archaeologists working in North Central Wisconsin in four fashions.

1) Pollen recovery. It was determined that pollen could be recovered from most of the kinds of sediments the archaeologist might obtain in his work. Some sediment types will yield little or no pollen; other sediment types will have to be given extensive laboratory treatment to recover the pollen they contain in

sufficient quantity for analysis. But about 44 percent of the archaeological samples yielded adequate pollen records using minimal laboratory procedures.

2) Recognition of ecological variation through time. Analysis of the pollen statistics of surface samples collected under known conditions of vegetation suggests that two types of ecological variation can be recognized from the pollen record. On the one hand, some of the major plant communities can be recognized; on the other hand, some habitats or environmental niches can be recognized. Much more work needs to be accomplished on this problem, but the essentials of the matter seem to be under control--or at least controllable.

There are variations in the pollen record through time--in fact, there is more variation than might have been anticipated. Bog pollen records from surrounding regions would indicate that long periods of post-glacial time have passed without causing change in regional vegetation patterns. This seems not to be the whole case, if the pollen spectra recovered on this project have been correctly interpreted. Though there is no indication that wholly different vegetation patterns have existed in this region on the Archaic and Late Woodland horizons, there is reason to conclude that there has been much change in the distributions of vegetation patterns through time in the region. Sites that now support Xeric Forest have supported Mesic Forest, probably within the last millenium. Sites that now support Mesic Forest have supported Xeric Forest in the recent past, and perhaps even more mesic vegetation than they now do as well.

Though the archaeologist recovers evidence of edaphic changes at a locality through the time periods involved, and though the possibility of genetic change through time cannot be ruled out, it seems probable that the main cause for these changes in vegetation pattern distribution has been climatic variation. It is likely that relatively minor changes in moisture and temperature values, operating over time spans of less than a century, are significant in shifting competition equilibria among the members of a flora in a locality. This allows their replacement by plants more adapted to the new conditions of habitat.

This is intriguing to the botanist for the value it has in explaining and demonstrating how plant migration and floristic change occur. Unfortunately for paleobotany, the archaeologist has other fish to fry. His concern is not with either the mechanics or the causes of plant variation through time, but with the effects such causes and such variation may have had upon the aboriginal population. The botanist sees a shift from wet to dry conditions as affecting the alder and pine by varying the height of the water table. The archaeologist sees the same phenomenon in terms of the restriction it may have placed on travel by birch-bark canoe, or in terms of the reduced availability of shallowly submerged land where wild rice might flourish and provide food for hungry Indians. To the botanist, cold is evaluated by reference to how many pine trees are replaced by hemlocks, or how many hemlocks by firs and spruces. To the archaeologist cold is evaluated in terms of increased need for firewood, snowshoes and warmer houses; in terms of a shorter growing season with fewer days in which to lay by a winter store; and in terms of increased infant mortality.

Recognizing the archaeological functions of my interpretations, I have suggested how the pollen record of the Late Woodland horizon might be utilized--through correlation with other pollen records in North America--to date parts of the Shannon and Robinson sites in absolute time between 1350 and 1600 A.D. I have also suggested what C-14 samples might be utilized to check this, and what level of sophistication in evaluation of the C-14 results might be needed. I have suggested that some aspects of the culture of ' Archaic peoples might be related to ecological conditions in their selection of camping sites. I well realize that these suggestions are based on little concrete evidence, but I believe that in the perspective of this investigation those suggestions are of more value than comments I might have to make about the paleobotany and paleobiogeography of the region.

3) Site Stratigraphy. One of the field problems the archaeologist faces is that of determining as much of the internal stratigraphy of a site as possible. Any independent check on the site's stratigraphy that can be recovered, short of excavating it all with dental tools, is extremely valuable. It appears that the pollen records of a site cannoffer such an independent check, for it seems that there is reason to believe that correlation of samples with similar pollen statistics is possible at a site.

At the Shannon Site a particular buried soil zone seemed to be a possible horizon marker linking two separate test pits. As this soil zone was not excavated between the two pits, and as artifactual data was minimal, one could not be positive. At another part of the site a buried soil zone was also encountered. It did not contain the same artifact assemblage as the first soil zone but the possibility existed that it represented the same horizon. The pollen records from the upper and lower portions of the soil zone encountered in the first test pits were essentially identical. This would reinforce the conclusion that this zone is a horizon marker. The sample collected from the upper portion of the soil zone with a different artifact content was not similar to samples of the upper portion of the first soil zone. This would reinforce the conclusion that the two buried soil zones represent different time horizons.

The internal stratigraphy of the pollen samples indicates that there are, actually, three buried soil zones in those portions of the Shannon site which have been excavated. As they have distinct palynological characteristics, pollen samples associated with both a soil zone and an artifact assemblage can be used to place the artifact assemblage in relative time.

Alternatively, as at the Robinson Site, similarities in pollen records from samples which the archaeologist has identified as disparate in time suggest situations in which the archaeologist may have misinterpreted the stratigraphy of the site. This allows the archaeologist an independent basis for reevaluation of stratigraphy, whether the suggestion is correct or not, and this is always valuable.

4) Regional Stratigraphy. There is a great value in archaeology for methods whereby the temporal relationships between sites in a region can be recognized. It appears, from our work at the Shannon and Robinson sites, that pollen records may yield this kind of information. No two widely disparate locations are expected to be identical. Thus while pollen statistics can be used to relate parts of one site to each other, it is necessary to rely on interpretations of those statistics in terms of regional climatic conditions to relate two disparate sites to each other.

Undertaking such interpretations on the basis of available data leaves a great deal to be desired, but the attempt seems to have been fairly successful. Conclusions about the temporal relationships of the sites were reached on paleoclimatic grounds which seem reasonably close to the conclusion reached by the archaeologist on the basis of ceramic associations. It appears likely that most of the occupation at Shannon post-dates most of the occupation at Robinson from the pollen record. If this can be verified by the analysis of two C-14 samples, it will allow some confidence that pollen records can be used to assist in the development of a chronology of the sites of this region.