THE UNIVERSITY OF MANITOBA

LATE HOLOCENE PALAEOECOLOGY OF THE HAND HILLS REGION OF ALBERTA: Implications for Archaeological Research

by

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LATE HOLOCENE PALAEOECOLOGY OF THE HAND HILLS REGION OF ALBERTA: Implications for Archaeological Research

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ABSTRACT

A 3600-year lake sediment core was obtained from Little Fish Lake in the Hand Hills region of southern Alberta and was analyzed to reconstruct the past vegetation. Principles of pollen transport and distribution were formulated, tested and applied to the analysis. Contemporary pollen rain mapping and the explanation of local anomolous distribution are of prime importance for the construction of analogs for the interpretation of past pollen spectra. The study presents confirming evidencefor prevalent assumptions and indicates directions for future research of pollen dispersal.

Using the core as basic data, the palaeoenvironment was reconsrtucted and past climates inferred. Minimal change has occurred in southern Alberta since the end of the Hypsithermal. The most noticeable was a cool moist period from about 200 AD to 600 AD. The effect on the prairie biome was slight but would have induced some modification of bison utilization of the study area. Accordingly, human utilization would have also altered slightly, mainly in aspects of seasonal location.

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CHAPTER I

INTRODUCTION

The environment plays a large role in the relationships between people, their material culture and their subsistence strategies. Specialized tools are evolved for particular tasks which are dependent upon climate (eg., winter and summer tool kits of the Inuit). Hunting strategies are often species specific, such as bison drives or moose stalking. Settlement patterns, especially with hunting and gathering populations, are intimately related to animal movements and plant availability.

Archaeologists, in attempting to assess the interaction of people and the environment, must have an unaltered baseline from which deviations can be observed. Pollen analysis, to a large extent, can provide this baseline. The pollen rainfall of a particular area can provide an understanding of the extent and composition of vegetational communities. Application of the principles of uniformitarianism and superposition allow the determination of previous floras by palynological analysis of former sediments. Use of ecological principles permits the projection of palaeoenvironmental relationships between the vegetation and the fauna and, ultimately, the role of human populations.

In this study, I intend to reconstruct the vegetation history of the Hand Hills region of southern Alberta. The primary tool will be palynological analysis. Grassland productivity will be assessed in terms of bison utilization. Bison, at the time of Contact and undoubtedly in the archaeological past, were the mainstay of the hunters and gatherers of the Canadian prairies. Variations within the prairie biome will influence the spatial locations of the human populations. Given an adequate knowledge of the palaeoecology of a region, the density, seasonality and locations of archaeological sites may be roughly forecast. Such a result would be overly ambitious for this study, as it is the first palaeoenvironmental investigation in the prairie region of southern Alberta. However, some speculations will be proposed and directions for further research will be suggested.

Some comments are relevant to the problem of ascertaining reasonable analogs from contemporary vegetation. First, the prairie has been severly affected by agricultural practises during the twentieth century. Second, the 'wind shadow effect' of the Rocky Mountains results in airborne montane pollen heavily masking local pollen assemblages. Third, the problem of adequately mapping the present pollen rain involved comparision of several contemporary collection techniques.

The test of contemporary collection will be undertaken first. To be considered as valid, the common use of vegetative polsters as pollen receptors must be shown to correspond, within statistical ranges, with other types of pollen collectors. It is hypothesized that polsters can provide a useful source from which contemporary pollen regimes can be ascertained and mapped by trend surface analysis. However, trend surface analysis provides only regional pattern and does not discern locally important variations caused by air-mass movements in relation to topography. The fluid behavior of air requires investigation of the effect of valleys and uplands upon pollen deposition.

The Mixed Prairie was chosen for study because the dominant local pollen taxa are readily distinguishable from the transported types. By deleting the extra-local pollen, variations of local taxa can be more readily discerned.

The reflection of modern agriculture in the pollen rain remains a problem. It has been addressed by several researchers (McAndrews, 1967; Strong, 1975; Webb, 1973). Few areas in southern Canada are unaffected by the presence of cereal agriculture and the attendant plants. An approach, using pollen samples from specific communities from which extra-local pollen has been excluded, will be attempted to enhance the applicability of analogies of present to past pollen assemblages.

STUDY AREAS

Various aspects of research have taken place in different locations in southern Alberta. The polster (Alhap) study was undertaken in the Aspen Parkland near Red Deer, Alberta (Figures 1, 3). The study of local variations in pollen deposition patterns occurred at Transect A on the Bow River, near Calgary, Alberta (Figures 1,2). The pollen core was taken from Little Fish Lake, 125 km east-northeast of Calgary (Figures 1,2). Specifics of each locality will be discussed in the relevant chapter.

LITERATURE REVIEW

Very little pollen research has occurred in Alberta until recently. Hansen (1949a, b) analyzed material from bogs near Edmonton, Alberta. He concluded that Pinus contorta invaded the region after deglaciation and that the present climate was cooler and moister than the post-glacial climate. Heusser (1956)

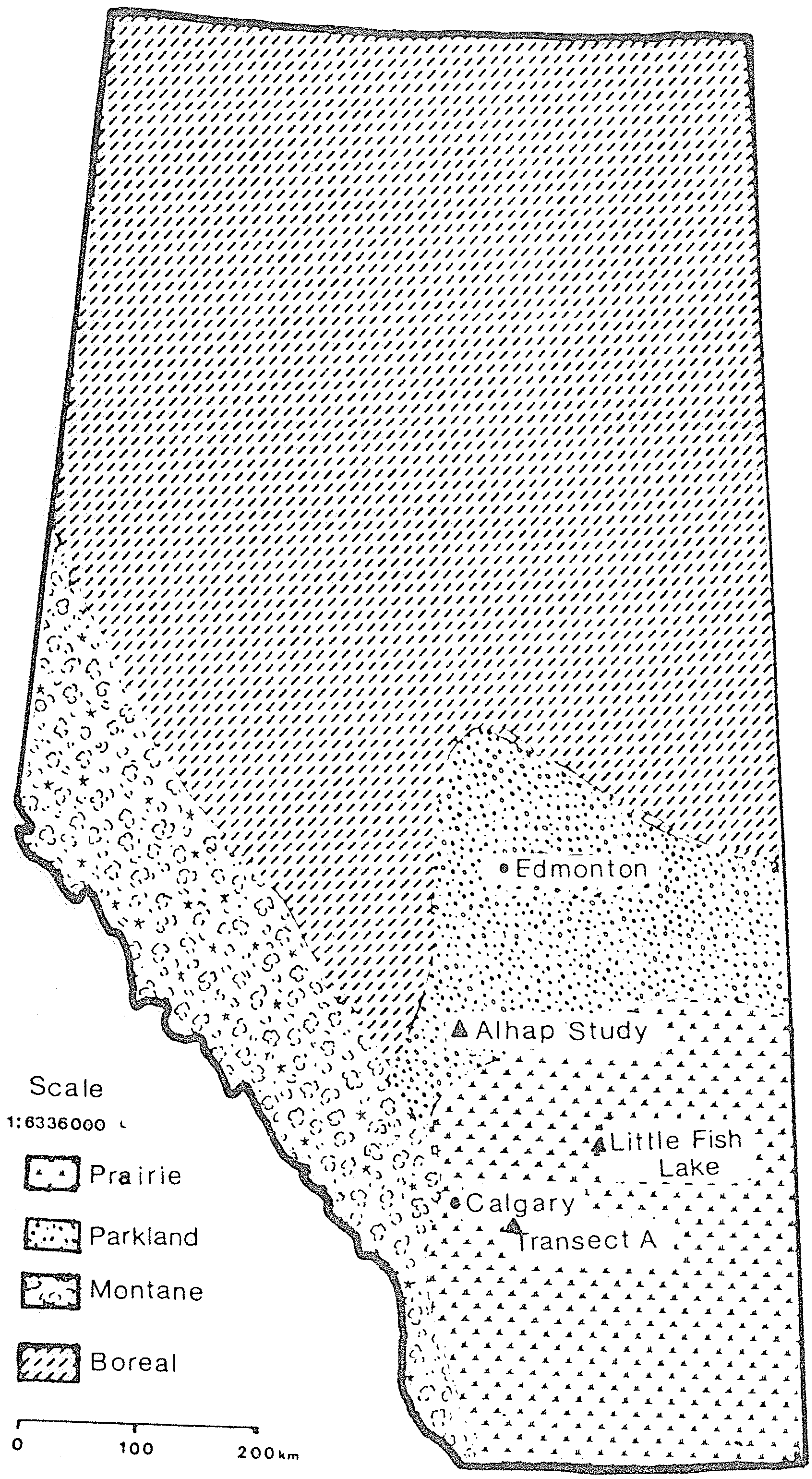


Figure 1: Vegetation Zones and Study Areas in Alberta (after Lichti-Federovich 1970)

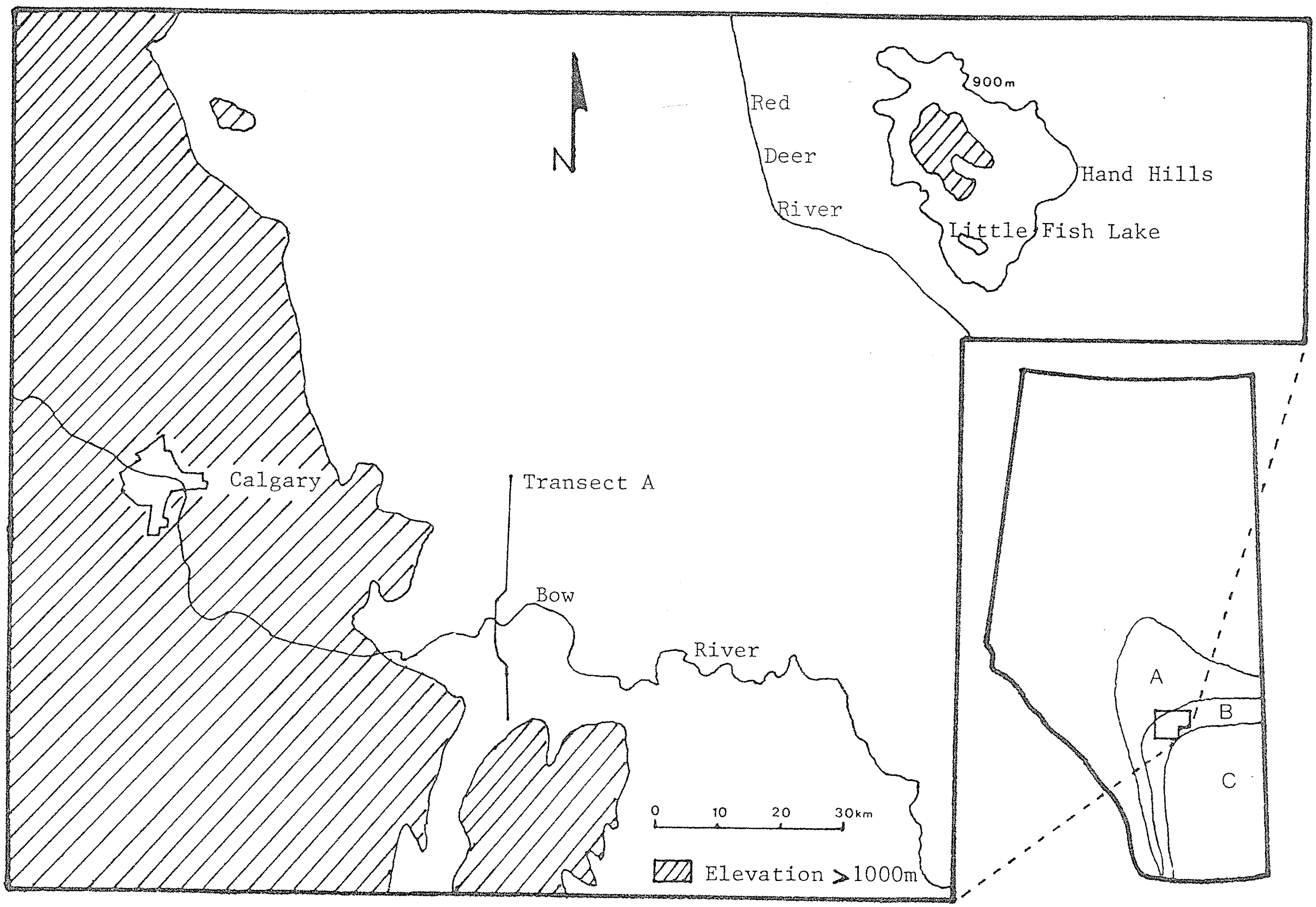


Figure 2: Southern Study Area. Inset Map Vegetation Zones: A - Aspen Parkland, B - Mixed Grass Prairie, C - Short Grass Prairie (after Strong 1975).

investigated bogs in the Rocky Mountains in conjunction with his glacial studies and concluded that "the environments implied by the pollen and glacier data are represented by intervals of cool and moist climate during the early and late post-glacial with the thermal maximum interposed" (1956: 299).

Lichti-Federovich (1970) studied a core from Lofty Lake which provides a record of pollen deposition since 11,400 BP. Her data indicate post-glacial colonization of the area by Populus, followed by a Picea forest. Boreal elements decreased between 9200 and 3500 BP. suggesting "a trend to increasing warmth and decreased precipitation, reaching a maximum development at about 5500 to 6000 BP after which there was a gradual deterioration in climate" (Lichti-Federovich, 1970: 944). She also concluded that "the composition of the forest vegetation in the precincts of this site has not varied markedly since ... 3500 BP" (1970: 942).

Christensen and Hills (1971) (unpublished manuscript noted in Strong, 1975) studied sediments from Linnet Lake in Waterton Lakes National Park in southwestern Alberta. Their data showed a series of fire-induced successional sequences involving Pinus contorta. Alley's (1972) data from Callum Bog in the southwestern foothills of Alberta indicated a warm dry climate from deglaciation to 5000 BP with a cooler and moister regime to present. Bujak (1974) obtained cores from lakes in the Waterton area which indicated a short cool, moist episode about 1600 BP. Holloway (1978) obtained a 16 m core from Wabumon Lake, 50 km west of Edmonton which yielded a palynological record back to 16,180 BP. He interpreted an initial tundra episode followed by early colonization by birch and alder with a culmination in the Boreal Forest. The Hypsithermal (9000 to 5000 BP) saw expansion of grasslands, followed by a re-establishment of the Boreal forest. Amelioration of the climate resulted in the establishment of the Aspen Parkland about 2000 BP.

Strong (1975, 1977) used palynological data from several lakes in southern Alberta, including Little Fish Lake, to determine settlement horizon in lake sediments. Palynological research beyond Alberta includes Mott's (1973) investigation of Clearwater Lake in Saskatchewan and Ritchie and Lichti-Federovich's (1968) study of cores from the Tiger Hills of southern Manitoba, both within the prairie region.

CHAPTER II

COMPARISON OF VEGETATIVE POLSTERS AND ARTIFICIAL POLLEN TRAPS

A major source of analogs for the analysis of Quaternary pollen diagrams is that of contemporary pollen distribution. Many studies of local and regional regimes have been published (eg. Lichti-Federovich & Ritchie 1968; McAndrews, Kroker & Slater n.d.; Mott 1969; etc.) Statistical techniques have reduced the subjectivity of these analogs (Birks, Webb & Berti 1975). However, determination of the contemporary pollen rain may vary due to differences in collection dates, collection matrices, laboratory techniques and analysis methods. The collection matrix has varied widely. Surface duff (McAndrews & Wright 1969), surficial limnic sediments (Ritchie & Lichti-Federovich 1967), water tank sediments (Potter 1967), moss polsters (McAndrews & Wright 1969) and artifical pollen traps (Ritchie & Lichti-Federovich 1967) have all been used.

In this portion of the study, I will compare data obtained from vegetative polsters. Heim (cited in Faegri & Iversen 1975: 68) stated that pollen spectra at different levels of a moss cushion vary and Faegri & Iversen question "whether statistically significant differences between top and bottom of moss cushions are due to short-term changes in flowering or to selective destruction" (1975: 68). They suggest that "only the youngest tips of the moss plants should be used for comparison with actual conditions in order to avoid selective destruction" (1975: 69). This may be valid when a single-season deposition is desired, but lake and bog deposits are time-integrated reflecting selective destruction and mixing. The pollen grains of some taxa, such as Populus and Acer, degrade rapidly under certain conditions (Sangster & Dale 1961, 1964). The suggested methodology would still not provide a pollen spectrum totally reflecting the actual deposition if the polster was sampled a considerable length of time after the flowering of those taxa.

Within most North American literature, the delineation of modern pollen regimes is with the underlying assumption of applicability to fossil assemblages. Therefore, a spectrum is desired which is generalized for a particular area and representing more than a single season. Within this framework, entire plants (Selaginella, Phlox, etc.) are utilized to obtain pollen spectra (King & Kapp 1963; McAndrews & Wright 1969) and in which time-integrated assemblage, accurately reflecting generalized depositional regime is assumed to pertain.

This assumption subsumes other assumptions. First, it is assumed that the date of collection is relatively immaterial. This assumption requires the concept of uniform decay rates for deposited pollen so that the annual influx of the pollen of each taxon does not produce a masking effect upon the previous assemblage. That is, a polster collected in the early spring should not show an over-representation of the early flowering taxa, as the influx of the previous year would have decayed more than that of the late flowering species of the previous season. This assumption is based largely upon a lack of quantified data (Faegri & Iversen 1975: 69), although it is recognized that some taxa have a very minimal survival rate. Second, it has been assumed that it is possible to discount the over-representation caused by the incorporation into the sample of parts of flowering plants that grow on or near the polster by deleting that taxon from the pollen spectrum of that sample.

ARTIFICIAL TRAPS

A plethora of mechanisms have been devised to collect pollen and spores. These include gravity sedimentation, impaction and volumetric air sampling devices. Some methods that have been applied to palynology shall be briefly discussed. For a detailed examination, see Gregory (1973) and Ogden et al. (1973) The volumetric techniques measure the number of grains in a given volume of air. Many volumetric samplers, such as the Hirst trap (Hirst 1952) require a high degree of servicing as the collection period is short (2 to 48 hours). Washout pollen cannot be collected. In many cases, an external power source is needed which may not be available in field situations. Finally, air sampling devices are often expensive which inhibits the establishment of several stations .

Impaction and sedimentation techniques measure the number of grains collected on either a vertical or horizontal surface. Impaction of pollen grains, usually on sticky cylinders, is dependant upon wind speed, the mass of the particle, the stickiness of the medium and the diameter of the cylinder (Gregory 1973:93). The short-term aspect of the collector, the inability to capture rain-borne pollen and the washing of impacted pollen are major disadvantages of the sticky cylinder. Sticky microscope slides have been in use since 1873 (Gregory 1973:128). Often the slide is exposed horizontally with the sticky surface open to the wind but sheltered from precipitation (eg., the Durham sampler (Ogden et al . 1973:50-51)). This eliminates the possibility of pollen capture from rain wash-out. Also, this technique is biased towards the selection of larger particles, (Gregory 1973:128), and pollen grains, such as those of Boraginaceae, Urtica and Primula, may not be adequately collected. The efficiency of capture is affected by edge effects (Davies 1960; Gregory 1973:98, 104) wherein edge shadow caused by wind striking the leading edge of the slide interferes with gravity sedimentation and diagonal impaction. Turbulent eddies around the slide also affect the capture of grains (Davies 1960; Gregory 1973: 99).

Other researchers have used a petri dish with the bottom covered with glycerine-drenched filter paper (Hesselman 1919, cited in Faegri & Iversen 1975), glycerine (Ritchie & Lichti-Federovich 1967) and water agar (Gregory 1973:105). Efficiency is impaired at wind speeds above 3.2 m/s due to edge shadow (Gregory 1973:105). Precipitation causes problems. Hesselman had to close his dishes during rainfall to prevent overflowing (Faegri & Iversen 1975:68). Ritchie and Lichti-Federovich (1967) placed their dishes in meteorological Stevenson screens. Their collection was biased against adequate gravity sedimentation due to the louvred arrangement of the screens because of impaction of the pollen on the louvres and the deflection of the air stream would tend to bias the quantifiability of their collections.

Given these problems, plus the fact that pollen-carrying insects may perish in the collectors (Faegri & Iverson 1975:68), both "the stationary microscope and petri dish are clearly poor tools for quantitative air sampling" (Gregory 1973:103).

The aerodynamic effects on petri dishes can be ameliorated by sinking them below a plane surface (Gregory & Stedman 1953:666). Tauber (1967) describes a sampler that allows operation during precipitation and without the drawback of edge effect. Turbulent deposition (Gregory 1973:118-119) would increase the efficiency of the Tauber trap. A drawback of this trap is the immersion of the pollen in a water/glycol solution which can lead to degradation of the grains through bacterial activity or breakage from swelling (Berezina & Tiuremnov, 1973). Also, pollen-carrying insects may perish in the trap.

The mechanisms of pollen deposition have been thoroughly discussed in the literature (Davies 1960; Gregory 1973; Hirst 1959; Ogden et al. 1973; etc.) and no technique of sampling has been found adequate for all purposes. Surface pollen traps which measure the deposition per unit area cannot yield results which are comparable with the results obtained by volumetric sampling devices as one cannot "define the volume of air sampled or ... compute the concentration of particles in that air" (Ogden et al. 1973:41).

For palynological purposes, a sampler that approximates the natural collection conditions of a lake or bog is more advantageous than a volumatric trap, as the determination of the actual deposition of grains per unit area per year is the basis of interpreting the character of the vegetational community that produced the pollen. While depositional regimes vary as a function of several factors: meteorological conditions, lake area, nature of vegetation, pollen size, etc., it can be seen that deposition resuts obtained from surface samplers are a comparable analog to those obtained from surficial limnic sediments.

Several arguments have been put forth against horizontal surface samplers:

(a) "counts are not comparable from one time or place to another unless meteorological conditions are identical (Ogden et al. 1973:41),

(b) "unrecorded fluctuations in spore concentration and wind speed during exposure prevent any reliable conversion of number caught into absolute terms" (Hirst 1959:536),

(c) they provide "little information on the concentration in the air above. Deposition on a dissimilar surface nearby may be very much different" (Ogden et al. 1973:42), and

(d) "at best, such samplers give an indication of the types of particles present and a very rough measure of their abundance" (Ogden et al. 1973:41).

However, Hyde (1959) has shown that gravity sampling demonstrated the same relative frequencies and seasonal variations of taxa as did the Hirst trap when long-range, generalized studies were performed.

ALHAP SAMPLER

An artificial sampler was designed to combine several of the advantages of the Tauber trap as well as to partially eliminate its drawbacks. The basic collecting unit is a 10 cm^2 pad of 2 mm thick foam rubber (Artfoam), impregnated with glycerine. The pad was placed in a single ice-cube holder (plastic) (approx. 3 X 4 cm) which had had the bottom perforated for drainage. A covering of fibreglass window screening (1.5 mm mesh) was glued (Epoxy resin) across the mouth of the holder. The sampler was placed in a second perforated ice-cube holder mounted on a stake one meter above the ground. After exposure for one week, the sampling unit was removed and sealed into a Ziplock bag. To reduce bacterial degradation, it is suggested that exposure not exceed ten days. Alternatively, the pad can be treated with formalin or another fungicide if longer collection periods are desired.

The Alhap sampler was designed to measure the rate of pollen deposition by gravity sedimentation and wash-out. As is the case with all sampling devices, both advantages and disadvantages occur. The advantages are:

(a) it is operative in rainy weather, capturing wash-out pollen which Tauber (1967) has measured as 20 to 35% of all deposition,

(b) servicing of the station is minimal and the collection period is variable,

(c) pollen-bearing insects cannot perish in the sampler,

(d) pollen deposited by gravity sedimentation will be captured on the pad, and

(e) the unit is inexpensive (approximately 10¢ per sampler).

Negative aspects of the sampler are:

(a) turbulent deposition is under-represented due to the screening which inhibits eddying effects,

(b) excessive precipitation may wash some of the glycerine from the pad and reduce the capturing ability,

(c) high temperatures combined with low humidity can cause the glycerine to dry out, thereby reducing the trapping of both gravity deposited and rain-wash pollen, and

(d) impaction deposition will be minimal, if indeed it even occurs due to the height of the cleared zone (Davies 1960).

Another bias is inherent in the height of the collector above level. Pollen produced by low herbs will be under-represented in a sampler above ground level (Potter 1967). Faegri & Iversen (1975:57-58) state that insufficient turbulence in the extreme bottom air layer will mitigate against all grains becoming effectively airborne. Thermal activity will lift some, but not all, of this pollen (Schmidt 1967). In many cases, the ground vegetation is under-represented in the pollen deposition in lake basins so that this bias of the collector is similar to that of lake sediments. Vegetative polsters, being at ground level, would be expected to demonstrate a higher incidence of low herb pollen.

STUDY AREA

The sites selected for establishment of the sampling stations were in central Alberta near Red Deer (Figures 1, 3). The area is gently rolling Aspen Parkland with some pine and spruce. The presence of these elements of the Boreal Forest leads Zoltai (1975) to place this region in the Parkland/Boreal Forest Transition Zone. Tree coverage is roughly 40% with poplar being the most common type.

The stations were established in conjunction with micro-meteorological stations of the Alberta Hail Project in easily accessible areas near farmsteads. Samplers were situated at least 50 m from the nearest trees. In most cases, herbaceous vegetation was less than 50 cm.

Data were obtained from the following stations:

Station 1: Knob-and-kettle terrain covered with a dense poplar parkland. Ground cover was low herbs and the nearest trees (Populus) were 120 m from the sampler.

Station 6: Gently rolling terrain with sparse poplar parkland with occassional pine. Much of the adjacent area had been cleared for agriculture so that the nearest tree (Acer negundo) was 200 m away.

Station 7: Rough knob-and-kettle terrain covered with a dense growth of poplar and willow with oocassional pine. The station was not optimum as poplar occurred 40 m from the sampler. A pine tree was 80 m distant.

Station 9: Gently rolling pine/poplar parkland which had been largely cleared for agriculture. Pine and introduced spruce were 80 m from the station.

The stations were serviced by technicians of the Alberta Hail Project and, on some occassions, the records were incomplete when a replacement sampling unit was not set out for the next collection period (Table 1).

Table 1: 1975 Collection Periods at Alhap Sampler Stations

COLLECTION PERIOD		STATIONS 1	2	3	4	5	6	7	8	9	10
I	June 24 - July 2	X			X	X	X	X		X	
II	July 3 - July 9	X			X	X	X	X		X	
III	July 10 - July 18	X			X	X	X	X		X	
IV	July 19 - July 27	X	X	X	X		X	X	X	X	
V	July 28 - August 5		X	X		X	X	X	X	X	
VI	August 6 - August 15	X		X						X	
VII	August 16 - August 24	X	X	X	X	X	X	X	X		X
VIII	August 25 - August 30	X	X	X	X	X	X		X	X	X

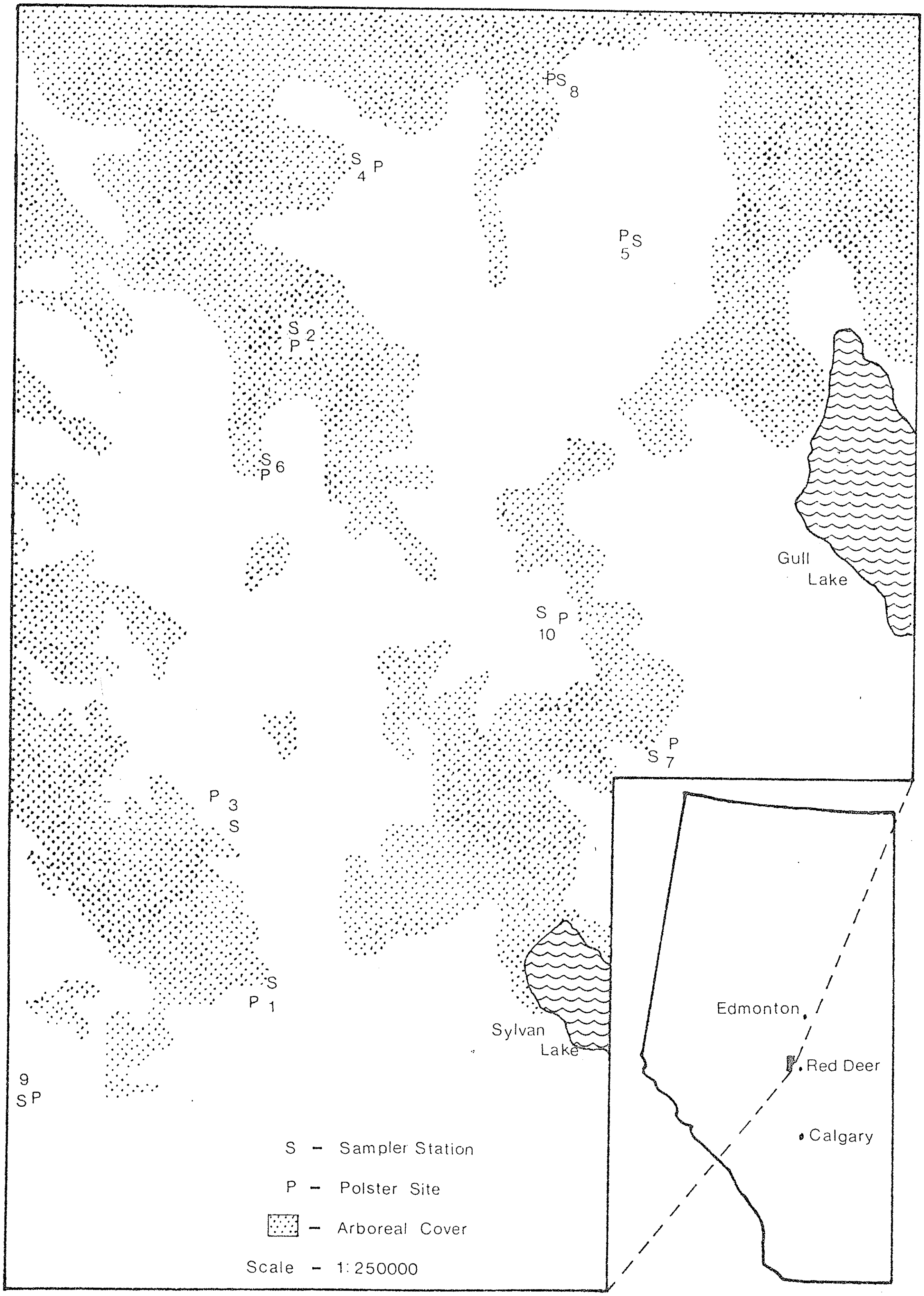


Figure 3: Alhap Pollen Sampler Study Area

The sampling units were not set out until June 24, thereby missing some of the early spring influx of Picea, Pinus, Abies, Salix and Populus. Under-representation of these taxa can be expected, especially as the conifers are prodigious producers of pollen (Faegri & Iversen 1975:52-53). The study had to be terminated at the end of August, so that late-flowering taxa, such as Artemisia and other Compositae, are only partially recorded.

Some pollen samples contained very few grains as a result of reduced influx during August. Bacteriological destruction of some pollen may have occurred as the sampling pads were not treated with a fungicide, although no degradation was observed during counting. Alternatively, intense local thunderstorms may have washed glycerine from the pad, thereby reducing the trapping capacity.

The polsters were collected as near the sampler as feasible (Figure 3). The necessity for a suitable vegetative collector (Selaginella or Phlox) occassionally precluded collection in the immediate vicinity of the sampling station.

LABORATORY TECHNIQUES

Laboratory procedures were devised to fulfill three functions; (1) release of the pollen grains from the collector, (2) acetolysis of the grains, and (3) absolute counting. The method below fulfilled all three functions with minimal damage to the pollen grains. It had been felt that possible degradation might occur due to the strength of the chemicals but control tests on pollen samples from Greer Laboratories indicated no degradation.

The technique uses the same chemicals as the basic method (Faegri & Iversen 1975), but the procedure and the proportions of the chemicals are different.

(1) Dissolve an exotic pollen tablet (<u>Lycopodium</u> or <u>Eucalyptus</u>) in a 50 ml centrifuge tube with 10% HCl, centrifuge, decant.

(2) Wash with distilled water, centrifuge, decant.

(3) Place Artfoam pad in tube, add 10 ml acetic anhydride.

(4) Add 5 ml concentrated sulfuric acid, stir until pad is totally dissolved.

(5) Dilute with 25 ml glacial acetic acid, centrifuge, decant.

(6) Wash with glacial acetic acid, centrifuge, decant.

(7) Wash with distilled water, centrifuge, decant.

(8) Wash with tertiary butyl alcohol, centrifuge, decant.

(9) Stain with Safranine O and suspend in silicon oil.

The various steps in the procedure were arrived at after considerable experimentation. The acetic anhydride disintegrated the pad but did not dissolve it. The addition of concentrated sulfuric acid dissolved the pad but the viscosity of the medium was too high to concentrate the grains by centrifuging. Dilution of the solution with acetic acid, in which both acetic anhydride and sulfuric acid are miscible, reduced the viscocity such that the pollen could be concentrated.

The slides were counted with a Wild Leitz Dialux microscope with a 10X ocular and a 25X objective lens. Higher magnifications (400X and 900X) were used for critical identifications. In most samples, at least 200 grains were counted. The pollen sum included all taxa except Cruciferae at Stations 1 and 6 where fields of cultivated <u>Brassica</u> (mustard) were adjacent to the sampler. The basic counts (Appendix A:1-4) were used to calculate the relative frequency of each taxon during each collection period. The frequencies for five selected taxa are depicted in Figures 4-7. These taxa are the most prevalent and show the highest variation throughout the collection periods due to their different pollination periods..

The addition of exotic (Eucalyptus) pollen, callibrated at 18,500 ± 500 grains per tablet, allowed the determination of the total deposition rates of grains per square centimeter per day for each of the collection periods (Table 2). The following formula was used,

$$N = \frac{p \times C}{c.x.a \times d}$$

where N = deposition rate in grains per square centimeter per day,

p = pollen sum

C = known amount of exotic pollen added,

c = number of exotic pollen counted,

a = area of sampler, and

d = days of exposure.

The formula can be applied to individual taxa in which case p is the number of grains of that pollen type counted,

RESULTS

As the highest depositional rate occurred early in the study, taxa which dominate the spectrum when the influx is highest will be the most strongly represented taxa when cumulative totals of deposition throughout the summer are considered. For example, during Period I at Station 7, 75 Pinus grains were deposited per square centimeter per day (86%). This influenced the relative frequency of the entire summer's deposition more strongly than the 14.5% of Artemisia during Period VII (0.3 grains per square centimeter per day).

To assess the contribution of selected taxa to the entire pollen

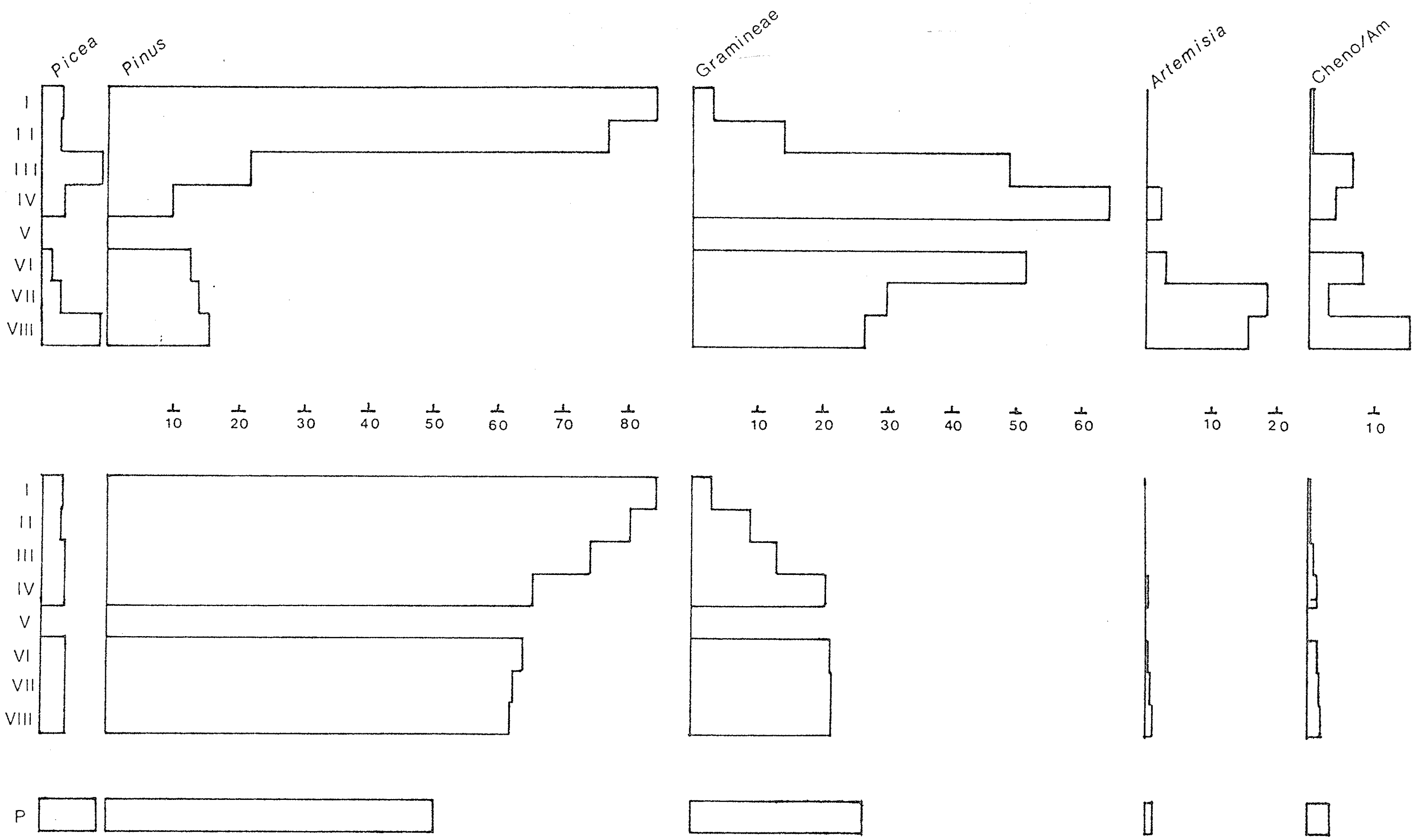


Figure 4: Comparison of Relative, Cumulative and Polster Frequencies of Selected Taxa at Station 1.
I - VIII: Collection Periods P: Polster Frequencies

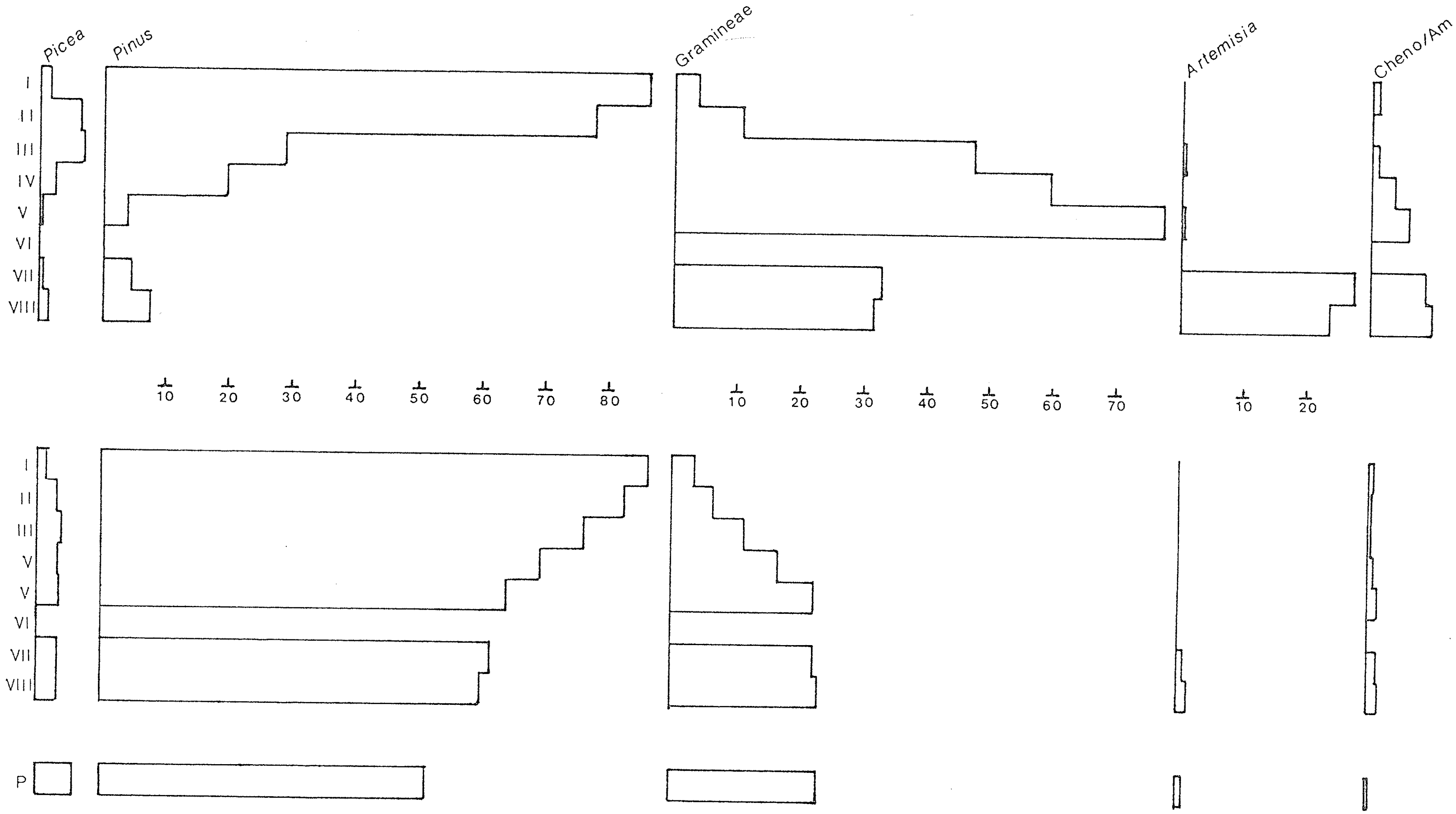


Figure 5: Comparison of Relative, Cumulative and Polster Frequencies of Selected Taxa at Station 6.
I - VIII: Collection Periods P: Polster Frequencies

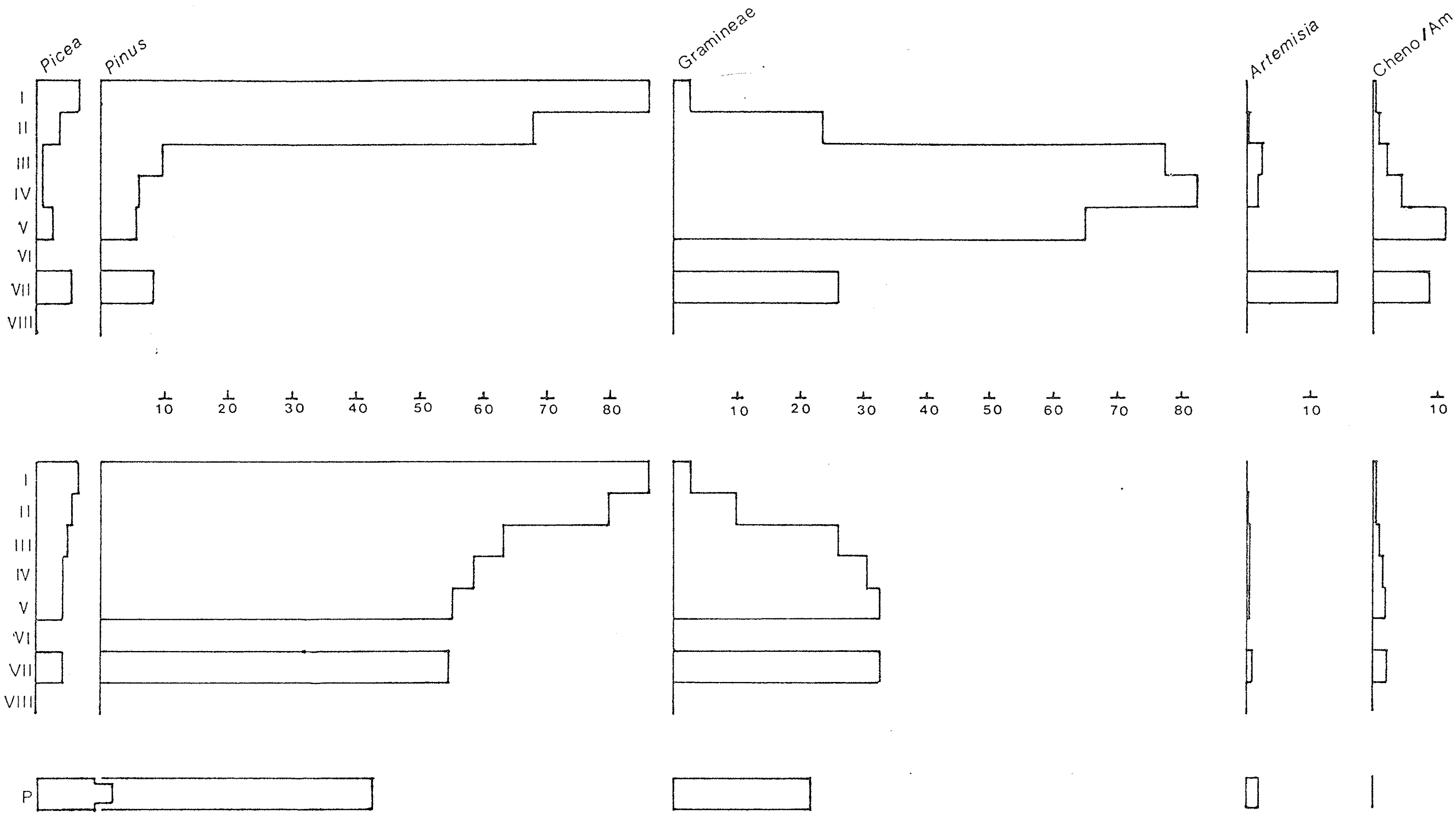


Figure 6: Comparison of Relative, Cumulative and Polster Frequencies of Selected Taxa at Station 7.
I - VIII: Collection Periods P: Polster Frequencies

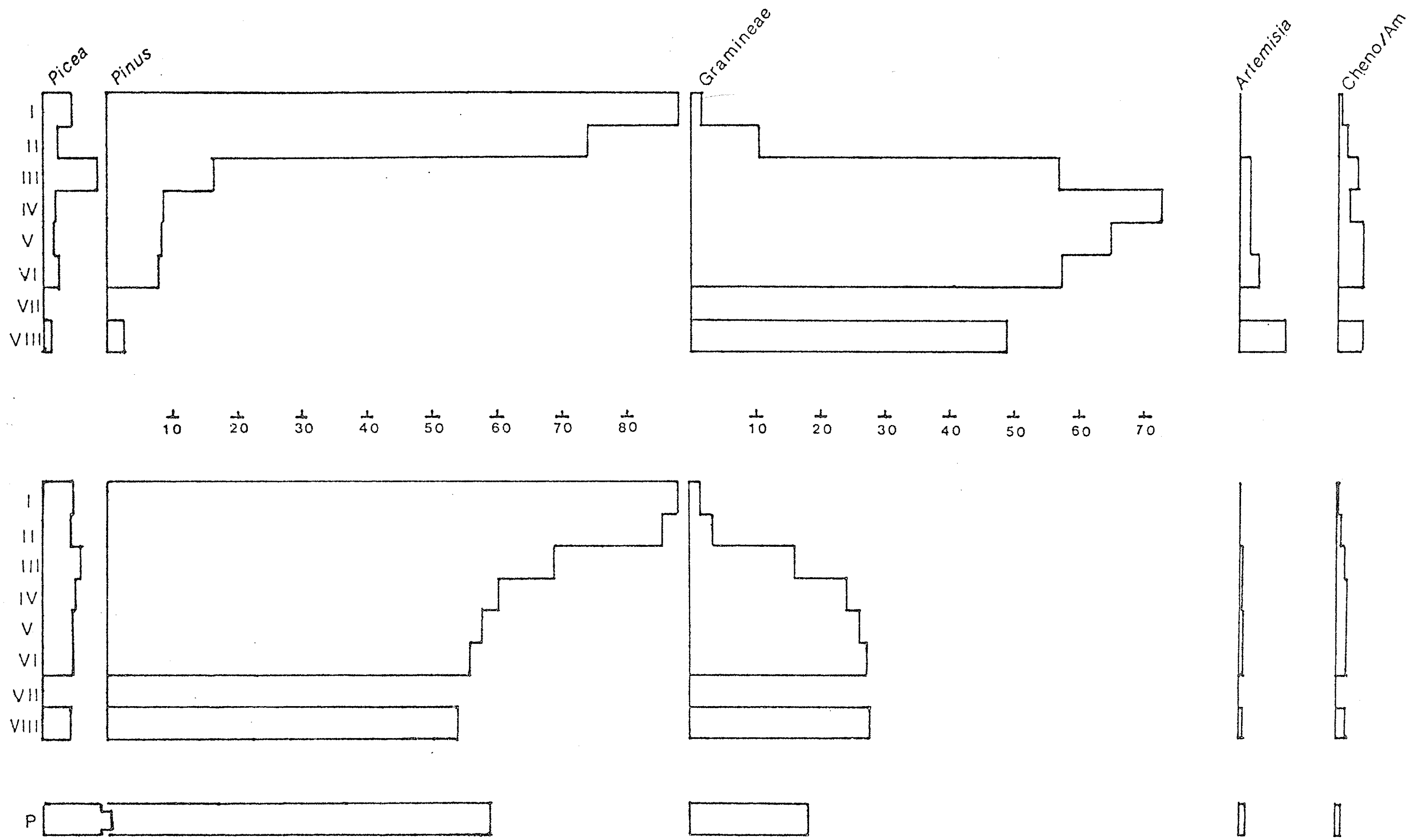


Figure 7: Comparison of Relative, Cumulative and Polster Frequencies of Selected Taxa at Station 9.

I - VIII: Collection Periods P: Polster Frequencies

spectrum for the study period, cumulative totals and percentages were calculated (Figures 4-7). As expected, Pinus dominates the spectra. Gramineae slowly increases from a minor component during the early periods to become the second highest taxon. Artemisia, Compositae and Chenopodiinae, which are strongly represented during the later collection periods, have little effect on the final character of the pollen spectra.

Table 2: Daily Deposition Rates (grains/cm^2)

Collection Period	I	II	III	IV	V	VI	VII	VIII
Station 1	55.1	82.6	17.5	21.4	M	4.2	3.7	3.5
Station 1*	55.9	108.8	31.8	24.4	M	4.4	4.0	3.6
Station 6	85.6	74.3	19.5	21.4	17.8	M	7.4	10.7
Station 6*	85.6	75.1	24.3	30.6	19.6	M	7.7	10.9
Station 7	86.6	59.8	41.6	15.2	12.6	M	2.4	M
Station 9	98.4	32.0	38.0	27.5	9.2	7.1	M	9.2

* Depositional rate includes Cruciferae   M - Missing Data

Polsters adjacent to each of the sampler stations were analyzed (Appendix A:5) and the relative frequencies of five taxa are displayed in Figures 4 through 7. Some variation is readily noticeable. Picea is more strongly represented in the polsters than in the sampler data. This is probably due to the lateness of the beginning of the sampler study. The anticipated under-representation of Pinus does not occur, suggesting that probably the study began at the inception of the pine pollination season.

The suspected under-representation of the late-flowering taxa is not evident due to the extremely low influx of pollen in August (2.4 grains/cm^2/day at Station 7 during Period VII). Gramineae, in some cases, has a lower frequency in the polsters than in the samplers. This effect is caused by a higher frequency of Picea and low herb pollen being deposited on the polsters.

There is a strong internal consistency of the data obtained from the samplers and the adjacent polsters (Table 3). The fit is not as good when polsters from the entire study area are considred, although it must be noted that only stations 1,6,7 & 9 were used to derive the sampler data.

Table 3: Means and Standard Deviations of Pollen Frequency

Taxon	Cumulative		Polsters 1,6,7,9		All Polsters	
	$\overline{X}$	S.D.	$\overline{X}$	S.D.	$\overline{X}$	S.D.
Picea	3.9	0.5	9.3	2.5	8.3	2.9
Pinus	57.8	3.9	51.4	6.5	49.1	12.3
Gramineae	26.3	4.9	22.4	3.1	27.0	15.7
Artemisia	1.1	0.4	1.1	0.6	1.8	1.3
Cheno/Am	1.9	0.2	1.8	1.4	1.7	1.8

CONCLUSIONS

The foregoing study cannot be considered definitive; too few stations were in operation to obtain complete data for the study area, the period of collection of the samplers did not encompass the entire period of pollen deposition and missing data weakens the conclusions.

However, it can be seen that *Selaginella* and *Phlox* polsters closely approximate the pollen depositional regime for the current season. Variation occurs between stations reflecting the local vegetation (eg. Cruciferae at stations 1, 6). In this region, most of the coniferous pollen is transported from the nearby Boreal Forest, but local taxa are sufficiently represented to produce distinctive spectra at each station.

The moss polsters were collected at various times throughout the study period and variation appears to be a function of vegetation and the attendant depositional regime rather than the date of collection. A factor worth noting is the continued deposition of early pollinating taxa throughout the study. This constant re-deposition may be a factor in maintaining a constant spectrum, over the seasons, in the polsters. Further research in this aspect is suggested.

While this study is not totally conclusive, it seems, in this area, that vegetative polsters can provide accurate representations of the contemporary pollen regime.

CHAPTER III

CONTEMPORARY POLLEN DISTRIBUTION

POLLEN MAPPING

Mapping of pollen deposition is not a recent practice. New techniques of presenting data are enhancing the use and accuracy of such maps. Early charts were pie diagrams or bar diagrams. Pie diagrams depict the variation of several taxa at sampling sites (Mott 1969). Similarly, histograms show co-variations of pollen types at points along transects or within regions (Lichti-Federovich & Richie 1968; McAndrews & Wright 1969).

Isopoll mapping of pollen frequencies was suggested as early as 1935 but has only been applied to contemporary pollen studies with the past decade (Davis & Webb 1975; McAndrews & Power 1973, Webb 1973; etc.). In contrast to the other methods, isopoll maps depict the regional distribution of a single taxon. Shortcomings occur due to areas of sparse data and anomalous data sets. While localized differences are important for the immediate area of the sample, they tend to obscure the regional pattern. To counteract this, trend surface analysis can be performed upon the data with a region. Trend surface analysis of a spatially distributed data set

> fits a polynomial function of the geographic coordinate (x for latitude and y for longitude) to the percentages of the pollen type and thus approximates the geographic trend of that pollen distribution... The derived equation has predictive value and can be used to estimate pollen percentages at a station, given its latitude and longitude (Webb & McAndrews 1976:274).

A previous study, using trend surface analysis of 269 surface pollen samples from Western Canada and adjacent states (McAndrews, Kroker & Slater n.d.) is utilized to examine the representations of five major pollen types in the prairie region. The original study investigated a larger number of taxa but many of those pollen types are a minor component of the pollen rain.

Spruce is a boreal genus and its range (the hatchured area) follows the 10% contour line (Figure 8). However, the genus is present in the Rocky Mountains (Zoltai, 1975) and *Picea* pollen is carried across the prairies by westerly winds. The polsters used in the Alhap study were not included in the trend surface analysis project and correlate well. The mean value of 8.3 $\pm$ 2.9% (Table 3) is close to the predicted value of slightly over 10%.

Pine occurs in both montane and boreal forests. (Zoltai, 1975) The map of *Pinus* pollen frequency indicates that presence is a function of the range and the prevailing winds. Winds can transport the buoyant, vesiculate grains hundreds of kilometers beyond the range (Ritchi & Lichti-Federovich 1967; Faegri & Iversen 1975). In Figure 8, the effect of westerly and north-westerly winds is evident. The analysis would predict 52% *Pinus* at the sampler stations. The observed value from polsters was 49%.

Grass is the dominate plant of the prairie. However, Gramineae does not appear to be readily transported and thus can be masked by over-representation of extra-regional pollen. Alternatively, local sites in agricultural areas will have more grass pollen than those in a natural grassland due to the dense ground cover of cultivated cereal grains. This appears to have been the case in the Alhap study where most polsters were collected adjacent to cereal crops. Polster frequency was 27% whereas the map predicted 13%

Artemisia is a major component in drier grasslands. It increases with drought and over-grazing. Coupland (1950) estimated that sage provides 7% of the ground cover in the Mixed Grass Prairie. The boundary of this vegetational zone approximates the 10% frequency line in west central Alberta. It would appear that for this portion of the province the genus is neither under- nor over-represented. The Alhap polsters contained 1.8% *Artemisia* pollen which compares well with the map prediction of 2.5%.

Chenopods and amaranths are native to western grasslands. Although they occupy many diverse habitats, agriculture has increased the number of species in the region as well as their range and density. In fact, the frequency of Cheno/Am pollen tends to correspond to the intensity of cereal agriculture. The predicted value from the trend surface analysis map is about 3%. The observed frequency was 1.8%.

Individual variations occur for microclimatic or topographic reasons. Poor correlations can be a result of disturbed land or biased surveying within an ecotone. The trend program interpolates where inadequate sampling has take place. Given these limitations, a test of the maps can be obtained from polsters at Little Fish Lake. The maps predict the following frequencies: *Picea* 6%,

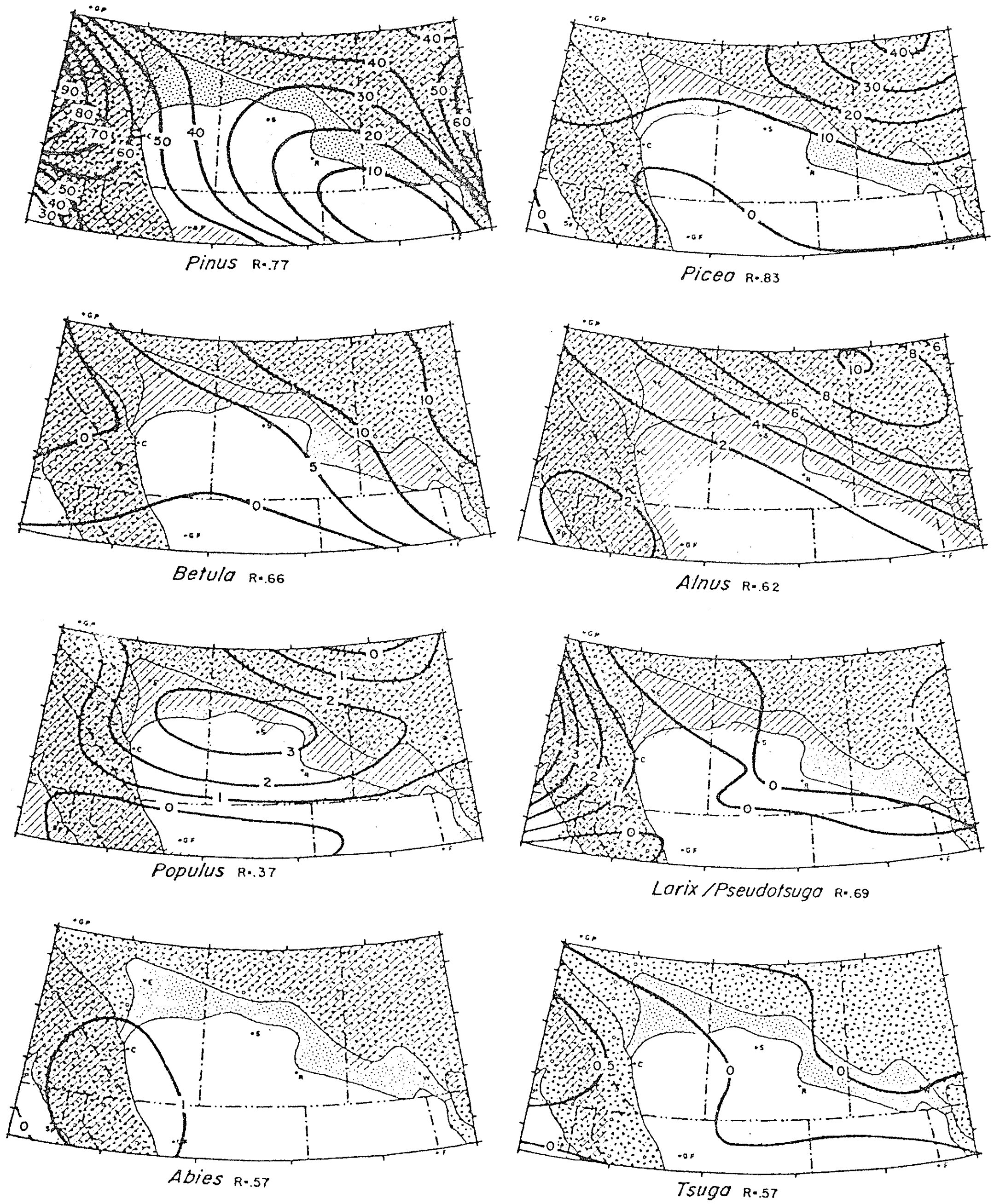


Figure 8: Vegetation Zones and Isopolls of Selected Taxa in Western Canada (from McAndrews, Kroker & Slater n.d.)

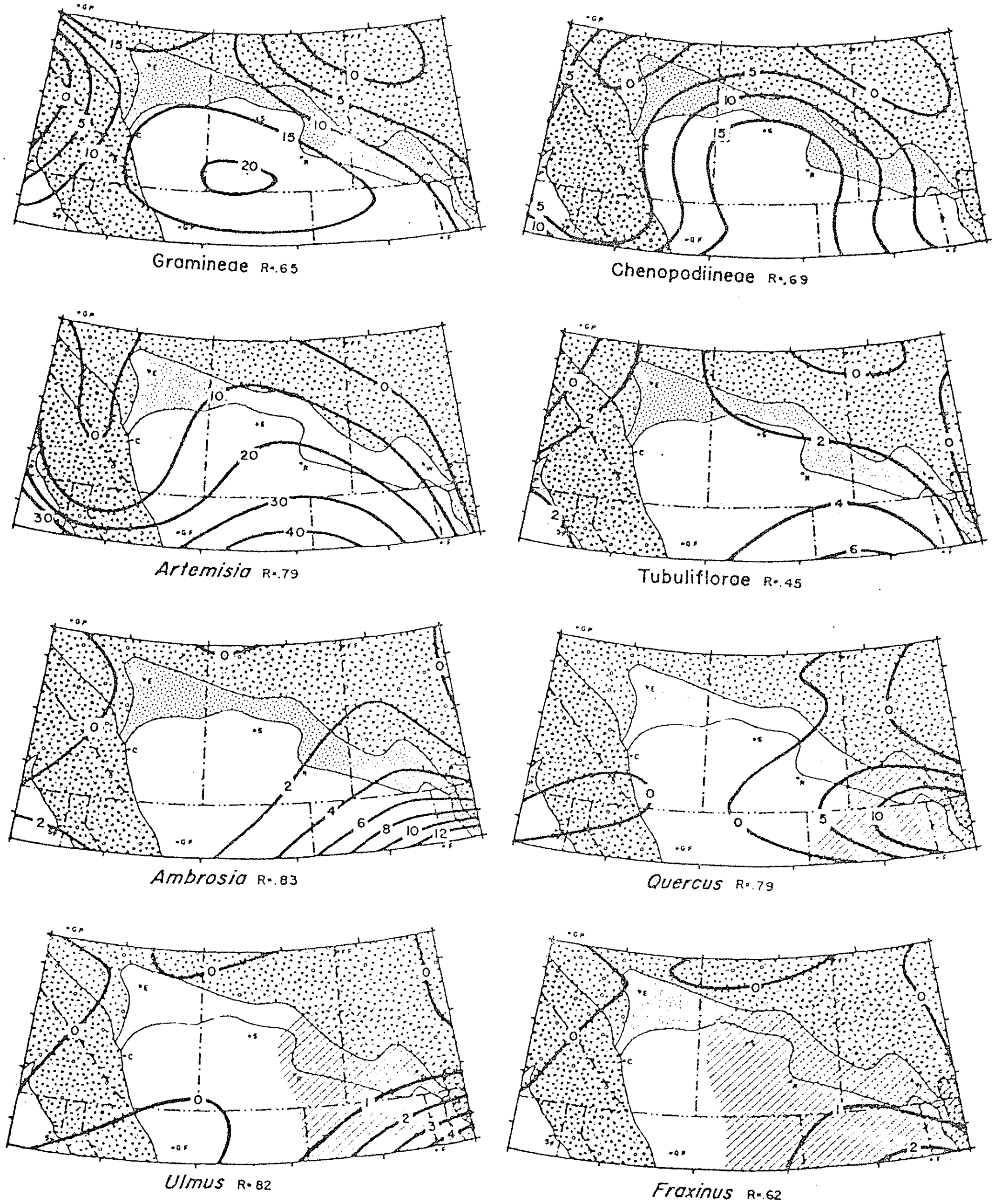


Figure 8: Vegetation Zones and Isopolls of Selected Taxa in Western Canada (from McAndrews, Kroker & Slater n.d.)

Pinus 48%, Gramineae 16%, *Artemisia* 6% and Cheno/Am 6%. The observed frequencies are *Picea* 4.3%, *Pinus* 42.2%, Gramineae 14.1%, *Artemisia* 10.3% and Cheno/Am 7.7%. Surficial limnic sediment values are *Picea* 8.8%, *Pinus* 37.6%, Gramineae 12.4%, *Artemisia* 12.1% and Cheno/Am 9.3%. The fit is quite close when one considers that Little Fish Lake lies on an upland. This explains the lessened montane pollen and the increased Artemisia. Trend surface analysis assumes uniform terrain. Uplift, rather than deflection around the upland, is required to attain the predicted conifer pollen rain.

TOPOGRAPHICAL EFFECTS

A topographical feature can cause localized anomalies within the regional pattern of pollen deposition. Two aspects must be taken into consideration during palynological analysis of the core from Little Fish Lake. The first is the 'valley funnel effect' (McAndrews, Kroker & Slater 1977) and the second is air mass resistance to topographic uplift. Both are facets of the fluid behavior of air and can be likened to the behavior of a river. Constriction of a river channel results in a faster flow with an increased load capacity. Similarly, an air mass funnelling through a pass in the Rocky Mountains and moving 'downstream' will flow faster through a river valley than on the plateaus above the valley (Powe 1968). As a greater volume of air flows through the valley, more pollen will be transported and more may be diagonally impacted into the surface. Also, as air spills over the top of the valley it will lose speed and suspended pollen may precipitate out. In the second case, due to resistance, air has a tendency to flow around an obstruction (Wilson 1968). This would tend to create 'pollen islands' at the tops of buttes and uplands where less extra-regional pollen has been deposited and in lee situations which will reflect the local pollen regime much more accurately than the facing slopes.

The 'valley funnel effect' can cause noticeable changes in the distribution of montane pollen within the prairie region east of the Rocky Mountains. Katabatic downslope winds in southern Alberta are known as chinooks during the winter and early spring. Similar effects occur throughout the year and can be observed in pollen distribution studies.

Moss polsters were collected along a 40 km transect perpendicular to the Bow River, east of Calgary, Alberta. The nearest conifers were in the foothills of the Rocky Mountains 100 km to the west. The frequency of montane pollen (Picea, Pinus, Betula, and Alnus) was calculated for the sampling sites and isopolls were plotted (Figure 9). The 50% line of montane pollen has two lobes; the southern, along the Bow Valley and the northern, due to prior funnelling along the Sheep River valley. The northern 40% lobe is probably due to prior funnelling through the Bow and Elbow River valleys. However, a tall butte, which extends from site 6 to site 8 with site 7 near the summit, is also important. The westerly flowing air is deflected north and south. This results in a lee situation on the northeastern and southeastern slopes where the samples were collected. The lee situation is reflected by montane pollen frequencies of 31% at sites 6 and 8 while slight uplift is indicated by the 38% value observed at site 7 (Figure 10).

Uplift is dependent upon the slope and extent of the topographic

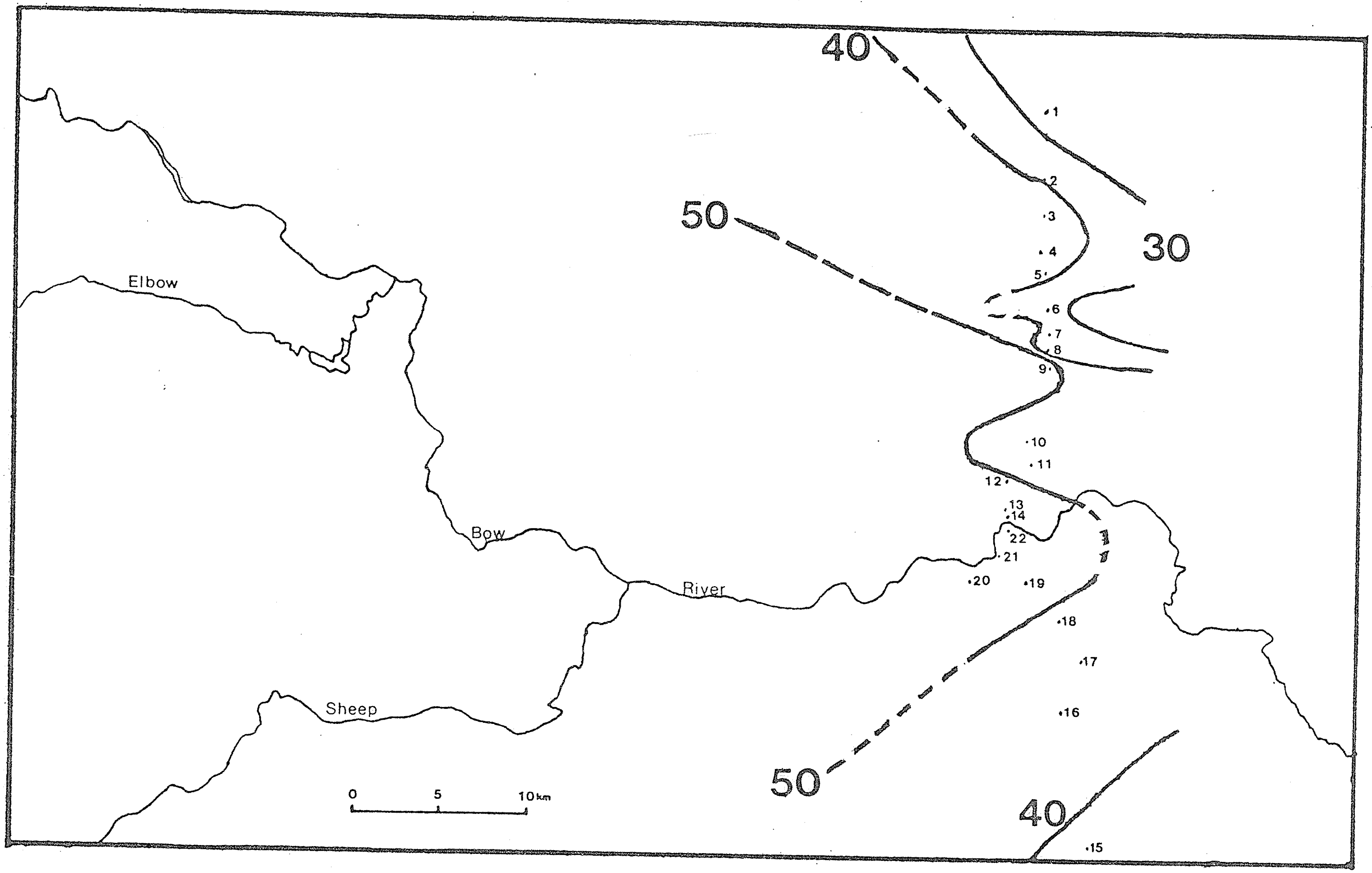


Figure 9: Montane Pollen Isopolls at Transect A

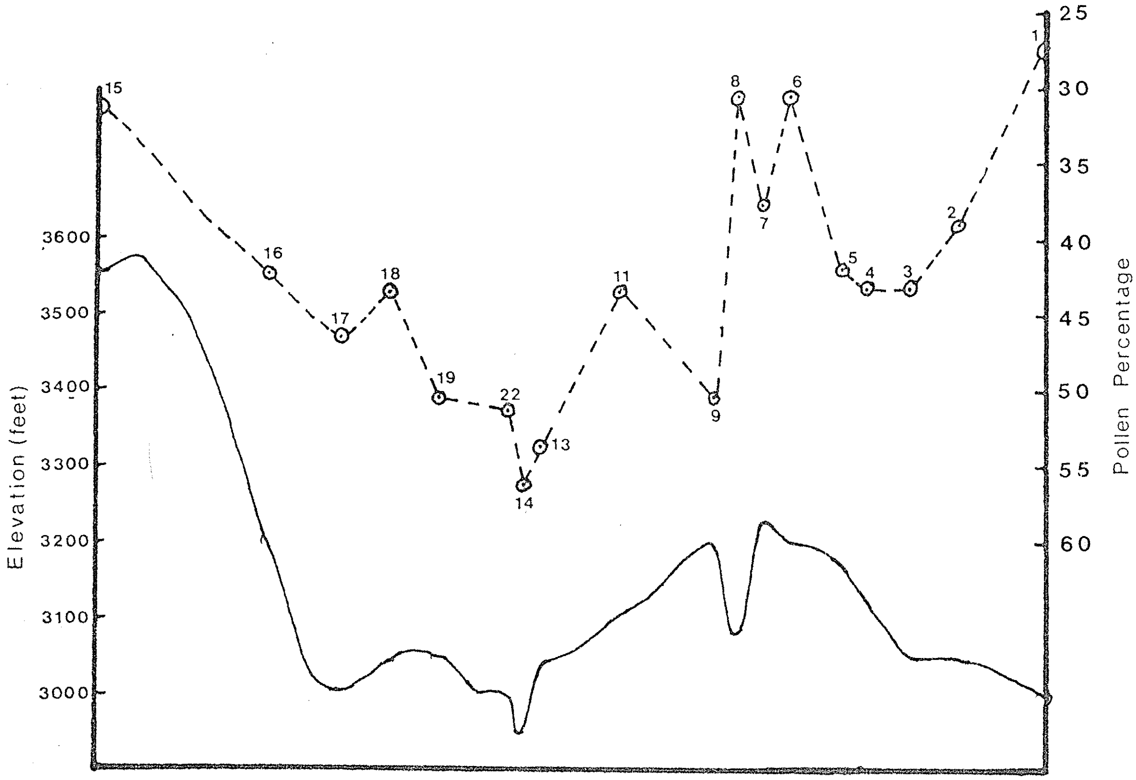


Figure 10: Elevation and Montane Pollen Frequency at Transect A

feature and the velocity of the airmass. A steep butte will generally cause deflection while a long sloping ridge will cause uplift. Funnelling is dependent upon the depth and width of the valley, its general direction, which cannot be at more than a 45^{o} angle to the motion of the airmass, and its proximity to a major pass in a mountain chain. As will be seen later, both of these fluid behavior traits (funnelling and uplift) must be taken into consideration as the extra-local pollen rain at Little Fish Lake is due to an interaction of both effects within the generalized summer wind patterns of the prairies (Figure 11). Westerly winds predominate during the pollination period, accounting for the preponderence of montane pollen found in prairie pollen spectra.

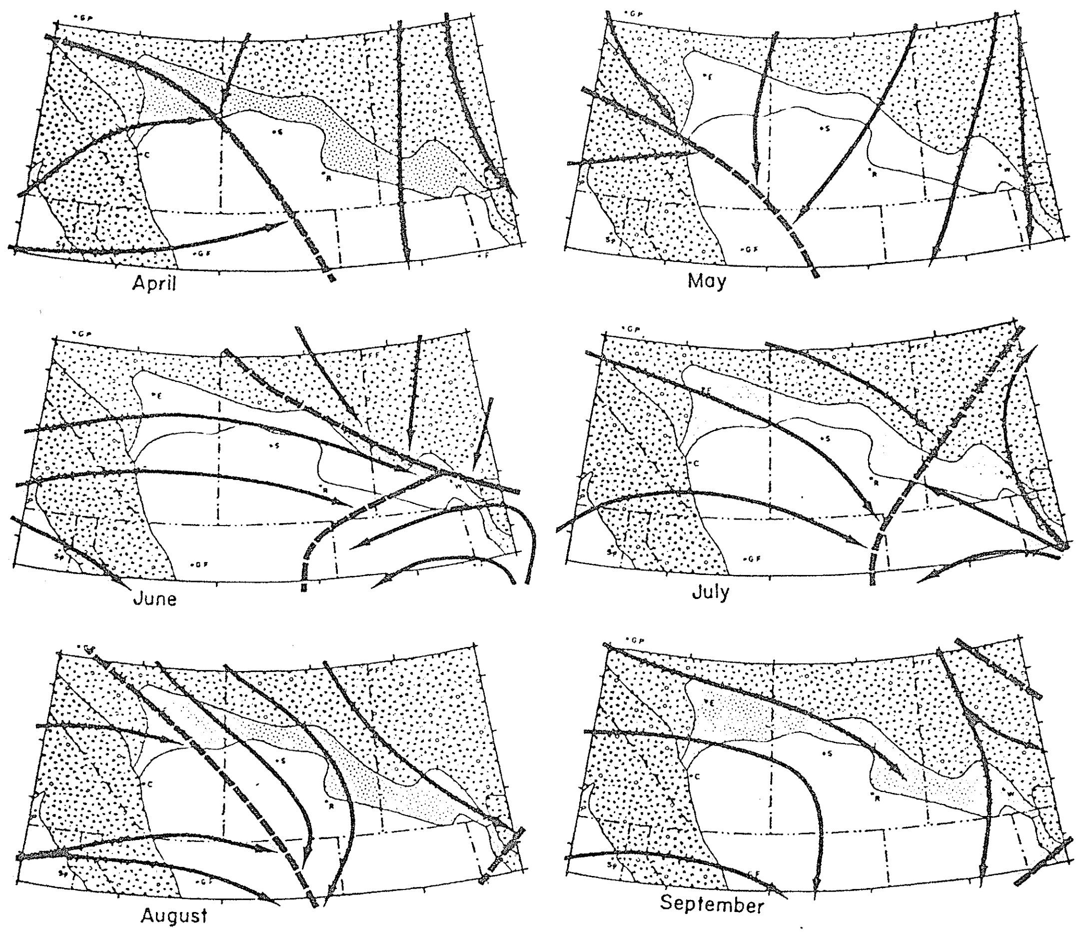


Figure 11: Predominate Summer Winds in Western Canada
(from McAndrews, Kroker & Slater n.d.)

CHAPTER IV

THE HAND HILLS REGION

LITTLE FISH LAKE

The lake lies in the Hand Hills Upland (Stalker 1973:6) in south central Alberta, about 125 km east-northeast of Calgary (Figure 2) at 51° 22'N and 112° 15'W. It has a tear-drop shape with a NW/SE orientation (Figure 12). Little Fish Lake is 5.5 km long and 2.5 km wide and lies in a slight basin at an elevation of 980 m above sea level. Strong (1975:32) lists the depth as 7.2 m, but a hydrographic survey by the Alberta Department of Fish and Wildlife, Calgary Division reported a depth of 5 m (Thomson 1977:personal communication). During coring operations in the summer of 1977, depth soundings recorded a maximum depth of 4.5 m. Whether this variation is a result of seasonal fluctuation or a steady decrease in lake levels is difficult to determine. However, the overflow channel at the northwest end does not appear to have experienced any appreciable down-cutting.

The lake is fed by Fish Creek which drains a basin 25 km long and 7 to 10 km wide. With spring meltwater, it becomes a moderate freshet which dries up during the summer except during intense local thunderstorms. The creek carries little clastic material and has not built any form of delta at the mouth on the northeast side of the lake.

GEOLOGY

The Hand Hills Upland, rising 200 m above the surrounding plains, is an isolated erosional remnant of pre-Wisconsin age (Stalker 1973:6-7). Protected by Pliocene gravels, it suffered minimal glacial erosion. Stalker (1973:17) records an average thickness of 15 m for these preglacial gravels which accounts for the shallow relief within the area.

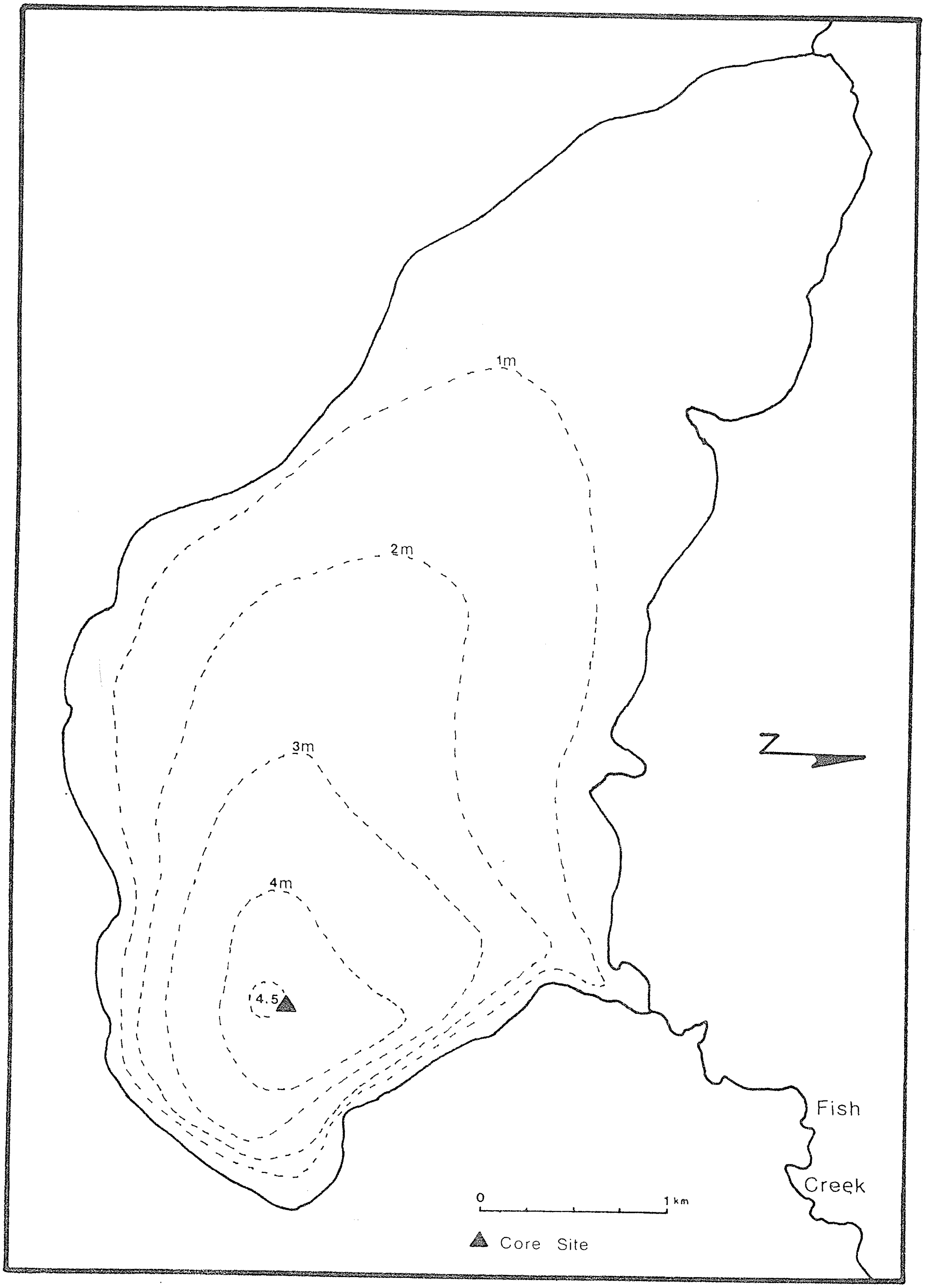


Figure 12: Little Fish Lake

However, the scab-lands to the northeast and southeast of the lake can be classified as hummocky terrain (Figure 13).

The glacial history of the Hand Hills Upland has been a source of contention. Tyrrell (1887:145, 1890:397) felt that some portions were never glaciated. Allen & Sanderson (1945, cited in Stalker 1973) suggested that parts of the Upland received no Wisconsin deposits but did not state whether the area had been glaciated. Stalker (1973:68-69) notes that glacial drift occurs near the tops of the Hand Hills and proposes a cover of 300 m of relatively inactive ice during the glacial maximum, producing depositional rather than erosional features. The Upland appears as a nunatuk after the retreat of the Innisfail Readvance and Little Fish Lake appears at the Tudor Outlet Stage of Glacial Lake Beiseker, about 400 or 500 years after the beginning of deglaciation (Stalker 1973). The lake is suspected by Craig

> to have been part of an integrated (pre-glacial) drainage system flowing to the southeast. Little evidence could be found to substantiate this except the radical change of the course of the stream draining the Hand Hills (cited in Stalker 1973:67).

CLIMATE

The climate of the Hand Hills is cool and semi-arid. The peak precipitation occurs in the summer and averages about 33 cm at Drumheller, 37 km west (Figure 14). Increased elevation of the Upland causes deflection of thunderstorm tracks and lessens the annual rainfall (Alberta Hail Project 1975). The local pattern is more similar to that observed at Medicine Hat in the Short Grass Prairie (Figure 14). The temperature regime is continental with hot summers and cold winters. The annual range is about 35° Celsius with summer temperatures reaching 20° C

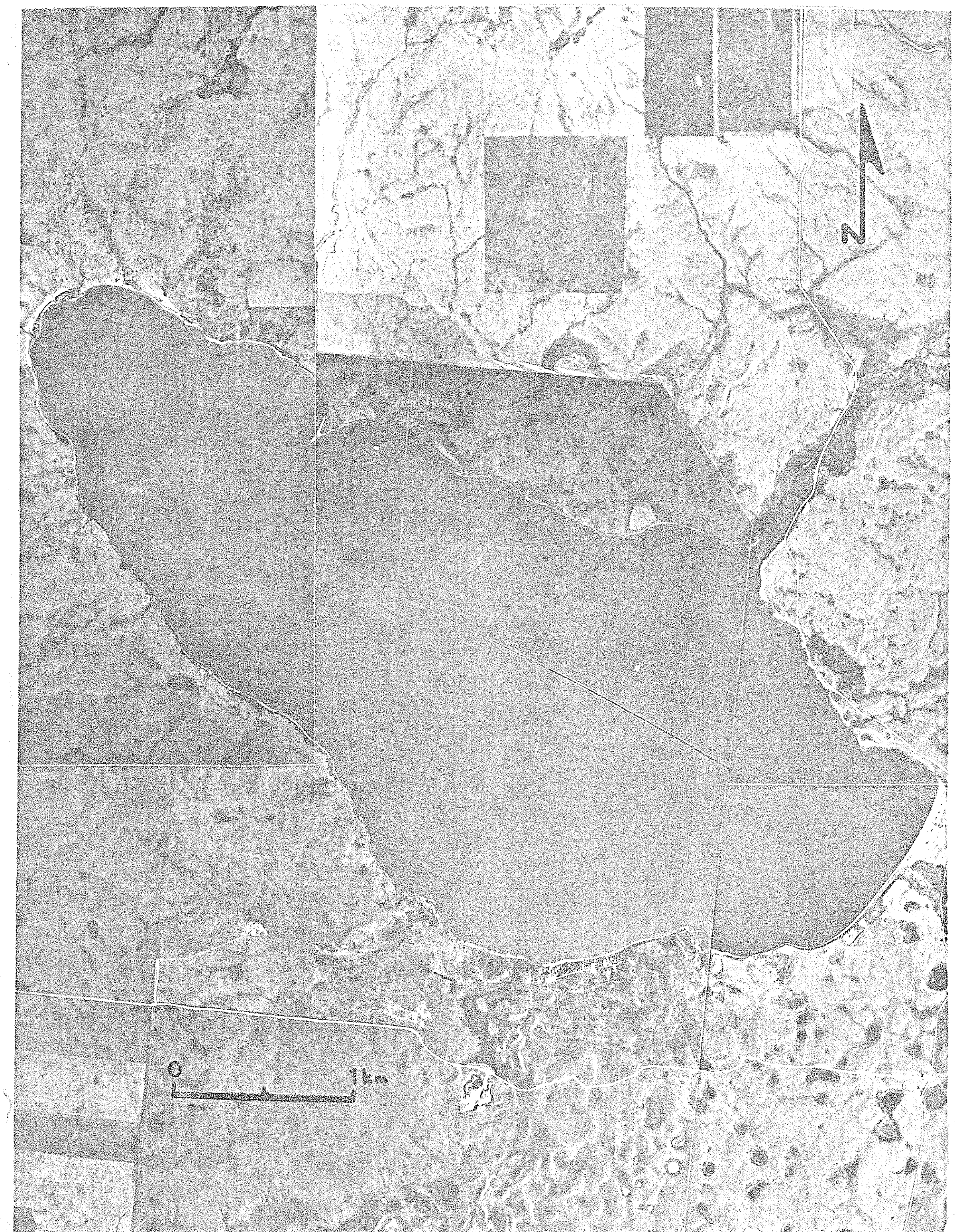


Figure 13: Composite Aerial Photograph of Little Fish Lake

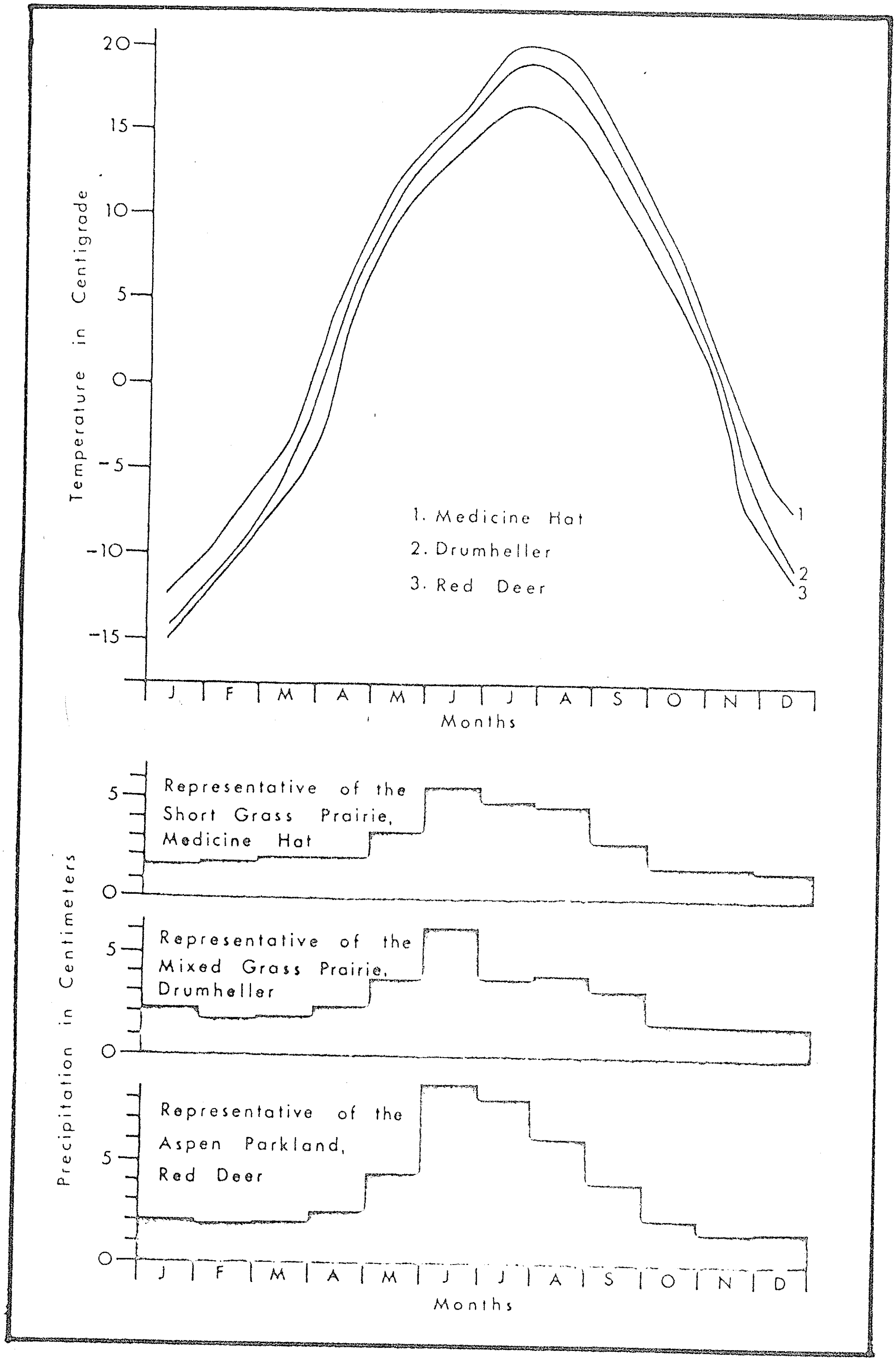


Figure 14: Mean Temperature and Precipitation (from Strong 1975)

(Figure 14). Winds in the region tend to be westerly and northwesterly due to the movement of Pacific Maritime Polar air over the Rocky Mountains (Figure 11).

VEGETATION

The vegetation of the Hand Hills is typical of the Mixed Grass Prairie (Moss 1955). Trees are uncommon. Draws along Fish Creek, the margin of the lake and some sloughs to the east support some willows and poplars. The main shrubs are wolf willow (Elaeagnus commutata) and buckbrush (Symphoricarpos occidentalis). Half-shrubs are Potentilla fruticosa, Artemisia cana and Rosa spp. Grass accounts for most of the vegetation with Carex eleocharis and Artemisia frigida comprising the majority of the remainder. Notable herbs are Phlox hoodii, Sphaeralcea coccinea, Anemone patens and several Compositae, including Gutierrezia diversifolia, Haplopappus spinulosus and Solidago spp. Selaginella densa is ubiquitous as an understory.

The dominant grasses are Stipa comata, S. spartea, Bouteloua Muhlenbegia cuspidata and Calamagrostis montanensis. Topography, soil types and available moisture result in several communities in which two or more of these species dominate the vegetation. Stipa spp. favor moister situations on medium soils. Bouteloua gracilis is abundant in drier areas. It is dominant in most communities (Bouteloua-Agropyron and Bouteloua-Stipa faciations), co-dominant in the Stipa-Bouteloua community and sub-dominant in the Stipa-Agropyron and Muhlenbergia-Agropyron communities. It is the most drought resistant species and increases under dry conditions. Agropyron spp. are sod-forming perennials reproducing by rhizomes. Muhlenbergia cuspidata occurs with Argopyron spp. in eroded area while Koeleria cristata is co-dominant with Agropyron spp. on clayey soils.

Some agricultural activity occurs in the Hand Hills (Figure 13) but the majority of the region is slightly disturbed grazing land. The gently rolling aspect of the region creates several micro-habitats with shrubs and tall grasses in the coulees and short grasses and herbs on the knolls.

CHAPTER V

PALYNOLOGY OF LITTLE FISH LAKE

METHODS

Field Techniques

A 141 cm core of limnic sediment was obtained from Little Fish Lake in September, 1977 with a hand-operated Livingstone pollen corer. Sampling was done from a boat at the deepest portion of the lake (Figure 12). The mud/water interface was determined by slowly lowering a metal disc until loss of tension indicated the sediment surface. A 4.5 cm diameter polyethylene tube, was plugged with a moveable piston and pushed into the sediments to obtain the upper 25 cm (Rowley & Dahl 1956). The remainder of the column was obtained with the 6 cm diameter Livingstone. A duplicate core was taken of the basal sediments.

The cores were wrapped in Saranwrap to prevent moisture loss. The upper sediments were sampled in the field by extruding the core through the polyethylene tube and extracting 10 ml of sediment at 2 cm intervals. These were placed in sterile vials for transport to the laboratory.

Sediment Processing

The core was sampled at 2 cm intervals and 0.9 ml samples were taken. These samples were placed in sterile porcelain containers, weighed and oven-dried at a temperature of 100° C for 12 hours . The dried samples were fired at 500° C for a period of four hours to burn off all organic material. The weight loss on ignition was calculated and divided by the dry sample weight to obtain an index to the organic fraction. After the 'organic burn', the samples were fired for four hours at 850° C to remove the carbon dioxide fraction (Dean 1974) for an indication of carbonates.

Pollen Processing

Samples of 0.9 ml were taken at the same 2 cm intervals as above. They were wet-screened through a 250 micron mesh to remove large sand particles and macrofossils. Standard chemical treatment followed (Faegri & Iversen 1975). The material was placed in a beaker with 10% HCl to eliminate carbonate compounds. Lycopodium tablets (11,850 ± 200 spores/tablet) were added to determine fossil concentration (Stockmarr 1972). The samples were treated with NaOH to dissolve organic material and HF to dissolve the silicate fraction. Acetolysis treatment to remove cellulose followed. The sample was then dehydrated with tertiary butyl alcohol, stained with Safranine O and suspended in silicon oil

The slides were counted with a Wild Leitz Dialux microscope with a 10X ocular lens. Identifications were made with a 25X objective lens, although 40X and 90X were used to identify difficult grains. Transects were made across the entire slide to counteract inaccuracies caused by the tendency of smaller grains to migrate to the edges (Brooke & Thomas 1972). A total of 300 grains, excluding Cyperaceae, Typha, Equisetum, aquatics and mosses, were counted. For the diagram of selected local taxa, all arboreal pollen except Populus and Salix (the two local genera) and all montane herbaceous pollen was excluded from the pollen sum. The sum, at least 150 grains, included all other taxa including Cyperaceae and Selaginella.

Diagrams based on the two counts were obtained by using a plotting program of Dr. John H. McAndrews of the Royal Ontario Museum on the University of Toronto computer. A third diagram was obtained by calculating the pollen concentration (grains/ml) at each level.

Radiocarbon Dating

To date the base of the core, a sample consisting of the entire bottom 18 cm was sent to S. Valastro at the Balcones Research Laboratory, University of Texas. The relatively large sample (approximately 400 gm) was required because of the low organic content.

RESULTS

Sediment Analysis

The water content of the core, obtained by calculating weight loss upon oven-drying of the samples, shows considerable fluctuation (Figure 15). The upper 59 cm show a decrease of moisture with depth due to oxidation of organic material and compaction. By 65 cm, the value has risen from 42% to 84% and then decreases to 34% at a depth of 93 cm. The moisture content more than doubles to 76% in the next 10 cm. The remainder of the column, from 103 cm to 141 cm, has rapid oscillations between 52% and 76%.

The organic curve shows similar variations (Figure 16). There is a steep decrease until 59 cm. Values rise sharply from 2.4% to 13% at 65 cm. Values decrease to 2% at 93 cm followed by a rise to 9.2% at 103 cm. Below this depth, rapid oscillations occur between 4% and 9%. The value of 14.8% at 117 cm is the result of a concentration of macrofossils.

The carbonate curve (Figure 17) shows three distinct maxima. The first occurs between 9 and 13 cm. After a decrease from 6% to 1.5% at 25 cm, the values remain relatively constant until 59 cm when they rise to 5.5% between 65 and 73 cm. The third maximum occurs at 105 cm where the value is 8% after which it decreases to 2%. The lower two peaks coincide with those observed for both water content and organic content.

Macrofossil Analysis

As suggested by the organic content, the core had very few botanical macrofossils. Some unidentifiable, linear fibrous strands were noted throughout the column. At 117 cm, several seeds of *Carex* were identified. While macrobotanical analyses can be used to confirm the presence of taxa in the immediate vicinity of a lake and its adjacent watershed, the study provided a minimal return in this project.

Chronology

Large quantities of microscopic charcoal are observed in the sediment column at 13 cm. These can be correlated with the 'Great Prairie Fire' of 1909 which burned more than 38,000 km^2 adjacent to Little Fish Lake (Christianson et al. 1967). The increase of Chenopodiineae pollen begins at 15 cm and indicates the beginning of Euro-Canadian agriculture (ca AD 1900). These data suggest an average sedimentation rate of about 1 cm/5 years for the upper 15 cm of the core. Compaction of sediments will tend to produce curvilinear rate and, thus, the above value must be seen as a mean.

The radiocarbon sample (Tx 2918) yielded a date of 3240 ± 150 BP using a C14 half-life of 5568 years. Correcting for a half-life of 5730 years, the date is 3337 ± 155 BP (before AD 1950), which permits the calculation of an average sedimentation rate of 1 cm/28 years for the lower section of the core. Overburden will tend to produce curvilinear sedimentation rates (i.e., more years per centimeter at the base than the top) (Maher 1972; Mehringer, Arno & Peterson 1977). However, using the above value as a minimum and extrapolating to the base, it would appear that deposition began in Little Fish Lake about 3600 BP, shortly after the end of the Hypsithermal (Heusser 1956:297).

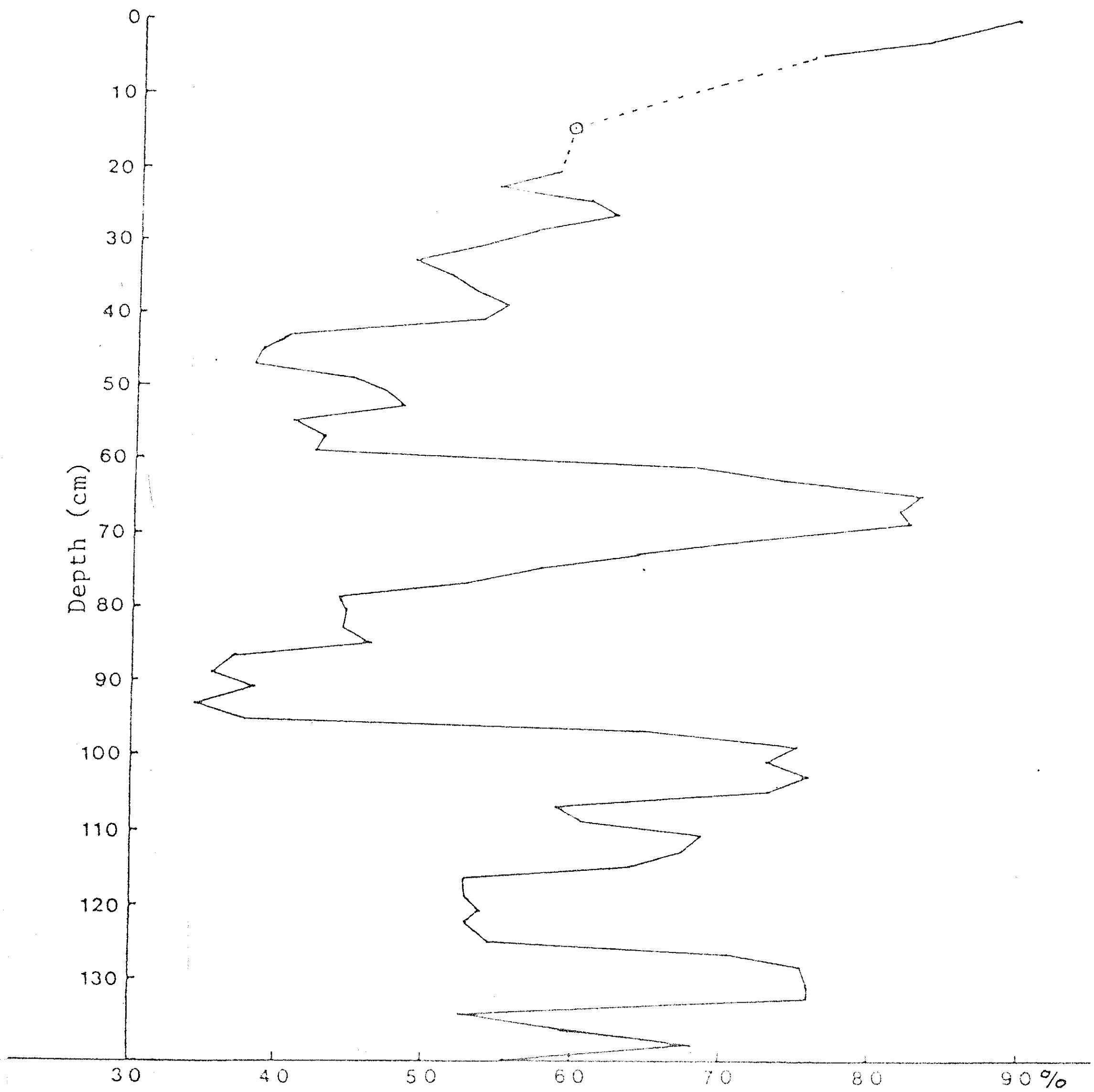


Figure 15: Moisture Content of the Little Fish Lake Core
(dashed lines represent interpolation)

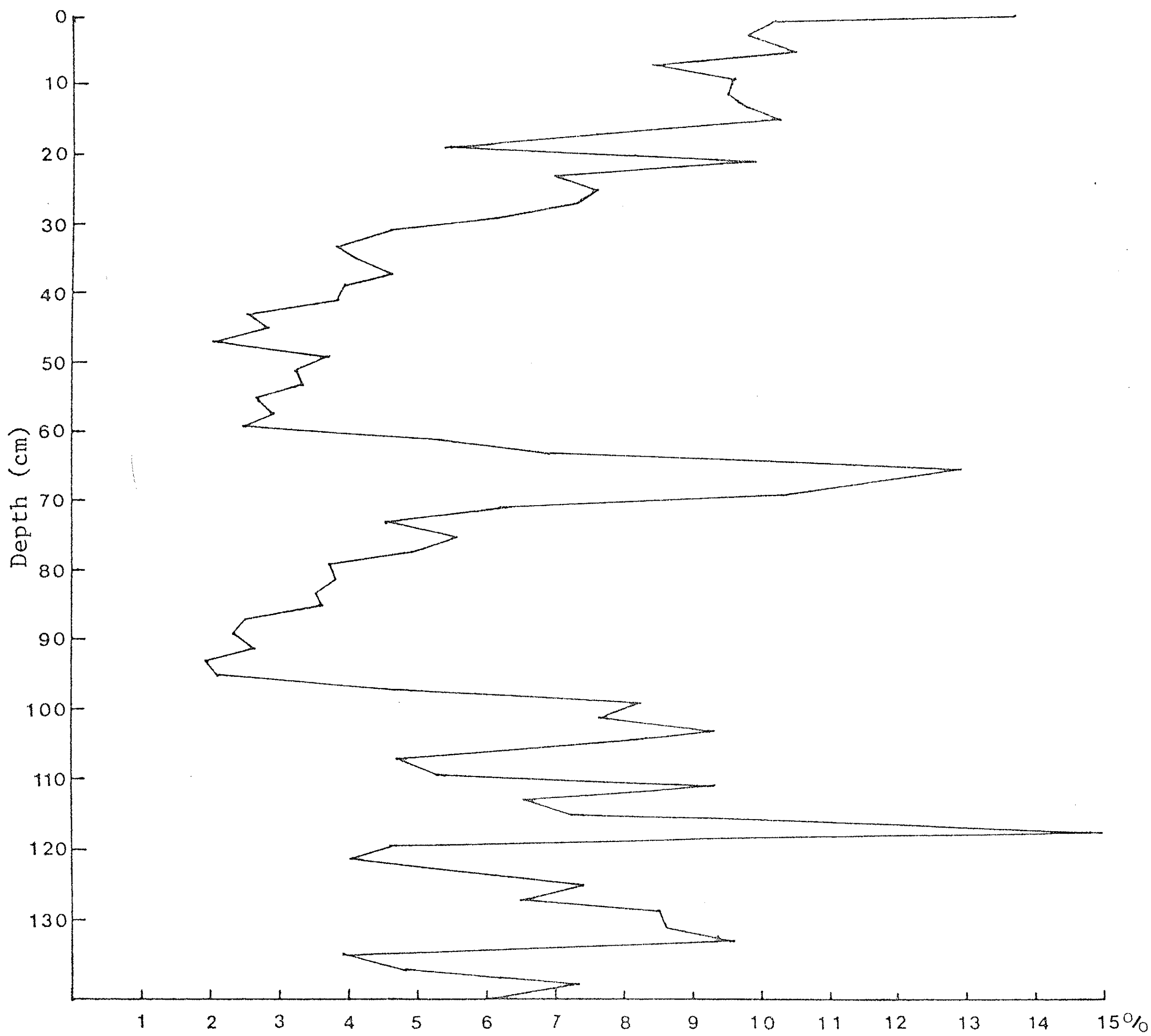


Figure 16: Organic Content of the Little Fish Lake Core

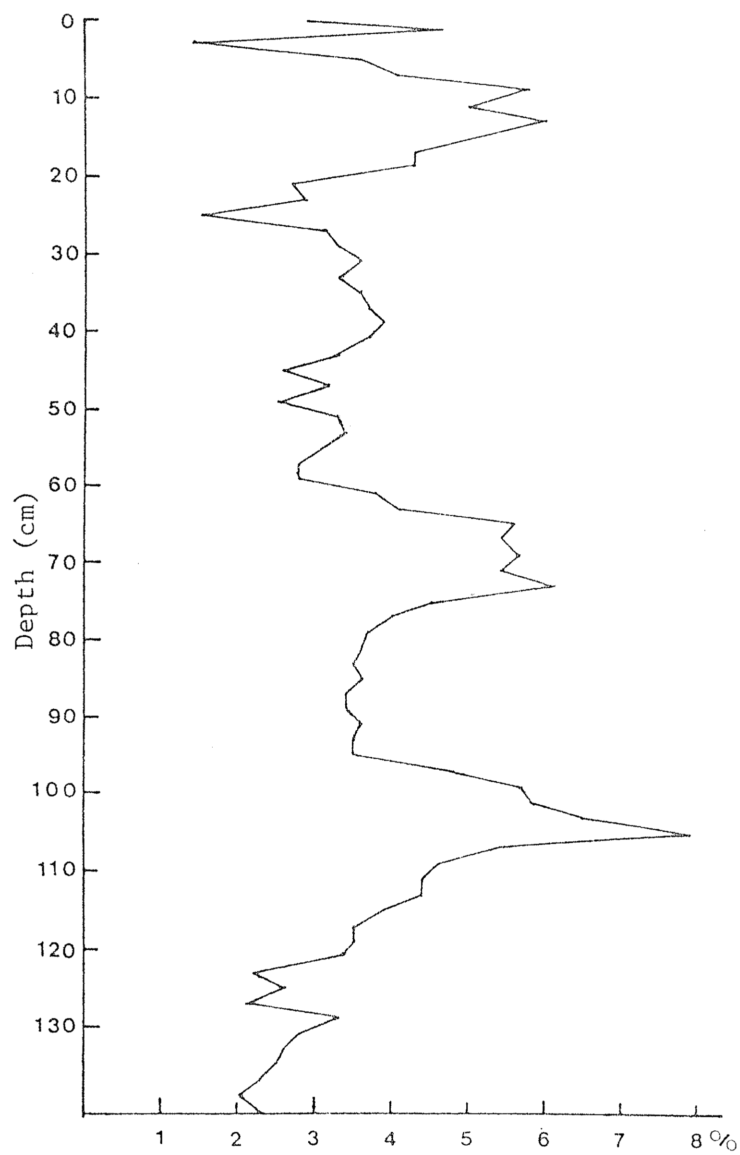


Figure 17: Carbonate Index of the Little Fish Lake Core (Weight Loss on Ignition at 850^{o} C)

POLLEN STRATIGRAPHY

Pollen Diagram

The diagram is relatively complacent (Figure 18). Zonation is based upon fluctuations of *Pinus*, Gramineae, *Artemisia* and Chenopodiineae.

Zone A, from 0 to 15 cm, is characterized by fluctuating *Pinus* (between 37% and 56%) and *Artemisia* (between 7% and 22%). Gramineae is relatively stable at about 10% except for a sharp drop to 5% at 13 cm. Chenopodiineae pollen rises from 4% at the base of the level to 10% at the top. Cruciferae remains at 2% except for two peaks of 5% at 0 and 5 cm. The base of the level is drawn at the beginning of the Chenopodiineae rise.

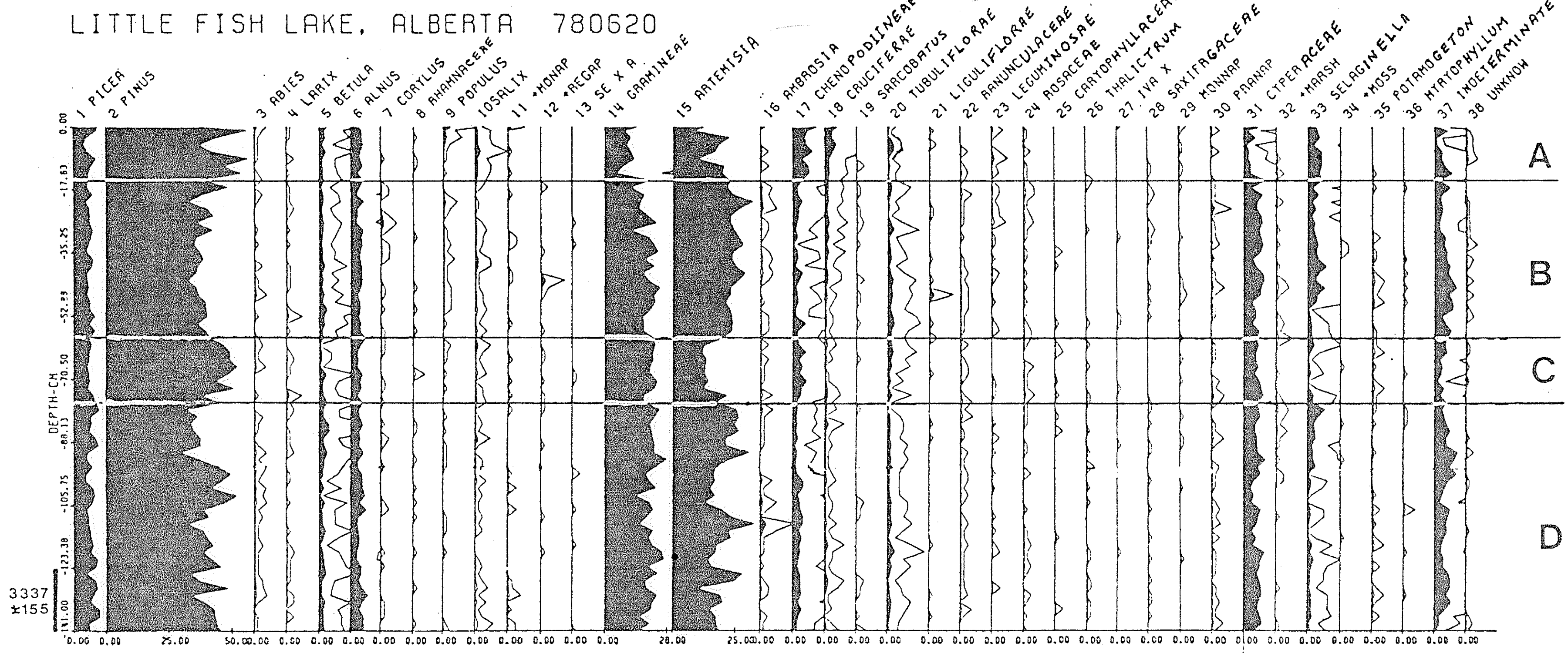
Zone B extends from 15 cm to 57 cm. The three main taxa remain stable throughout the zone. *Pinus* comprises about 40%, *Artemisia* about 25% and Gramineae about 15% of the pollen rain. All other taxa also remain stable except for *Selaginella* which decreases from a constant 4% to less than 1% in the basal 6 cm of the zone.

Zone C is distinguished by higher *Pinus* (47%), Gramineae (20%) and Chenopodiineae. *Artemisia* is lower (12%) and *Selaginella* is barely represented. The zone extends from 57 cm to 75 cm.

Zone D, from 75 cm to the base, has an oscillating pattern. *Pinus* and *Artemisia* co-vary while Gramineae, Chenopodiinae and *Selaginella* remain constant. *Pinus* values range from 35% to 51%. *Artemisia* ranges from 15% to 27%. Gramineae values oscillate slightly about 18% and *Selaginella* remains low at about 1%. The zone gives the appearance of several fluctuations resembling Zones B and C.

Local Pollen Diagram

Zone A is marked by abundant Chenopodiineae pollen, reaching 20% of the local pollen rain at the surficial level. Gramineae, *Artemisia* and



11 +MONAP - Other Montane Arboreal
12 +REGAP - Other Regional Arboreal
13 SE X A - Southeastern Exotic Arboreal
27 IVA X - *Iva xanthifolia*

29 MONNAP - Other Montane Non-arboreal
30 PRANAP - Other Prairie Non-arboreal
32 +MARSH - Other Semi-aquatics
34 +MOSS - Other Pteridophytes

Figure 18: Pollen Diagram of Little Fish Lake

Cyperaceae vary. Selaginella is high. The upper 3 cm are characterized by decreasing Artemisia and increasing Gramineae, Chenopodiineae, Cruciferae, Cyperaceae, Populus and Salix. Below this, Artemisia and Cruciferae rise sharply with corresponding decreases of Gramineae, Cyperaceae and Selaginella. The lower portion of the zone has decreasing Artemisia and Cyperaceae, with increasing Salix, Chenopodiineae, Cruciferae and Selaginella. Gramineae frequencies decrease sharply and increase equally abruptly.

Zone B is characterized by high, slightly increasing Artemisia (50%), and moderate, slightly decreasing Gramineae (35%). Chenopodiineae maintains stable low frequencies (5%). Selaginella exhibits a generally low frequency (7%), but has a high peak in the middle of the zone. Other taxa are stable.

Zone C is marked by high Gramineae (45%) and low Artemisia (35%). Chenopodiineae is stable at 10%. The upper portion is characterized by rapidly increasing Artemisia while the lower portion is marked by a decreasing frequency. Selaginella is low (2%).

Zone D is marked by rapidly co-varying frequencies of Gramineae and Artemisia. Selaginella has a peak in the upper part of the zone and remains constant at a low value to the base. Other taxa remain constant. The highest value of Gramineae (54%) occurs at 121 cm.

Fossil Pollen Concentration

Pinus shows the most variation in the concentration diagram (Figure 20). Five peaks are observed, the greatest at the base of the core and others at 131 cm, 103 cm, 65 cm, and 15 cm. These are echoed, albeit more weakly by Picea, Alnus, Gramineae, Chenopodiineae and Cyperaceae. Artemisia is relatively stable from the base of the core to 45 cm, at

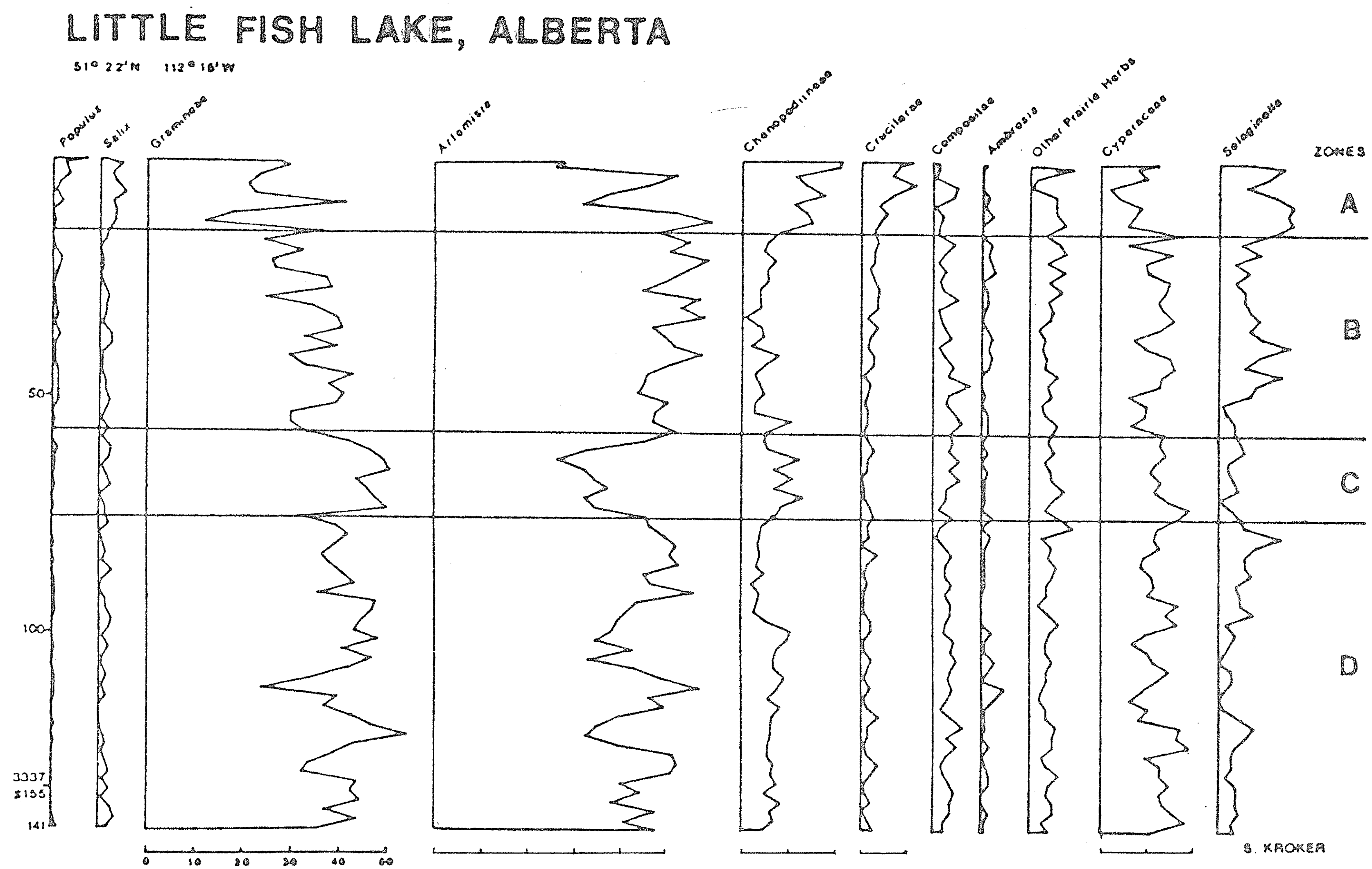


Figure 19: Diagram of Local Taxa at Little Fish Lake

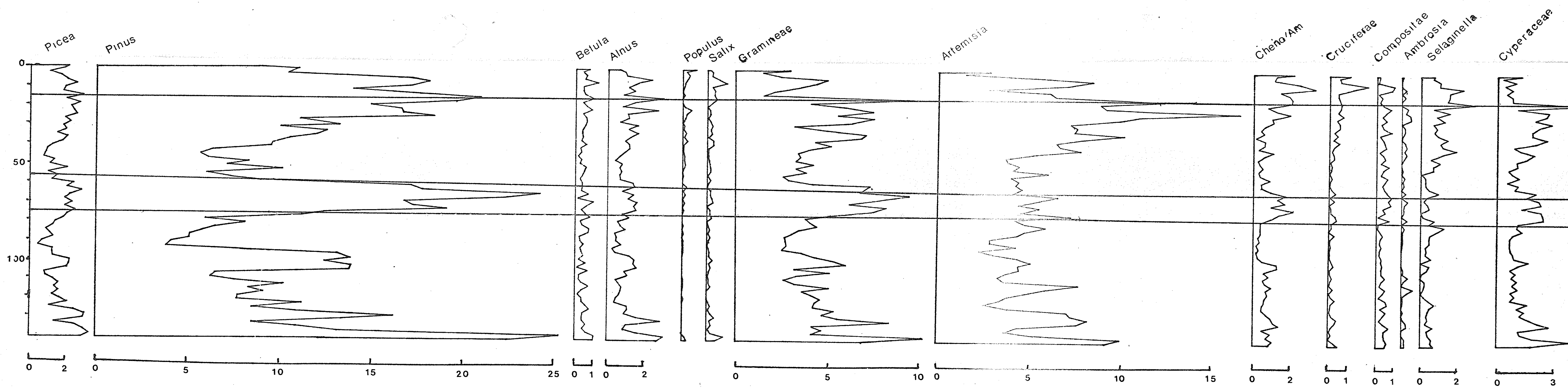


Figure 20: Fossil Pollen Concentration (grains/cm^3 x 10^3)

which point it increases to its maximum at 21 cm, Selaginella remains low until 45 cm after which it increases until 7 cm. Salix and Cruciferae attain maximum values at 5 cm.

INTERPRETATION

Sediment Data

The moisture, organic and carbonate contents (Figures 15, 16, 17; Appendix C) all show similar variations. Moisture content of a limnic sediment is a function of the amount and volume of organic material, particle size, adsorbed cations, interstitial electrolyte solution and degree of compaction (Rieke & Chilingarian 1974:7, 9). A high organic content will be reflected by a high percentage of moisture in the sediments. Maxima of organic content can be the result of increased organic deposition, decreased deposition of inorganic material or reduced decomposition of organic matter. Minima can be explained as a result of increased clastic deposition, greater oxidation of organic material or reduced deposition of organic matter. During the fall of 1977, Little Fish Lake was so densely populated with algae that visibility into the water was less than 30 cm. Even so, the organic content at the mud/water interface was only 13.5%. It would appear that prairie lakes receive little organic material and much of that appears to be rapidly oxidized (Strong 1975).

Carbonates in limnic sediments are derived from limestone and dolomite in the surrounding area or are biochemical in origin. When the source is geological, either limestone particles are carried into the lake as part of the stream load or free carbonate radicals are carried in solution and eventually concentrate in the lake. Biochemical sources add directly to the chemical regime of the lake. In either case, the chemistry of the mud/water interface would be altered as free carbonate radicals and calcium or other cations would occur (Reike & Chilingarian 1974:19). The presence of an interstitial electrolyte causes clay particles to form edge-to-surface contacts (at right angles) such that these particles occupy a larger volume, the interior of which is occupied by the electrolytic fluid (Reike & Chilingarian 1974:81, 110, 225-264). This type of formation is more resistant to compaction by overburden than a formation when a non-electrolytic fluid (i.e., water without free radicals and cations) is the suspending medium. Thus, a higher moisture content in sediments can be expected during periods of high carbonate percentages at the mud/water interface.

Accounting for carbonate maxima is difficult. Given confirmation of a geological source, increased water transport, either in particle form or as radicals would be an explanation. Biochemical sources are poorly understood and appear to fluctuate widely. If one assumes a geological source, the first maximum (9 to 13 cm) could be a result of increased moisture. This period, at the lower portion of Zone A, which encompasses two droughts and two moist periods between 1900 and 1975, falls near the earlier date. The 13 cm level had previously been correlated with the prairie fire of 1909 and would seem to appear to be prior to the drought of the 1930s. This period was characterized by adequate moisture for adequate crop yields (Christianson et al 1967). Given the same assumption, the subsequent decrease between 9 cm and 3 cm could be the result of lessened moisture during the following drought. Chronological controls are not sufficiently rigorous to state that the above was the case. Furthermore, the source of the carbonate is not determined. The above discussion seems to point to some association between the carbonate index and the moisture regime, although the linkage is tenuous.

Organic content can be examined in terms of increased moisture resulting in more organic debris being transported into a lake by increased run-off. However, increased run-off often increases erosion and, subsequently, higher clastic transport into the lake, unless the vegetative cover of the ground is sufficiently binding to prevent soil wash.

All three curves appear to co-vary (Figures 15, 16, 17, Appendix C). Replication of the curves by analysis of the second basal core (Appendix B) indicates that the original results are not the result of sampling error. The coincidence of maxima and minima on all three curves suggests a common cause, whether this be increased or decreased moisture, increased temperature and evaporation or increased aquatic flora in the lake. Increased lake plant life would increase the organic content and moisture content but the result on the carbonate index values is indeterminable at present. However, following from the previous discussion, if one assumes that increased moisture, organic and carbonate values are indicative of increased moisture, then the data indicate two periods of increase. The first occurs at about 100 cm and the second at 65 cm. Conversely, the minima would be associated with drier periods. Size particle analysis would have perhaps assisted in the interpretation of the sediment data as increased run-off could have transported larger particles. The data, as seen now, tenuously suggests a linkage between moisture regime and character of lake sediments.

Pollen Diagram

Zone A is drawn at the beginning of the Chenopodiineae rise and is a reflection of recent agriculture. Temporally, it is placed at AD 1900. Euro-Canadian settlement in the area began in the late 1880's and early 1890's as ranchers moved into the area. The continuing rise of mustard and chenopod is seen as a reflection of the intensification of cultivation. *Pinus* frequencies reach 50% and may be a reflection of increased transport from the Rocky Mountains. The concentration (Figure 20) is quite high. *Artemisia* increases in the middle of the zone and may be a reflection of decreased transport of pine pollen rather than an increase of sage. The major prairie fire of 1909 is demonstrated by the sudden Gramineae drop near the base of the zone.

Zone B is dominated by *Pinus* and *Artemisia*. Gramineae and the montane taxa have minimal variation. The lack of fluctuation of the transported conifer pollen may indicate a stable climatic situation with less influence of the westerly winds than at present and, probably, a lower summer precipitation regime. The presence of *Ambrosia* and *Sarcobatus*, although in small quantities, support the interpretation of a drier climate. These taxa occur only in drier portions of Alberta region at present (Moss, 1955).

Zone C has similarities with portions of Zone A. *Pinus* has a somewhat higher frequency and may indicate an increased westerly flow. *Artemisia* decreases suggesting a moister climate in which Chenopodiinae and Gramineae increase. Much of this increase is masked by the intensity of the *Pinus* increase as seen in the concentration diagram. The zone is seen as a moister period with a cooler temperature, as suggested by the almost total disappearance of Selaginella.

Zone D shows alternating moist and dry periods, but rarely does any episode appear to continue for a considerable length of time. Three Artemisia peaks, reaching the values seen in Zone B, suggest dry periods with corresponding decreased Pinus. Alternating with the xeric conditions are episodes in which Pinus has higher frequencies, suggesting moister conditions.

The increases of Pinus may be explained by increased westerlies being channelled down the Red Deer River valley resulting in greater amounts of pollen transported from the montane regions. The implication is that the increased westerly flow of Pacific Maritime air masses will increase the precipitation regime of the Hand Hills as well as that of the foothills. Such a change could result in pine migrating downslope and becoming established on the lower flanks of the Rocky Mountains. The Pinus peaks in the concentration diagram (Figure 20) are nearly coincident with Zones A and C. These suggest that the increase of montane pollen in the sediments is due to increased wind transport rather than decreased sedimentation as there is not a corresponding increase of Artemisia in Zone C. The sediment data has shown a slight correlation with increased moisture and all three curves have maxima in Zone C.

Interpretation of the Local Taxa

Zone A, the agricultural zone, is drawn at the beginning of the Chenopodiineae rise (ca AD 1900). Agriculture and other historical phenomena, such as the 'Great Prairie Fire' have had pronounced effects upon the pollen spectrum since the turn of the century.

Intense cultivation is indicated by the high percentages of mustard and chenopod pollen in the upper portion. Coupland (1950:302) notes that Selaginella densa decreases with grazing pressure while Strong (1975:68) states that the species is an indicator of over-grazing. My observations have been similar to Coupland's and the high frequency is interpreted to mean that the region has not experienced recent over-grazing. The middle of the zone sees an increase of Artemisia, with Gramineae and Selaginella being depressed. Pinus decreases in the regional diagram, indicating reduced westerlies and drier conditions diminishing pine pollen production and transport. Chenopodiinae experiences an early rise and Cruciferae increases throughout. As this zone includes the droughts of 1931-1939 and 1952-1956, the pollen diagram is consistant with historical facts. Large areas of farmland were abandoned and taken over by ruderals, particularily Salsola kali, Thlaspi arvense and various mustards. Artemisia frigida is also an early invader of abandoned land, followed by other Compositae (Coupland 1950:309). Reduced forage resulted in over-grazing (Christianson et al 1967) as suggested by the reduction of Selaginella frequency. Xeric conditions result in a reduction of the grass community in terms of cover and standing crop (Albertson et al. 1955:43). Many grasses become dormant for part or most of the summer (Weaver 1958:70). Both aspects may reduce the Gramineae contribution to the pollen rain. Carex eleocharis, the dominant sedge of the prairies, is affected by drought such that no seed is produced in dry years (Coupland 1950:299). The episode indicates continuing dry conditions for nearly thirty years during which drought resistant native species and introduced ruderals increased.

The base shows a combination of factors. The most notable is the sharp reduction of Gramineae and Cyperaceae due to the 1909 fire. The concentrations of both taxa are reduced to one-sixth of their former value while Artemisia and Selaginella are 50% of the pre-fire condition (Figure 20). Prairie fires tend to move rapidly and inflict greater damage to grasses than to woody herbs such as Artemisia cana. The first species to recoup after such an event are the annuals and sage. Early settlers have recorded that it took several years for the prairie to recover (Christianson et al. 1967). The short-term increase of Artemisia appears to be reversed by successful competition of the grasses. The historically noted moist character of the early part of the century seems to be obscured by the effects of the prairie fire and the intense settlement of the area with large areas of native prairie going under the plow.

Zone B is dominated by Artemisia and Gramineae. It would appear that grass and sage pollen were replaced by Chenopodiineae and Cruciferae in Zone A, so that slightly higher populations would be expected during this period. The mean frequency of Artemisia for zone B is $49.7 \pm 4.4\%$ (n=23) with the range from 43% to 58%. The maximum value observed in Zone A is 51%, only slightly higher than the mean. This would imply that the conditions of Zone B were as favorable for sage as the best situation in Zone A. Artemisia occurs in all of the grass communities around Little Fish Lake. Coupland's study showed that sage made up about 7%

of the Mixed Grass Prairie (1950:283-291).

Grasses and sedges differ in response to dry conditions (Weaver 1958:66-71). Most are relatively drought-resistant in terms of species survival but long-term droughts can reduce the ground cover to a small percentage of that observed during wet periods (Albertson, Tomanek & Riegel 1955:43). Cyperaceae produces 11.7 $\pm$ 3.4% of the pollen rain for Zone B, with a range from 6% to 17%. Upland Carex species comprise 14.7%, 8.6% and 16.3% of the vegetation (Coupland 1950:283-291). The contemporary pollen frequency is 12%. If the upland species were the only population in the area, a conversion factor could be derived. In 1977, the shore of Little Fish Lake and the shallow north end (Figure 12) supported a large sedge community. Semi-aquatic sedges shed pollen onto the water surface which is transported by water circulation, as well as contributing airborne pollen to the sediments. The uplands and aquatic populations have different responses to moisture variations. Increased precipitation will enhance production of prairie sedges. Xeric conditions will inhibit the growth of upland sedges but the semi-aquatic plants may migrate with the shrinking lake margin and contribute more to the pollen rain. As the factors are too variable, Cyperaceae pollen was not used for explaining or establishing pollen zones. Also, Populus, although present in small quantities from Zone C to the present, was not used for zone determination. The genus, having variable preservation as well as being able to reproduce vegetatively, may be present in the region but not necessarily represented in the pollen rain.

Grass is the dominant plant in the mixed prairie. In Zone B

Gramineae provided 34.0 $\pm$ 5.6% of the pollen rain with a range from 24% to 43%.

The present ratio from moss polsters of Gramineae: Artemisia is 1.5:1 (p.33). The ratio of Zone B is 0.7:1 which would suggest that sage was more dominant during Zone B than at present. Using the maps of pollen frequency (Figure 8), the 1:1 ratio appears to center in the Short Grass Prairie region while the 1.5:1 ratio line runs close to the boundary of the Mixed Prairie. The implication is that during much of Zone B, the vegetation was more similar to the Short Grass Prairie than today. Selaginella frequency is lower than that of the Short Grass Prairie (Strong 1975:51) and it is most probable that the zone was a slightly drier version of the present.

The present frequency of sage in the vegetation is about 7%. It provides 28% of the local pollen rain. This value would reach 40% if Chenopodiineae and Cruciferae are reduced to pre-agricultural levels to recreate a total prairie situation (base of Zone A). Strong (1975:50) has stated that it is under-represented by a factor of three which would mean that the frequency, according to his figures, would be 2 to 3% of the local pollen rain. Using the factor of five, sage would make up about 10% of the vegetation during Zone B, slightly higher than that observed by Coupland.

Grass, about 70% of the present vegetation, provides 28% of the local pollen rain, although if Chenopodiineae and Cruciferae are reduced to pre-agricultural levels, the frequency becomes 40%. It is difficult to establish a baseline due to intensive cultivation at present.

Coupland (1950:280) conducted his studies on land where "the vegetation appeared to be in climax or near-climax stage and where little disturbance was observed due to grazing, cultivation or proximity of cultivated land." Pollen rain is not so area-specific and incorporates the production of all anemophilous taxa - those growing on disturbed land as well as on undisturbed prairie. Coupland noted that grass makes up about 70% of the Mixed Grass Prairie (1950:283-291). Using the above frequencies, it would appear that grass is under-represented by about two times. This compares with Strong's (1950:50) estimate of an under-representation of "approximately three times." The correspondence figures would indicate about 70% grass, roughly similar to present.

In summary, Zone B is seen as a semi-arid climate during which Artemisia is the dominant pollen type. The continuous presence of Ambrosia indicates xeric conditions or southeasterly winds as the taxon is presently found only in the extreme southeast of Alberta in the drier portions of the Short Grass Prairie (Moss 1955). Fluctuations of Gramineae and Selaginella reflect short-term droughts and moist periods. The long-term trend throughout the Zone is for a decrease in Gramineae with a corresponding increase in Artemisia suggesting increasing aridity.

Zone C has Gramineae as the dominant pollen type with a significant depression of Artemisia values. The mean Artemisia frequency is $33.6 \pm 5.2\%$ and Gramineae is $46.9 \pm 5.8\%$ ratio. The Gramineae: Artemisia ratio is greater than 1.5:1, similar to values observed at the eastern edge of the foothills Aspen Parkland and the southern edge of the Aspen Parkland near Red Deer (Figure 8). Using the previously determined correspondence figures, Artemisia would be about 5% of the vegetation and Gramineae about 90%. This composition is similar to the grassland component of the Aspen Parkland (Moss & Campbell 1947; Strong 1975). As Populus has a variable preservation (Sangster & Dale 1961, 1964), its minimal presence does not contradict the hypothesis that the fescue prairie associated with the Aspen Parkland was displaced to the south and east during this period. The pollen frequencies of other taxa are comparable to those of the contemporary fescue prairie (Strong 1975:53). A strong increase is noted in the concentration of montane pollen, especially Pinus. During this period, all local taxa increase except Artemisia, which maintains a stable concentration and Selaginella, which decreases. The increased quantity of montane pollen may be the result of increased westerlies funnelling down the Red Deer River valley and being uplifted over the Hand Hills. Whether or not the montane forests expanded towards the plains is a moot point. Increased circulation with more frequent and more intense storm tracks will bring about the same result. The decrease of Selaginella could be a function of increased grazing, lower temperature, increased moisture or increased competition by grass (Vān Dyne & Vogel 1967). However, the decrease plus other pollen evidence, frequency and concentration, points to a cooler, moister climate under the influence of strong westerly airmass movements.

Bujak (1974:52) notes an Alnus rise in Waterton National Park at around 1600BP. She correlates this with a cooler, moister period that corresponds to the Audubon Stade of the Neoglacial (Mahaney 1972). Mahaney dates this episode between 1200 and 1800 BP, a slightly shorter period than Benedict's Arikaree Stade (1970) or Richmond's (1965) Late Temple Stade. Alley's (1972) diagram from

Callum Bog has a spruce peak ca 1500 BP which he interprets as a cooler episode. The upper portion of Ritchie & Lichti-Federovich's (1968) column from the Tiger Hills of Manitoba show an increase of arboreal pollen. Using the mean sediment date for Little Fish Lake (1 cm/28 years) the boundaries for Zone C are calculated at ca 1350 and 1750 BP. While the chronological control is not sufficient for accurate dating of the episode, the above dates correlate well with glacial and palynological data. As well, a palaeosol, dated at ca 1500 BP is known from southern Manitoba (David 1911:297). Thus it would appear that a weakly pronounced, but noticeable period of cooler, moister climate occurred in Western Canada from about 1800 BP to 1300 BP. A slight displacement of forest borders may have occurred, but at Little Fish Lake the evidence points to a shift from Mixed Grass Prairie to the fescue prairie associated with the Aspen Parkland. This shift would require a movement of about 50 km of the groveland belt . This may imply a concommittant increase of poplar in the region which is not indicated by Populus pollen at the southern and eastern edges of the Aspen Parkland.

The fluctuations of Zone D are similar to Zones B and C. The upper portion is similar to Zone B, although Gramineae values are slightly higher. Selaginella also is high in this portion of the zone, indicating warmer temperatures than Zone C. The vegetation was probably Mixed Prairie with adequate moisture and a higher temperature. Immediately prior to this, Gramineae drops sharply to less than 25% while Artemisia rises to 55%. Ambrosia reaches the highest values observed. The Gramineae: Artemisia ratio of

0.4:1 and the presence of ragweed pollen suggest this is a period of severe drought. The lower portion of the Zone has a Gramineae peak equivalent to Zone C with a situation similar to Zone B to the base of the core. The lower part of the core suggests rapid and severe variations of climate from moist to extremely arid with corresponding variations of prairie types; fescue, mixed grass and short grass prairies.

CHAPTER IV

PALAEOENVIRONMENT OF THE HAND HILLS REGION

VEGETATIONAL HISTORY

The contemporary vegetational pattern is reflected by the upper section of Zone A and shows increased cereal grain production. Ruderals are prevalent due to the intensive production northwest of Little Fish Lake. Uncultivated land has various faciations of mixed grass prairie depending upon soil and topography (see page 44). *Salix* and *Populus* are found on the lake shore, some sloughs and the valley of Fish Creek. The dominant forbs are *Artemisia frigida* and *Phlox hoodii* on the uplands with *Symphoricarpos occidentalis* and *Elaeagnus comutata* forming patches in moister low areas. *Selaginella densa* provides the basal cover of the grass faciations.

The middle of the core appears to document the effect of the two droughts of 1931-1939 and 1952-1956 with increased production of chenopods and mustards on abandoned farmlands. *Artemisia* increases, largely as a result of colonization of abandoned fields. Reduced forage production during the droughts increased grazing pressure, enhancing the dominance of sage as it is not readily eaten by herbivores. The aspect of over-grazing is reflected by the decrease of *Selaginella* (Coupland 1950:302; Van Dyne & Vogel 1967:440).

The base of the zone is a result of interactions of human and climatic factors, as previously discussed. This period sees the replacement of some native grasslands with cultivated cereals and the attendant panoply of annual weeds.

Zone A documents the interrelationships of slight climatic fluctuations and human alteration of a mixed prairie community. Abstraction of trends during moist and dry periods, as historically documented, of the pollen rain at Little Fish Lake allows for the construction of analogies with events earlier in time.

In Zone B Artemisia dominates the pollen rain and shows a slight increase in frequency while Gramineae experiences a slight decline. The vegetation is seen as climax Mixed Grass Prairie with the major faciations present. Exact mapping of the extent of specific communities is impossible but it is assumed that each occupied the same niche as described by Coupland (1950). Analogy with Coupland's study would indicate that Gramineae and Carex composed most of the vegetation. Artemisia would be the dominant herb with the occurance of other xeric adapted taxa.

Increased moisture, suggested by the carbonate curve, and historically documented, at the top of the zone would bring about increased vigor of the bunch grasses, allowing them to compete successfully with Agropyron and other xeric increasers. An increase of shrubs and woody herbs can be expected at the end of the episode.

Artemisia pollen concentration remains stable in Zone C while Gramineae increases dramatically. The increased flow of westerlies, indicated by the increased transport of montane pollen, could cause higher precipitation in the region. Cooler conditions would reduce summer evaporation and enhance the productivity of tall and mid-grasses. The fescue grassland associated with the Aspen Groveland produces a similiar pollen spectrum and it would not be untoward to speak of a southern displacement of 50 km of the Aspen Groveland in which tall grasses would have been dominant. Increased grass productivity would have resulted in a greater standing crop of cured grass for late fall and winter utilization. Increased precipitation may have resulted in heavier snowfall in the adjacent Aspen Parkland and would have caused higher herbivore utilization of upland areas as winter pasturage for winds would bare much of the hilly topography.

Zone C terminates abruptly. Pollen concentration drops sharply, similar to the decrease noted in Zone A when the surrounding region was burned by a prairie fire. No charcoal was observed in the samples at this level. The sudden decrease of Gramineae is explained as a rapid shift to the Mixed Grass Prairie of Zone B.

Zone D has the over-all characteristics of a mixed prairie environment with short-term fluctuations of dry and moist periods. Neither climatic condition appears to last for a really prolonged period. The vegetation appears to be in a constant state of flux; changing from short grass to tall grass to short grass. The resulting faciations would have had mid-grasses as co-dominants.

In summary, the Hand Hills region has been prairie since the beginning of post-Hypsithermal deposition in Little Fish Lake. Differences in the moisture and temperature regime have undoubtly caused fluctuations in the frequency and production of several species of grass. Moister situations can lead to the dominance of tall grasses similar to current fescue grasslands in the Aspen Groveland. Drier periods could have seen the decline of tall and mid-grasses and the increase of short grasses as now occurs in the Short Grass Prairie to the south.

The region was possibly Short Grass Prairie at the end of the Hypsithermal when increased moisture brought about the development of a Mixed Grass Prairie. Zone D would have had several fluctuations from short grass dominated prairie to fescue grassland. Several species of grass would have occurred as short-term dominants until supplanted by another species for which the current conditions were more advantageous. Zone C was the first episode which lasted long enough to produce a definite pollen zone. Cooler and moister conditions between ca AD 200 and AD 600 (1750-1350 BP) permitted the establishment of a fescue grassland. During this period the Aspen Parkland was probably displaced to the south. A drought terminated this episode and gave rise to a mixed prairie vegetation. The current moister period enhanced the growth of the mid-grasses so that the uncultivated and ungrazed portions of the region can now be considered as Mixed Grass Prairie (Gordon 1979:Figure 1).

FAUNAL HISTORY

The current fauna (Table 4) has been disrupted by agricultural activity. The populations of non-domesticated herbivores are small. White-tail deer, mule deer and antelope congregate in small herds in the draws of the scab-lands of the northern portion of the Hand Hills throughout the year. Smaller mammals, such as jack and snowshoe rabbit, porcupine and ground squirrels are common in the uncultivated area. Coyotes and weasels are the dominant carnivores.

Avifauna (Table 5) is largely migratory as Little Fish Lake lies within a major waterfowl flyway. Several species of ducks and geese are spring and autumn transients. Others (mallards, pintails and teals) nest in the area and are common throughout the summer, as are shore birds. The main upland birds are sharp-

Table 4: Mammalian Check-list of the Hand Hills (after Banfield, 1974)

**Bison	Bison bison
Mule deer	Odocoileus hemionus
White-tailed deer	Odocoileus virginianus
Antelope	Antilocarpa americana
**Wapiti (Elk)	Cervus elaphus
Cottontail rabbit	Sylvilagus nuttallii
Snowshoe hare	Lepus americanus
Jackrabbit	Lepus townsendii
Porcupine	Erethizon dorsatum
**Beaver	Castor canadensis
Muskrat	Ondrata zibethicus
Richardson's ground squirrel	Spermophilus richardsonii
Thirteen-lined ground squirrel	Spermophilus tridecemlineatus
**Black-tailed prairie dog	Cynomys ludovicianus
American red squirrel	Tamiasciurus hudsonicus
Northern pocket gopher	Thomomys talpoides
Deer mouse	Peromyscus maniculatus
*Sagebrush vole	Lagurus curtatus
Prairie vole	Microtus ochrogaster
Meadow vole	Microtus pennsylvanicus
Coyote	Canis latrans
*Wolf	Canis lupus
Red fox	Vulpes vulpes
**Swift fox	Vulpes velox
*Black bear	Ursus americanus
**Grizzly bear	Ursus arctos
*Raccoon	Procyon lotor
Long-tailed weasel	Mustela freneta
*Ermine	Mustela erminea
Least weasel	Mustela nivalis
**Black-footed ferret	Mustela nigripes
**Mink	Mustela vison
**Wolverine	Gulo gulo
Badger	Taxidea taxus
Skunk	Mephitis mephitis
*Mountain lion	Felis concolor
Bobcat	Lynx rufus

* Occassional in the area at present and presumed more prevalent prior to Euro-Canadian settlement.

** Not found in the area at present but known to have occurred in the past as either indigenous populations or seasonal transients.

Table 5: Partial Check-list of Birds of the Hand Hills[1] (after Salt & Wilk 1966; Godfrey 1966)

Migratory Species

Whistling swan	Olor columbianus
White-fronted goose	Anser alibfrons
Snow goose	Chen hyperborea
Oldsquaw	Clangula hyemalis
Red-breasted merganser	Mergus serrator
Common merganser	Mergus merganser
**Whooping crane	Grus americana
Sandhill crane	Grus canadensis
Semipalmated plover	Charadrius semipalmatus
Golden plover	Pluvalis dominica
Black-bellied plover	Squatarola squatarola

Summer Residents

Common loon	Gavia immer
Red-necked grebe	Podiceps griseyena
Horned grebe	Podiceps auritus
Western grebe	Aechmorphorus occidentalis
**Trumpeter swan	Olor buccinator
Canada goose	Branta canadensis
Mallard	Anas platyrhaynchos
Gadwall	Anas strepera
Pintail	Anas acuta
Green-winged teal	Anas carolinensis
Blue-winged teal	Anas discors
Widgeon	Mareca americana
Shoveler	Spatala clypeata
Ring-necked duck	Aythya collaris
Redhead	Aythya americana
Canvasback	Aythya valisneria
Lesser scaup	Aythya affinis
Goldeneye	Bucephala clangula
Bufflehead	Bucephala albeola
White-winged scoter	Melanitta deglandi
Ruddy duck	Oxyura jamaicensis
Yellow rail	Coturnicops novaboracensis
Sora rail	Porzana carolina
Bittern	Botaurus lentiginosus
Coot	Fulica americana
Wilson's snipe	Capella gallinago
Willet	Catotrophorus semipalmatus
Yellowlegs	Totanus flavipes
Godwit	Limosa fedoa
Avocet	Recurvirostra americana
Mourning dove	Zenaidura macroura
**Passenger pigeon	Ectopistes migratorius

Table 5: (continued)

Year-round Residents

Ruffed grouse	Bonasa umbellus
**Prairie chicken (Pinnated grouse)	Tympanurchus cupido
Sharp-tailed grouse	Pedioecetes phasianellus
**Sage grouse	Centrocercus urophanasianus
*Hungarian partridge	Perdix perdix
*Ring-necked pheasant	Phasianus colchicus
*Rock dove (Domestic pigeon)	Columba livia

1 Only larger species of birds are listed which could be considered to be of economic importance. Numerous species of smaller songbirds occur as do several taxa of predatory birds (hawks, eagles, owls. etc.)

* Introduced taxa

** Species believed to be more plentiful in the past and either absent or rare in the region at present.

tailed grouse, Hungarian partridge and ring-necked pheasant. Predatory birds include several species of hawks and eagles.

Zone A is a period of trauma for native species. Range is curtailed and ecological relationships disrupted. The most obvious occurrence is the disappearance of the bison prior to AD 1900. The disappearance of the bison also caused the disappearance of the plains grizzly and the wolf from this region. The occassional beaver had been seen in the area prior to 1920 but hunting pressure in the foothills of the Rocky Mountains curtailed the range. Disturbance among the avifauna was not severe.

During Zone B, bison would have been the dominant mammal with large migratory herds utilizing the area most of the year. Sheltered areas would have been used as calving grounds. Summer grazing would have been on the surrounding prairie lowlands and around the innumerable pot-holes in the scab-lands. Winter would have seen small herds of bison grazing on the wind-swept uplands. Other taxa would have been present in about the same numbers as at Contact and avian populations would have varied only slightly throughout this zone.

As Zone C is interpreted as a fescue grassland with nearby Aspen Parkland, northern species would have been more frequent. Utilization patterns by the bison may have changed. The nearness of the wooded areas would have resulted in larger herds wintering in the region. Summer utilization would probably have been less as the cooler, moister climate would have produced lush growth in the summer range in the prairie regions to the south and east. The probable result upon avian fauna would have been to increase the number of nesting waterfowl as more sloughs and pot-holes would have contained water during the summer.

Zone D had oscillations from moist to dry conditions. Most appear to have been of short duration and it is expected that species were not seriously dislocated. Antelope populations may have expanded at the expense of deer and bison may have used the area in smaller numbers during the drier periods. Sage grouse may have moved into the region and displaced sharp-tailed grouse. Waterfowl frequency would have decreased due to dessication of sloughs.

The wetter periods do not appear to bring about the equivalent of Zone C but probably resulted in a more productive version of Mixed Grass Prairie. Herbivore usuage would be similar to the transition between Zone B and Zone C. Avian populations would have fluctuated in response to the amount of standing water.

BISON UTILIZATION OF THE PRAIRIE REGION

This section will consider the western population of Bison bison. Gordon(1979:23) discusses the rationale for considering herds as discrete units within a population but questions the territorial range. Lack of quantified data during Contact and the unreliability of projecting behavioral models of woods bison onto the plains bison makes generalized statements most reasonable.

Bison moved into the Mixed Grass Prairie in May (Morgan 1978 cited in Gordon 1979:15). This coincided with the spring growth of the dominant grasses (Coupland 1950:296-300). Gordon (1979:36) suggests that the western population "may have averaged two months on the southern summer range." However, the leaves of Stipa spp., Bouteloua and Agropyron smithii are not cured until September and those of Agropyron dasystachyum and Koeleria cristata until October (Coupland 1950:296-299). Carex eleocharis comprises up to 23% of the plant cover and the bases of the leaves remain green throughout the summer. Summer rains will also induce new leaves in the fall (Coupland 1950:300). The suggestion of limited food supply during July in the Short Grass Prairie (Gordon 1979:36) is supported by Clarke et al. (1943) who noted that Stipa, Bouteloua, and Agropyron attain 100% of their yield at the end of July. Their studies were undertaken at Manyberries, Alberta, in the heart of the Short Grass Prairie. Rutting occurred mainly in July and August in the Mixed Prairie (Arthur 1975) when bull and cow herds coalesced.

The lack of drinking water (Morgan 1978 cited in Gordon 1979:36). due to the ephemeral nature of many prairie sloughs, may have reduced the grazing range during drier years. However, many sloughs remained viable during the drought of the 1930's in the area south and east of the Hand Hills. The Bow, Milk and Red Deer Rivers flow through the summer range and herds could have travelled some distance from water sources for forage (Arthur 1975:40).

Bison probably remained in the mixed prairie until fall when they began moving toward the Aspen Parkland. The Fescue Prairie (Aspen Groveland) had rejuvenated since the passage of the bison southward and eastward in May and was able "to sustain herds in autumn and sometimes into winter" (Gordon 1979:36).

Inclement weather (heavy snowfall and blizzards) would have forced the herds to seek shelter in the Aspen Parkland or in coulees among plateaus such as the Hand Hills, the Wintering Hills and the

Cypress Hills. McHugh (1958) states that bison were able to dig through four feet of snow to feed on Festuca scabrella. Morgan (cited in Gordon 1979:37) suggests foraging in open areas near the Aspen Groveland after the first snowfall. Chinooks in southern Alberta would have induced herds to move back onto the prairie for forage (Gordon 1979:37). Arthur notes that bison tend to be sedentary on their winter range (1975:59). The wintering units tend to be larger than the summer aggregates (Soper 1941:380; Arthur 1975:60).

Calving occurred in the early spring, peaking in April and May (Arthur 1975:51). Gordon (1979:37) suggests that this happened at the edge of the winter range. Soper's study (1941:384) indicates that herd movements out of the wintering range begin as early as March.

IMPLICATIONS FOR HAND HILLS

During the free-range period of Euro-Canadian settlement (1880-1920), the Hand Hills were considered as prime wintering range. Several early settlers have related how horses and cattle were driven to the Uplands in the late fall prior to the first major snowfall and left to forage unattended until spring round-up. The reason given was that snow depths on the plains were too great while the Hand Hills were relatively bare. Losses were minimal as the animals could shelter in the draws when blizzards struck. Steele noted that during the winter of 1875, "to the south between Buffalo Lake and the Hand Hills, vast numbers of buffalo covered that country" (1915:87). Nearly a century earlier, in February 1793, Peter Fidler saw large numbers of bison in the same area. He estimated that "they numbered some millions ... as no ground could be seen for them in that compleat semi-circle and extending at least ten miles" (MacGregor 1966:82). Ten days later, Fidler was still passing through this vast herd which was moving west to cross the Red Deer River. Large numbers of Metis would travel long distances and remain on the hunt for considerable periods of time (Hornaday 1889; Hind 1971). These hunts extended from the Red River, in Manitoba, and later Batoche, in Saskatchewan, into Alberta. From the 1860's to 1880's, two large communities of 1500 to 2000 peoples occurred at Tail Creek and Buffalo Lake, slightly north of the Hand Hills (Fryer 1976: 100-101, 106-107).

These reports indicate that the Hand Hills were heavily utilized, at least on occasion, by bison herds during the winter. Grinnel (1962) noted that large herds wintered in the foothills of the Rocky Mountains. The Hand Hills are a short distance (125 km) from the flanks of the mountains and it can be expected that small herds regularly wintered in the region due to the forage and protection provided by the coulees and valleys. Migration patterns (Grinnell 1962:234; Gordon 1979: Figure 3) would result in montane-wintering herds passing through or near the area in the spring onto the prairies. During the fall, as the smaller summer aggregates were moving toward the Aspen Parkland, large numbers would again traverse the area.

Patterns through Zone B would be the same as those noted historically. The southern and eastern displacement of the Aspen Parkland during Zone C would have brought the large wintering herds closer to the Hand Hills. The increased snowfall would have induced many animals to move from the more densely treed portions of the Aspen Parkland and the Hand Hills for easier foraging. This would have increased the resident populations, especially during January through March when the cumulative aspect of snowfall is most severe. Summer would have seen almost total abandonment of the area for the lush prairies to the south and east.

The fluctuations of Zone D would have caused variations in use. Moister periods would result in conditions where wintering populations in the Hand Hills would increase. The drier episodes would minimize forage and lessen carrying capacity, thereby reducing the size of the herd that the region could support. During seasons with lower precipitation, Agropyron smithii and A. dasystachyum will replace bunch grasses. From 1933 to 1940 in Kansas, Agropyron smithii expanded from small stands to occupy "fully one-half of the entire prairie area...(as)...dense vegetation with one to two thousand stems per square meter" (Albertson & Weaver 1944b:400). As this species reproduces mainly by vegetative means, pollen production would be low even at a time of maximum expansion. Total forage production would decrease with the dominance of the shorter grass but food would have been available for herbivores. Data from Kansas in 1940, at the termination of the drought indicates that short-grass pastures (Bouteloua gracilis and Buchloe dactyloides) produced 3260 to 9250 kg/ha (600-1700 lb/acre) under clipping to simulate intensive grazing. Yields were higher under intermittent clipping which would be more analogous to grazing conditions caused by free-ranging animals (Albertson & Weaver 1944a).

Drier conditions on the plains would cause the spring and fall migrations to be closer together. The sparser cover would cause more rapid movement through the Mixed Grass Prairie and the length of time spent upon the Short Grass Prairie would be less due to reduced forage and water sources. Early autumn would have seen the aggregates coalescing in the Mixed Grass Prairie for the fall movement into the Aspen Parkland. Reduced snow cover during dry periods may have induced the bison to remain on the plains through the winter (Arthur 1975:54), although the decreased carrying capacity during dry periods (Albertson & Weaver 1942, 1944a, 1944b; Weaver & Albertson 1936; Robertson 1939) would have forced most bison to move into the more productive Aspen Groveland and Fescue Grassland. The Hand Hills region would still have had small herds during the winter and possibly the summer, but the major utilization would have been during the spring and fall migrations (Gordon 1979:Figure 3).

Bison were probably a conspicuous element of the Hand Hills since the end of the Hypsithermal. Densities and seasonal locations of the herds would have varied throughout time with the greatest utilization of the region occurring during the winters of Zone C and the lowest during the drier episodes of Zone D. Seldom would the area have been devoid of bison except in occassional cases where fires (Hind 1971:109) or unusual weather (Nelson 1973:167) temporarily altered the seasonal patterns of movement or the normal routes of migration.

CHAPTER VII

PREHISTORIC ECONOMIES

POST-CONTACT RESOURCE UTILIZATION STRATEGIES

Bison was the mainstay of the native peoples of the plains at the time of Contact. The animal supplied meat for food, hide for clothing, and horn and bone for tools. The economic and social life of the prairie peoples was based upon the bison (Frison 1974:109). Communal hunting techniques and transhumance due to bison migration added to the interplay of various ethnolinguistic groups.

The most noticeable technique of bison procurement was the communal drive over a buffalo jump or into a pound (Arthur 1975:72-84). Natural terrain plus drive lines channeled the stampeding animals toward the kill area (Arthur 1975:85-87). Cocking (1908) provided the first historical recording of a bison drive, that of the Gros Ventre in 1772. The last known occurance was a drive into a pound by the Blackfoot about 1873 (Ewers 1949:360). The introduction of the horse into the northern plains (ca 1740) diminished the necessity for the drive which was the most archaeologically visible hunting technique.

Other techniques included the surround and the chase. These became prevalent after the introduction of the horse as

> horse surrounds required little time or preparation and permitted the Indians to kill at least as many animals as they obtained in drives. The acquisition of the horse in considerable numbers plus the relative ease with which equestrian hunters could carry out a large slaughter were important factors in the increased use of the surround and the gradual demise

of the traditional drives (Arthur 1975:66).

Surrounds had been used in pre-horse times (Kelsey 1929:13; Grinnell 1970:280) and were probably a function of local terrain. Coulees and hills could be utilized to drive bison in a desired direction but over flat prairie the direction of movement would have been unpredictable.

Even after the introduction of the horse, the ancient technique of stalking occurred. De Smet noted that an Indian with bow and arrows could kill six or more bison before detection (Arthur 1975:62). Group stalking could create a situation similar to a surround. Stalking, to obtain the proper placement of people, in relation to the bison herds, was the initial and possibly most crucial phase of the drive (Arthur 1975:64).

Bison hunting occurred throughout the year with techniques varying according to the season, the size of the herds and the number of available hunters. Arthur documents the use of "jumps and pounds from late fall throughout the winter and also at other times of the year" (1975:106). Stalking was a favored practice during the winter (Arthur 1975:63-64) as was miring in snowdrifts (Stanford 1979). The latter techniques could be employed by small groups, either independently or as part of a larger winter encampment which also utilized drives. The size of the exploiting social unit would be dependent upon the available resources. While the premise that Indian bands fissioned into smaller groups to survive through a harsh winter (Frison 1970:41) has held sway for considerable time, (Arthur 1975:110-113) introduces historical evidence of large winter camps which exploited the large, sedentary herds of bison in adjacent winter pasturage.

The Hand Hills are in the region that was controlled by the Blckfoot Confederacy at Contact. References to the Piegan, Blood and Blackfoot are particularily relevent. Peter Fidler, while wintering with the Piegan, described the use of pounds and jumps from December through March (MacGregor 1966). Ewers (1955:165) provides a list of documented bison drives among the Blackfoot during the winter. It is probable that drives occurred regularly in all seasons. Henry states that the Piegans "keep a stock of dried provisions on hand for emergencies, as buffalo sometimes disappear, and it may be several days before they can get a fresh supply. When they are reduced to dried provisions they call it starving" (Henry & Thompson 1965:725). The obvious implication is that the Indians hunted regularly throughout the year and not only in 'The Great Fall Hunt'. Cocking (1908) describes the use of a pound by the Gros Ventre during the winter of 1772-1773, in which 'a few' more than seven bison were obtained by pounding from October to April.

The myth of the annual hunt appears to be derived from accounts of agricultural groups like the Mandan and Arikaree where large-scale, organized hunts occurred in the fall after the crops were harvested (Denig 1961). The communal hunts of the Sioux (Hassick 1964) and others, while not at any specific time, contributed to this belief.

Historically, the inhabitants of the Hand Hills region moved with the bison, wintering near the herds and migrating with them to the summer pasturage on the Short Grass Prairie. The size of the human aggregate appears to be a function of the size of the bison

(Lewisia pygmaea) provided a welcome change from the winter diet of meat and dried food (Ewers 1955:127) Saskatoons (Amelanchier alnifolia) and chokecherries (Prunus virginiana) were staples for the manufacture of pemmican. Many species were used for food, seasoning or medicinal remedies (Hellson 1974; Kerik n.d.).

PRE-CONTACT RESOURCE UTILIZATION STRATEGIES

Projecting the historical patterns into the past, similar practices could be expected during Zone B. The early accounts of communal hunts were recorded shortly after the introduction of the horse to the Blackfoot and

> give us descriptions of communal drive methods that were very close to, or identical with, the drives employed on the northern Plains in late prehistoric times (Arthur 1975:96).

Drives and surrounds would have been utilized throughout the year when sufficient bison were available. Isolated kills by stalking would have been utilized by smaller groups in any season. As little variation in the ecology of the region occurred during this period which began ca 1350 BP (AD 600), significant departures in hunting strategies would be culturally originated. However, as Gordon notes, "common prey is conducive to similar hunting methods" (1979:75-76).

Differences can be expected in Zone C, especially with regard to winter hunts. The Aspen Parkland would be nearer and the Hand Hills would have been even more favored as a wintering area. Higher bison utilization for this episode, which spans about 500 years from about 1750 to 1350 BP (AD 200 to 700). Summer utilization would be greatly lessened unless the human populations were sedentary and subsisted on deer, antelope, small mammals and birds until the bison returned in the fall. My hypothesis is that the populations moved with the bison, and thus, summer sites would be sparse, if not totally absent.

The drier, warmer periods of Zone D would result in similar bison utilization patterns to those of Zone B. Projecting similar human procurement practices, subsistence strategies would be similar to the immediate pre-Contact period. Winter kill sites would occur during the moister periods, with transhumance onto the plains during the summer and some utilization of the area during the spring and fall migratory periods. The drier phases would have seen lessened summer and winter occupation with the major activity being the interception of migrating bison in the spring and fall. Archaeological sites, which would date to these periods, would be short-term, small group temporary campsites.

In summary, the Hand Hills region should have been used continuously since the end of the Hypsithermal, but occupation would not have occurred with the same intensity or seasonality in all periods. The Mixed Prairie episodes of Zone B and Zone D would have had patterns of utilization similar to the historically documented events. Winter usage would have been moderate, probably by small groups exploiting small wintering herds of bison. Spring and fall activities would have been the interception of migrating aggregates of bison, again by small groups of hunters. Summer utilization would have been minimal, especially during the drier periods. Variations would have occurred during Zone C. Winter sites would have been larger as a function of increased bison population. Spring and fall sites would be similar although less frequent. Summer sites would be non-existant or very sparse.

ARCHAEOLOGICAL EVIDENCE

Evidence from the Hand Hills is minimal due to a lack of research. The Alberta Provincial Park at the eastern end of the lake was surveyed in 1975 by Ross Thompson of the Alberta Provincial Parks Department and no material was located (personal communication). A site with three tipi rings occurs near the mouth of Fish Creek but it never has been investigated. Most evidence for human occupation comes from adjacent regions. Kooyman & Brumley (1978:94) excavated a site (EhPb-1) on the Red Deer River south of Little Fish Lake (Fig. 2). No diagnostic material was located but the authors estimate that the site was occupied between AD 1830 and 1870. The estimate is based on tipi ring size. Finnegan (1978:128) recorded four sites along the Red Deer River southwest of the Hand Hills. Two, EiPd-2 and EiPd-3, were excavated by Brumley & Heikkila (1979:108-109). No culturally diagnostic artifacts were recovered at EiPd-2 which contained bison bone and a stone boiling pit. EiPd-3 contained bison bone, two hearths and four projectile points which "are small and difficult to equate with defined types. However, their size suggests they are atlatl points, and basal fragments show closest similarities to Besant or Pelican Lake Phase points" (Brumley & Heikkila 1979:109). The bone sample includes foetal bison suggesting a winter-early spring occupation.

Major site concentrations in adjacent regions, are a function of research programs rather than a reflection of the activities of prehistoric populations. Also, large archaeologically visible sites have received a great deal of investigation. These are usually buffalo jumps such as Old Women's (Forbis 1960) and Head-Smashed-In (Reeves 1978).

The time span of the core from Little Fish Lake includes the latter portion of the Meso-Indian period, represented by the McKean Complex, Pelican Lake Phase and Besant Phase. McKean and Pelican Lake are present at the Cactus Flower site (Brumley 1975, 1978), while McKean is absent at Head-Smashed-In. Reeves (1978) suggests that this is due to cultural differences and that

> McKean peoples did not know how to use a bison jump of the complexity of operation of Head-Smashed-In ... their lack of knowledge, and use of more traditional methods of game interception, such as suggested at the Cactus Flower site in southeastern Alberta, indicates that they were a population which lacked bison in any great numbers. Involved communal bison hunting techniques such as would have been required at Head-Smashed-In had simply not been developed (1978:172).

Alternatively, the lower portion of Zone D shows a Mixed Prairie community and most bison herds may have been found north of the South Saskatchewan River, using the Red Deer River as a major water source. This would agree with Brumley's (1975:79) suggestion of a spring through autumn occupation for the Cactus Flower site. The McKean period encompassed part of the Hypsithermal and it would be expected that bison herds would be denser to the north with only occassional use by small groups in southern Alberta. The logical entailment is that human occupation of the drier areas of the Mixed Prairie would be intermittant utilization by small groups.

Zone C roughly corresponds with the period when Avonlea and Besant co-existed on the plains. Avonlea appears to be an indigenous development from Pelican Lake (Gordon 1979:63) while Besant appears be intrusive. Avonlea is missing at Old Women's jump (Forbis 1962) and present at Head-Smashed-In, while the reverse is true of Besant (Reeves 1978:172). Avonlea appears to have originated in central Saskatchewan and moved westward over several centuries (Gordon 1979:69) perhaps as a result of people following the westerly migrating bison from the western prairie herd. The increased carrying capacity of the Mixed Prairie during this moister period would have resulted in increased populations which may have expanded the summer range to the extent where the eastern and western herds could have intermingled. At this time, Besant peoples moving with the Montana herds could have entered southern Alberta. Calder notes extensive use of the Majorville cairn by both Avonlea and Besant from AD 200 to AD 1000 (1977:36). Using the hypotheses developed earlier, it would be expected that only winter sites of both archaeological cultures would be expected in the Hand Hills, with summer activities occurring to the south and east at jumps such as Head-Smashed-In and EdPc-8.

Pollen Zone	Approximate Time Range	Vegetation Type	Inferred Climate	Bison Use	Human Use
A	1975 AD 1900	Agricultural/ Mixed Prairie	Semi-arid/ Continental	Nil	Euro-Canadian Agriculture
B	1900 600	Mixed Prairie	Warmer/ Drier	Spring- Migratory Summer- Little Fall- Migratory Winter- Little	Small-scale transitory Minimal small-scale Small-scale transitory Small-scale intermittent
C	600 200	Fescue Prairie	Cool/ Moist	Spring- Migratory Summer- Absent Fall- Migratory Winter- Heavy sedentary	Small-scale transitory Very sparse, if any Small-scale transitory Large-scale sedentary
D	200 BC 1650	Mixed Prairie with periods of short grass and fescue	Generally Warmer/Drier Hot/Dry and Cool/Moist Periods	Variations of the Patterns of Zones B and C	Variations of the Patterns of Zones B and C

Table 6: Palaeoenvironmental Summary of the Hand Hills Region of Alberta

CHAPTER VIII

SUMMARY AND DISCUSSION

SUMMARY

In Chapter II, I examined the problem of obtaining accurate representations of contemporary pollen rain from vegetative polsters. A single season deposition pattern was obtained from artificial samplers and compared against time-integrated assemblages from moss polsters. The cumulative frequency of the taxa collected by the samplers closely corresponded to the polster assemblages. This yielded confirming evidence for the prevalent, but previously untested, assumption that polsters provide an accurate representation of the pollen rain.

Chapter III consisted of an examination of trend surface analysis of pollen distribution in Western Canada. The predictive value of maps based on this technique was confirmed. Anomolous situations (i.e., the 'valley funnel effect' and 'pollen islands') were investigated and explained in terms of air mass behavior as influenced by topography.

The palynological core obtained from Little Fish Lake was discussed in Chapter V. The core was analyzed for moisture, carbonate, organic, macrofossil and pollen content. Correlation of the data enabled me to determine the vegetation of the Hand Hills for the past 3600 years and to infer the regional climate. Variations in the pollen record showed that, while the area had been prairie since the end of the Hypsithermal, different types of grasslands had occurred.

I hypothesized that the vegetation was composed of sod-forming grasses and xeric-adapted forbs at the end of the Hypsithermal. A series of moisture fluctuations caused tall and short grasses to co-vary until ca 1750 BP (Zone D). A cool, moist period brought about the formation of a fescue grassland community which lasted to ca1350 BP (Zone C), when drier conditions changed the changed the character of the vegetation to mixed prairie (Zone B) which has continued to present.

The reconstructed vegetational and faunal history was discussed in Chapter VI. The influence of the environment on prehistoric economies was examined in Chapter VII. I concluded that subsistence strategies recorded at Contact could be extended back to the fescue grassland period as minimal variation had occurred. The fescue grassland episode may not have induced any change in resource utilization patterns on a large scale but the alteration of the local vegetation would have been reflected by a change in the seasonal use of the Hand Hills by prehistoric populations. I hypothesized that the procurement patterns between the end of the Hypsithermal and the beginning of the fescue grassland period would have been similar to those expected for Zone B. Different timing of the seasonal round would have occurred during the moist and dry episodes.

Archaeological evidence for the study region was inconclusive due to paucity of recorded sites, lack of diagnostic material and poor preservation of faunal material. Regional evidence has shown occupation from early post-glacial to present but large gaps occur in the record. It was noted that the fescue grassland period coincides with the development of Avonlea and the intrusion of Besant. It is difficult to accept the minor climatic change as a causal mechanism although altered bison migration routes and pasture areas may have brought about increased culture contact among nomadic hunters.

DIRECTIONS FOR FURTHER RESEARCH

The Little Fish Lake core should not be seen as a total study for the mixed grass prairie. Additional lakes should be cored to enable the establishment of a regional palaeoenvironmental baseline. Re-coring of Little Fish Lake with special equipment will obtain pre-Hypsithermal data, from below the hard-pan level which terminated this core. Cores should also be obtained from the peripheral Aspen Parkland as well as other uplands such as the Cypress Hills. As sediment rates appear to vary greatly, adequate radiocarbon dating is a necessity. All other possible analyses, including particle size analysis, should be preformed.

Eventually, given a sufficient number of palynological records for the area, trend surface analysis at selected temporal horizons will be able to document the extent of vegetational change as reflected by pollen distribution. Variations from the expected values can be explained in terms of pollen transport and micro-environmental factors or human alteration of the vegetation.

Archaeologically, the Hand Hills region requires intensive work. Further research may be able to confirm the hypothesis that human utilization was heaviest during the fescue grassland period. Suitable evidence would be dated sites containing foetal bison bone. The hypothesis that the area was largely unoccupied during the summers of this period would be weakened by the discovery of sites containing sub-adult antelope and deer remains. Finally, the area may have been a focal point in the shift from Pelican Lake to Avonlea. Evidence of this development may be found as well as possible interactions with Besant.

CONCLUSIONS

The study has provided a baseline, albeit incomplete, of recent Holocene vegetational communities in the Hand Hills of southern Alberta. Variations of prairie communities, due to climatic change, would have caused differences in faunal resources and, thereby, the seasonality of human utilization. Implications for changes of prehistoric economic life are minimal within the broad pattern of plains adaptations although transhumance would result in different occupational periods of the study area during each of the climatic episodes since 3600 BP.

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APPENDIX A

BASIC DATA

ALHAP SAMPLER STUDY

	I	II	III	IV	V	VI	VII	VIII
Picea	6½	6½	20	8	M	3½	4	8
Pinus	166½	165	45	20½	M	25½	19	14
Abies	1	–	–	1	M	1	–	–
Alnus	1	–	1	–	M	1	3	1
Betula	3	–	1	4	M	8	6	2
Salix	1	–	6	–	M	1	–	–
Populus	1	–	–	2	M	4	–	1
Juniperus	–	2	1	2	M	–	1	–
Elaeagnaceae	–	–	–	1	M	–	–	–
Gramineae	6	30	99	134	M	100	41	24
Cheno/Am	1	1	13	8	M	16	4	14
Compositae	1	2	1	4	M	3	7	2
Artemisia	–	–	–	4	M	6	25	14
Ambrosia	1	–	–	2	M	3	7	3
Cruciferae*	3	68	270	28	M	8	12	4
Plantago	1	–	–	–	M	–	1	–
Caryophyllaceae	1	–	–	–	M	1	1	–
Leguminosae	–	1	1	3	M	7	4	1
Rosaceae	–	–	–	–	M	–	2	–
Thalictrum	–	2	–	–	M	–	–	–
Primulaceae	–	–	–	–	M	–	1	–
Onagraceae	–	–	–	–	M	–	1	–
Sarcobatus	–	–	1	–	M	–	–	–
Saxifragaceae	–	–	2	–	M	1	–	–
Scrophulariaceae	–	–	–	–	M	1	–	1
Urtica	–	–	–	1	M	3	1	–
Cyperaceae	5	3	2	3	M	1	2	2
Typha	–	2	2	–	M	–	1	–
Selaginella	–	–	1	–	M	1	–	1
Indeterminate	–	2	5	2	M	3	3	1
Unknown	1	–	1	1	M	2	2	3
Pollen Sum	197	214½	202	201	M	192	136	90
Eucalyptus	735	686	3054	1928	M	8360	7553	7943

* Not included in pollen sum

Table A-1: Pollen Sums during Collection Periods at Station 1.

	I	II	III	IV	V	VI	VII	VIII
Picea	3	13	14	4½	1½	M	1	5
Pinus	183	155	58	39½	8½	M	9	14½
Abies	1½	–	–	–	–	M	–	1½
Alnus	1	1	2	–	1	M	4	1
Betula	–	–	3	5	3	M	7	6
Salix	1	–	1	2	1	M	–	–
Populus	2	2	1	–	–	M	1	2
Juniperus	–	2	1	2	–	M	–	–
Corylus	–	–	2	–	–	M	–	–
Acer	–	–	–	–	–	M	4	–
Ulmus	–	–	–	–	–	M	1	–
Cupressaceae	–	–	–	–	1	M	–	–
Psuedotsuga	–	–	–	1	–	M	–	–
Gramineae	8	21	96	119	159	M	65	63
Cheno/Am	2	–	2	7	12	M	17	19
Compositae	6	–	2	–	3	M	7	16
Artemisia	–	–	1	–	1	M	54	47
Ambrosia	–	–	1	1	1	M	6	4
Cruciferae*	–	2	51	86	20	M	8	5
Plantago	–	–	3	–	5	M	–	–
Caryophyllaceae	–	1	–	4	–	M	2	1
Leguminosae	1	–	3	3	3	M	–	–
Rosaceae	–	–	–	1	–	M	3	5
Ranunculaceae	–	–	2	–	–	M	–	1
Iva	–	–	–	–	–	M	2	–
Polygonaceae	–	–	1	–	1	M	–	–
Urtica	–	–	5	3	1	M	2	–
Rubiaceae	–	–	–	2	–	M	–	–
Labiatae	–	–	–	–	1	M	–	–
Cyperaceae	1	2	2	3	–	M	1	1
Typha	–	–	1	–	–	M	4	3
Equisetum	1	1	–	–	–	M	1	–
Selaginella	–	–	–	1	–	M	2	2
Indeterminate	2	1	2	2	1	M	3	3
Unknown	–	1	1	–	2	M	1	4
Pollen Sum	212½	200	203	200	206	M	205	204
Eucalyptus	510	711	2145	1920	2375	M	5706	5906

* Not included in pollen sum

Table A-2: Pollen Sums during Collection Periods at Station 6.

	I	II	III	IV	V	VI	VII	VIII
Picea	14	6½	2	2	4½	M	8½	M
Pinus	186½	138½	21½	12½	11½	M	13	M
Abies	–	–	–	–	–	M	2	M
Alnus	2	–	–	–	2	M	1	M
Betula	2	2	1	1	3	M	13	M
Salix	–	1	1	1	–	M	1	M
Populus	1	–	–	–	–	M	1	M
Corylus	–	–	–	–	1	M	–	M
Caprifoliaceae	–	–	–	–	–	M	2	M
Gramineae	6	48	170	174	133	M	41	M
Cheno/Am	1	2	5	10	23	M	14	M
Compositae	1	–	1	1	2	M	11	M
Artemisia	–	1	6	4	1	M	23	M
Ambrosia	–	–	–	–	–	M	9	M
Cruciferae	–	2	6	1	5	M	7	M
Caryophyllaceae	–	–	–	2	5	M	1	M
Leguminosae	–	–	3	–	1	M	1	M
Thalictrum	–	–	–	–	1	M	–	M
Polygonaceae	–	1	–	–	–	M	–	M
Campanulaceae	–	–	–	–	–	M	2	M
Urtica	–	–	2	1	5	M	2	M
Cyperaceae	1	–	–	1	–	M	–	M
Typha	–	–	1	–	4	M	1	M
Selaginella	1	1	–	–	–	M	1	M
Indeterminate	1	1	1	–	1	M	2	M
Unknown	–	–	–	1	1	M	2	M
Pollen Sum	216½	204	220½	211½	204	M	158½	M
Eucalyptus	514	901	1089	2855	3317	M	13727	M

Table A-3: Pollen Sums during Collection Periods at Station 7.

	I	II	III	IV	V	VI	VII	VIII
Picea	9½	5½	17	4½	3	5	M	2½
Pinus	179½	152	33	18½	17	16	M	5
Abies	1	1	2	1½	–	–	M	–
Alnus	–	1	1	1	1	3	M	4
Betula	1	2	–	2	3	3	M	1
Salix	–	–	–	–	1	–	M	–
Populus	2	10	4	2	2	1	M	2
Juniperus	–	–	–	1	–	–	M	–
Larix	–	–	1	–	–	–	M	–
Acer	–	–	–	–	–	2	M	–
Ulmus	–	–	–	–	–	–	M	1
Elaeagnaceae	1	–	–	–	–	–	M	–
Caprifoliaceae	–	–	–	–	–	1	M	–
Myricaceae	–	–	–	1	–	–	M	–
Gramineae	3	21	114	157	130	113	M	99
Cheno/Am	1	3	6	4	8	8	M	8
Compositae	–	1	2	–	1	3	M	40
Artemisia	–	–	3	3	3	6	M	14
Ambrosia	–	–	–	–	2	3	M	5
Cruciferae	–	–	3	5	4	10	M	5
Caryophyllaceae	–	–	–	2	–	2	M	–
Leguminosae	–	–	1	2	3	14	M	7
Rosaceae	–	–	–	–	5	–	M	1
Onagraceae	1	–	–	–	–	–	M	–
Polygonaceae	1	–	–	–	–	1	M	–
Gentianaceae	–	1	–	–	–	–	M	–
Liliaceae	–	–	1	–	–	–	M	–
Iridaceae	–	–	–	–	1	–	M	–
Pyrolaceae	–	–	–	–	1	–	M	–
Berberidaceae	–	–	–	–	1	–	M	–
Cyperaceae	1	3	7	5	7	2	M	4
Sparganaceae	1	–	–	–	–	–	M	–
Nymphaceae	–	–	–	–	–	–	M	1
Typha	–	–	1	–	–	–	M	–
Equisetum	–	–	–	–	1	1	M	–
Selaginella	–	1	–	–	–	–	M	–
Lycopodium	–	–	–	–	–	1	M	–
Indeterminate	2	3	4	4	4	1	M	2
Unknown	–	1	–	2	2	1	M	1
Pollen Sum	204	205½	200	215½	200	197	M	202½
Eucalyptus	426	1697	1082	1612	4457	5123	M	6777

Table A-4: Pollen Sums during Collection Periods at Station 9.

	1	2	3	4	5	6	7	8	9	10
Picea	8.9	1.5	9.4	10.6	8.6	6.0	12.0	–	10.3	8.6
Pinus	50.8	38.9	54.8	65.2	52.9	52.2	43.4	20.8	59.2	52.3
Abies	–	–	0.5	4.3	–	0.3	0.5	–	–	0.2
Alnus	0.8	0.5	4.8	1.0	1.5	1.9	1.4	2.5	1.3	2.8
Betula	1.2	–	1.0	1.4	2.0	3.9	4.2	3.8	1.8	2.8
Salix	0.4	1.5	1.4	1.4	1.0	1.4	2.8	2.5	0.4	2.3
Populus	–	1.0	1.0	0.5	–	–	–	0.8	0.4	0.5
Larix	–	–	0.5	–	–	–	0.5	–	–	0.5
Gramineae	25.6	51.3	19.3	9.2	22.1	23.7	21.7	59.5	18.4	18.7
Cheno/Am	3.7	–	0.5	0.5	1.5	0.5	–	1.3	0.9	0.9
Compositae	0.8	1.0	–	0.5	4.9	–	1.9	–	1.3	1.9
Artemisia	1.2	–	–	0.5	1.0	0.5	1.9	2.5	0.9	1.9
Ambrosia	0.4	–	–	–	–	–	0.5	0.4	–	–
Cruciferae	2.0	–	1.9	1.0	0.5	3.4	2.8	1.6	0.9	4.2
Caryophyllaceae	–	–	–	–	–	0.5	–	0.4	–	–
Leguminosae	0.4	1.5	0.5	–	0.5	2.4	–	0.4	0.9	0.5
Rosaceae	–	–	–	–	–	–	–	0.4	0.4	–
Thalictrum	–	–	–	–	–	–	1.4	–	–	–
Polygonaceae	–	–	–	–	–	0.5	–	–	–	–
Ranunculaceae	–	–	–	–	–	–	–	–	–	0.9
Urtica	–	–	0.5	–	–	–	–	–	–	–
Violaceae	0.4	–	–	–	–	–	–	–	–	–
Umbelliferae	0.4	–	–	–	–	–	–	–	–	–
Solanaceae	0.8	–	–	–	–	–	–	–	–	–
Liliaceae	–	–	–	–	–	–	0.5	–	–	–
Cyperaceae	0.8	1.5	0.5	1.9	–	1.0	1.4	0.4	1.3	–
Typha	–	–	–	–	–	–	0.5	–	–	–
Equisetum	–	–	–	–	–	–	0.5	0.4	–	–
Indeterminate	1.2	1.5	3.4	1.9	3.4	1.4	2.4	1.3	1.3	0.9
Unknown	–	–	–	–	–	–	–	0.4	–	–
Totals	99.8	100.2	100.0	99.9	99.9	99.6	100.2	99.4	99.7	99.9

Table A-5: Polster Pollen Frequencies in Study Area

APPENDIX B

SEDIMENT ANALYSES

LITTLE FISH LAKE

CORE #2

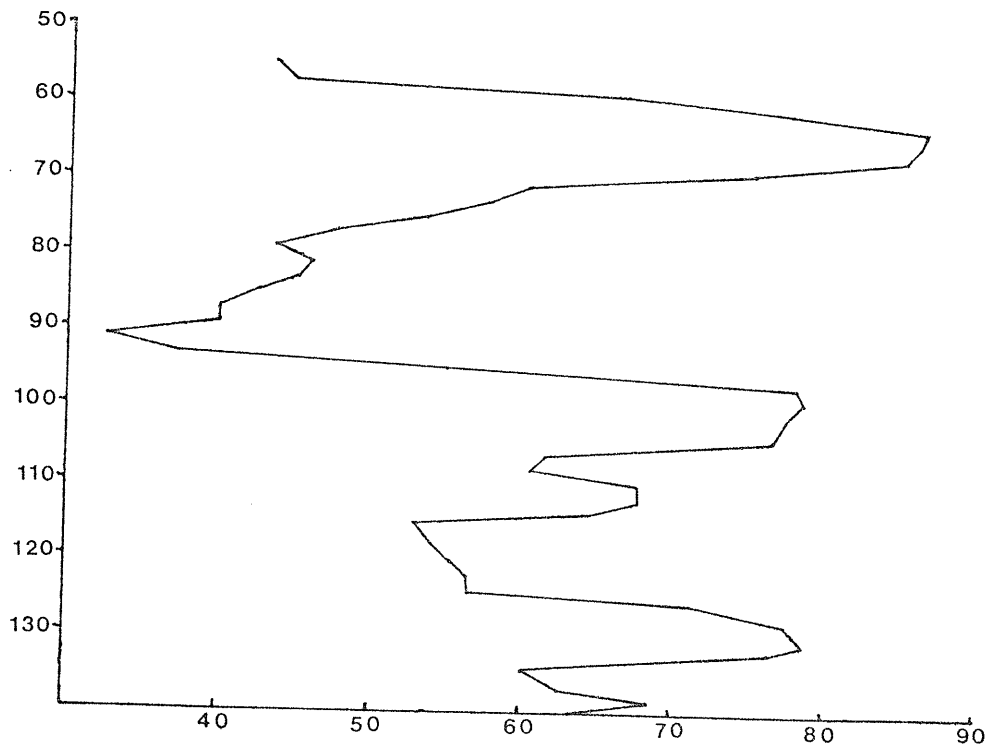


Figure B-1: Moisture Content of Little Fish Lake Core 2

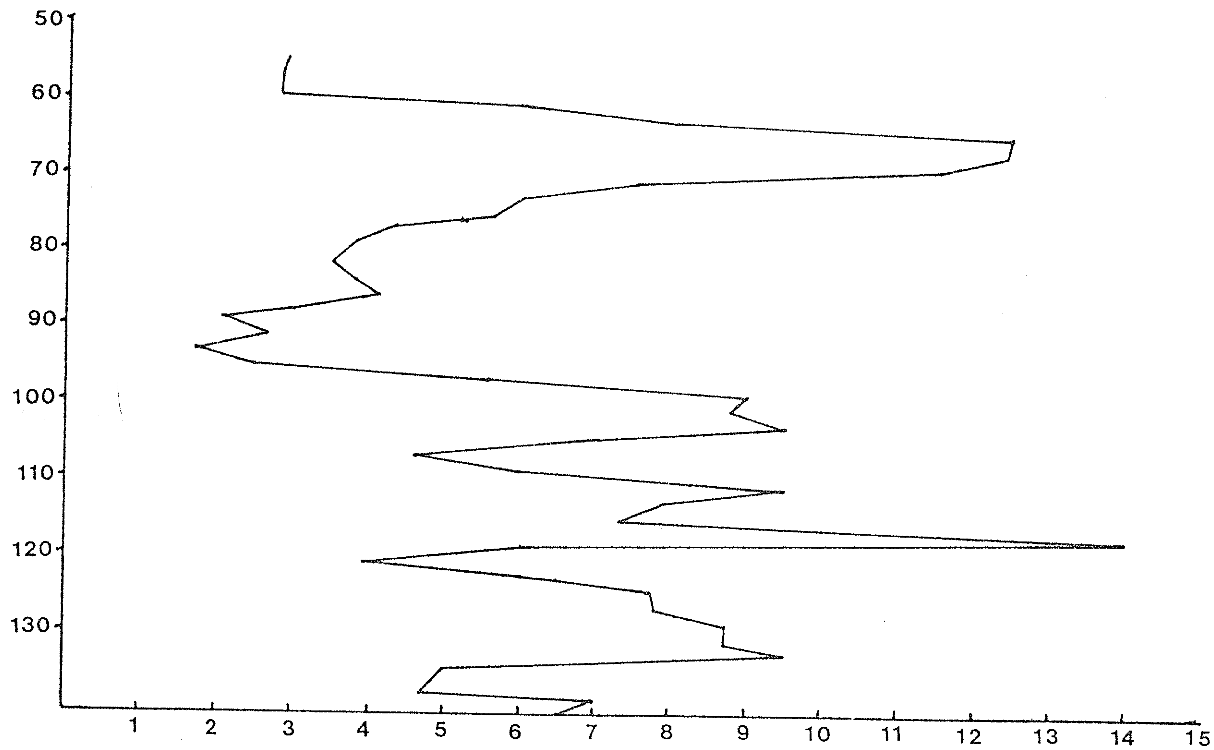


Figure B-2: Organic Content of Little Fish Lake Core 2

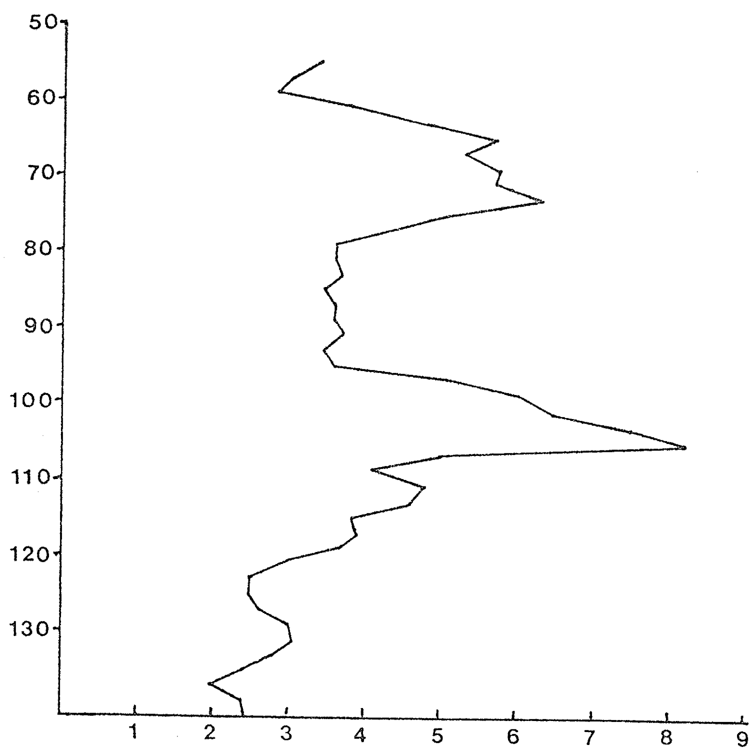
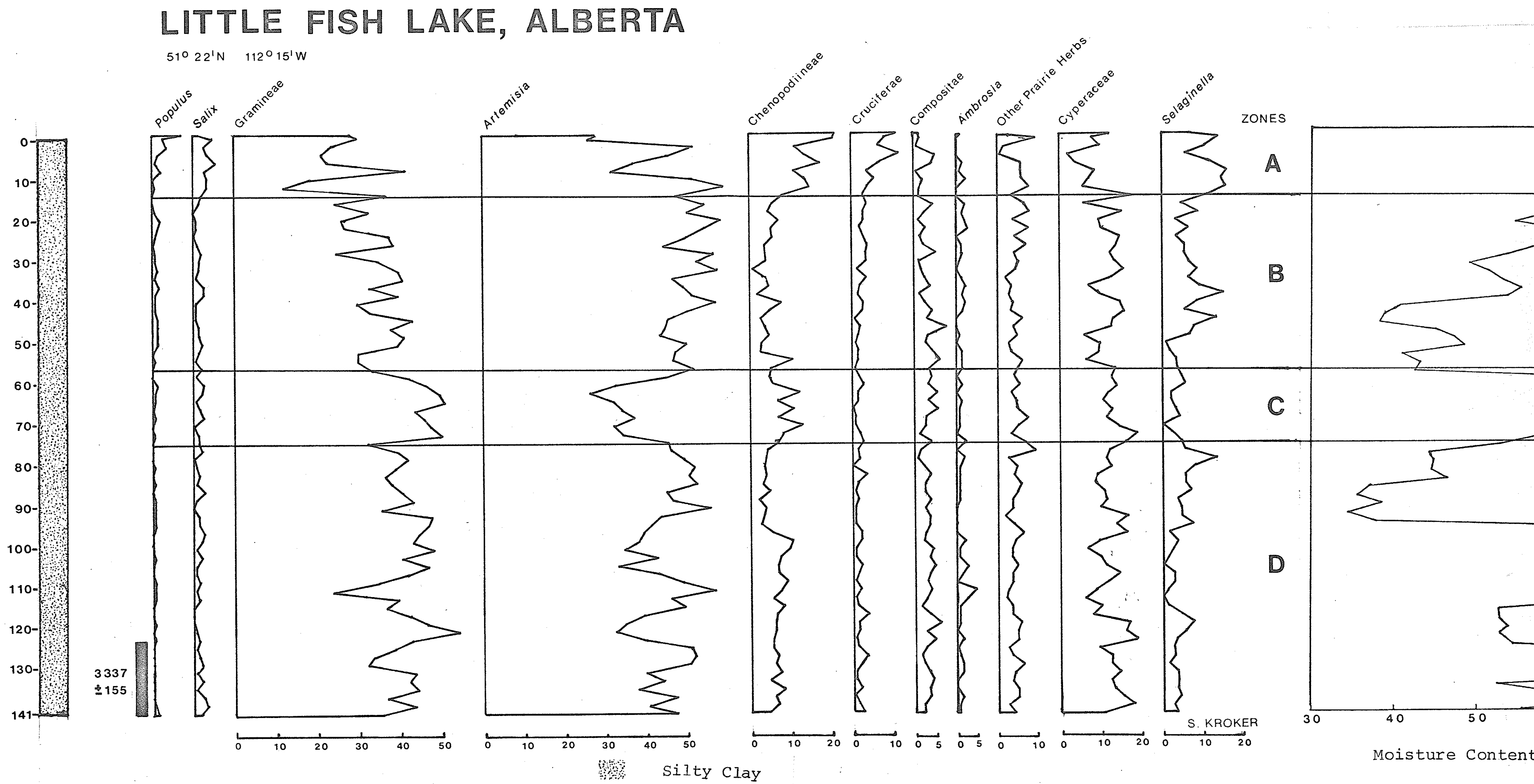
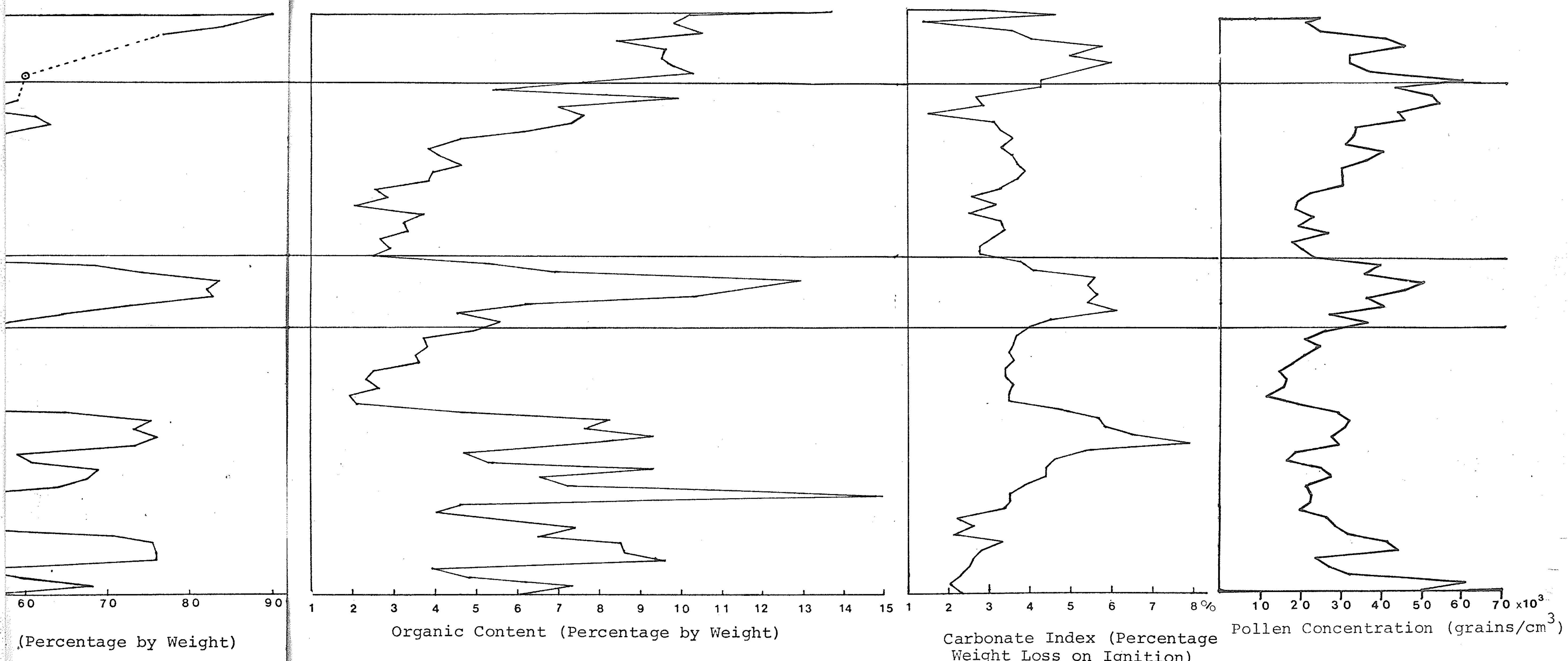


Figure B-3: Carbonate Index of Little Fish Lake Core 2


LITTLE FISH LAKE, ALBERTA
51° 22'N 112° 15'W
Populus
Salix
Gramineae
Artemisia
Chenopodiineae
Cruciferae
Compositae
Ambrosia
Other Prairie Herbs
Cyperaceae
Selaginella
ZONES
A
B
C
D
0
10
20
30
40
50
60
70
80
90
100
110
120
130
141
3337
±155
0 10 20 30 40 50
0 10 20 30 40 50
0 10 20
0 10
0 5
0 5
0 10
0 10 20
0 10 20
S. KROKER
Silty Clay
30 40 50
Moisture Content


60 70 80 90
(Percentage by Weight)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Organic Content (Percentage by Weight)
1 2 3 4 5 6 7 8 %
Carbonate Index (Percentage Weight Loss on Ignition)
10 20 30 40 50 60 70 x10³
Pollen Concentration (grains/cm³)