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NAME OF AUTHOR/*NOM DE L'AUTEUR* Robert Earl Vance

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NAME OF SUPERVISOR/*NOM DU DIRECTEUR DE THÈSE* Dr. Charles Schweger

DATED/*DATÉ* April 20 '79 SIGNED/*SIGNÉ* R. Vance

PERMANENT ADDRESS/*RÉSIDENCE FIXÉ* #14 10757-83 Ave
Edmonton, Alberta
T6E 2E5

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LATE HOLOCENE PALEOECOLOGY OF THE ASPEN PARKLAND REGION OF WESTERN CANADA

By

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Late Holocene Paleoecology of the Aspen Parkland Region of Western Canada" submitted by Robert E. Vance in partial fulfilment of the requirements for the degree of Master of Arts in Anthropology.

Charles Schweger
Supervisor

Ruth Gruhn

Marvin J. Dudas
External Examiner

March, 1979

ABSTRACT

Two sediment cores were collected from a pond and a bog in Elk Island National Park. These cores were analyzed for their pollen content and the results combined with quantitative data on modern vegetative composition and modern pollen rain provided a basis for interpretations on vegetative dynamics of the Aspen Parkland region of Alberta. The results show that at 4,000 years B.P. the area now occupied by the Aspen Parkland was an open grassland, indicating a more northerly position for the Aspen Parkland at that time. Over the following 1200 years the ancient grassland became gradually more treed and by 2,800 years B.P. the Aspen Parkland of central Alberta became established in its present-day position. Additional research into ethnographic and archaeological literature revealed that the Aspen Parkland may have served as an important area of cultural interchange between aboriginal groups of the Great Plains and Boreal Forest regions of Alberta due to seasonal resource abundance.

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CHAPTER 1 INTRODUCTION

Few would argue with the statement "man actively alters his environment." The evidence is apparent in almost every aspect of our existence, it manifests itself in the air we breathe and in the appearance of the landscape around us. Less apparent, especially to the "civilized" peoples of the world, is the fact that the environment is capable of exerting a powerful influence on man.

Archaeologists and cultural anthropologists have actively been addressing themselves to the role of the environment in relation to culture and, more recently, to the question of environmental influence on culture change. A.L. Kroeber, one of the earliest workers interested in the influence of environment on culture was mainly concerned with mapping "cultures" of North American Indians. Noticing that there existed certain correlations between particular cultures and particular environments he stated that:

> Plant cover is obviously almost always likely to stand in relation to culture. It largely expresses climate; it tends heavily to determine the fauna; and it enters directly into subsistence, besides at times affecting travel and transport. (Kroeber 1939:351).

Such cataloguing exercises and the realizations they generated led the way to a more operative frame of reference that began to ask questions concerning the role of the environment in culture change. Julian Steward is probably the best known theorist in this regard. Steward felt that the concept of ecology has "naturally been extended to include human beings since they are a part of the web of life in most parts of the world" (1955:31). He went on to name this line of research concerned with evaluating environmental influences on culture as cultural ecology.

One of the stated aims of cultural ecology is "a determination of how culture is affected by its adaptation to environment" (*ibid*:31). Stated in a more operative form, cultural ecologists must concern themselves with aspects of culture that are directly related to the environment (the "culture core"), and from this concern they must attempt to gauge the effects of these directly related aspects to those aspects of culture that are less closely tied to the environment. Implicit in this line of research is an understanding of how culture is affected by changes in the environment. That is, if we are to fully understand culture change, we must know the possible environmental changes that the culture in question may have been subjected to.

This aspect of cultural ecology has, for the most part, received little attention. The tendency on the part of cultural ecologists seems to be to treat the environment as a constant and pursue their line of research from this given. The reality is that environments are constantly changing. To appreciate fully the relationship of culture to environment both elements and their dynamic tendencies must be examined. It was with this theoretical framework in mind that the research at hand was initiated.

Archaeologists working in Alberta have had few reliable paleoecological studies to refer to. Therefore, in order to better understand environmental conditions in prehistoric Alberta this palynological study was begun.

Two locations within the confines of Elk Island National Park were chosen for study. Two factors determined the study location. Firstly, a research contract was granted by Parks Canada to develop an interpretive program dealing with successional processes in bog and pond environments, a type of program that would ideally be based on a palynological study. Secondly, Elk Island National Park is situated near the northern boundary of a distinct environmental zone, the Aspen Parkland. This location is of special interest to the palynologist since the Aspen Parkland is a transitional zone between two major North American environments, the Great Plains and the Boreal Forest. Presumably any environmental changes will involve boundary adjustments of these zones. Furthermore, since each zone possesses a distinctive flora, any boundary adjustments should be clearly reflected in the pollen record.

In addition to the obvious objective of documenting environmental changes, a secondary objective was formulated. This secondary objective concerned the archaeological record of Alberta. What role did the unique environment of the Aspen Parkland play in Alberta's cultural development? Also, does there exist any correlation between cultural changes evident in the archaeological record and environmental changes apparent in the pollen record? A review of archaeological research was necessary in order to address these questions.

CHAPTER 2 PREVIOUS RESEARCH

Paleoecology

The Neothermal refers to the time period spanning the last 13,000 years, from the time of the last deglaciation to the present (Bryan and Gruhn 1964). It is a time period that has been subject to a great deal of research and speculation that includes investigations concerning the nature of Neothermal climates.

Certainly one of the earliest, significant contributions to the understanding of Neothermal climatic regimes came from Ernst Antevs. Basing his work on geological observations, Antevs (1955) deduced that during the Neothermal there occurred three major climatic events. Immediately following deglaciation was a climatic regime cooler and moister than today, the Anathermal. Subsequent to the Anathermal was the Altithermal, a climatic period warmer and drier than any other in the Neothermal. Following this period of maximum warmth and aridity was the Medithermal, a period typified by a climate like that of today.

Equivalents to Antev's Altithermal were recognized by many researchers in Europe and North America. Generally, European workers termed the event as the Atlantic. North American workers coined a variety of terms. In an effort to standardize the terminology Deevey and Flint (1957) suggested that this post-glacial thermal maximum be known as the Hypsithermal interval. Deevey and Flint stated further that the Hypsithermal interval, at its very broadest temporal extent, lies between 8,950 years B.P. and 2,550 years B.P. (ibid), although regional variations in time and duration have been documented (Bryan and Gruhn 1964).

Antev's model of Neothermal climates became entrenched in the literature. Subsequent research has been aimed mainly at a sophistication of the three phase concept. Bryson (1968) has addressed questions regarding the duration of the climatic intervals, the length of the transitional periods, and the atmospheric circulation that brought about these climatic changes. These lines of research have led to a more detailed view of Neothermal climates while essentially maintaining Antevs (1955) original framework.

Paleoenvironmental research was initiated in Alberta by H.P. Hansen (1949a, 1949b, 1952). Although his studies, by today's standards, can only be described as inadequate, he did establish a base from which later researchers worked.

Hansen analyzed the fossil pollen content of seven cores from unspecified locations in the vicinity of Edmonton with the stated purpose of studying post-glacial vegetative migrations and climatic trends (1949a). Obvious methodological limitations included the lack of radiometric control and the small number of pollen grains counted per sample. Furthermore, Hansen distinguished the pollen of white (Picea glauca) and black spruce (Picea mariana) as well as jack (Pinus banksiana) and lodgepole pine (Pinus contorta). It is now generally conceded that these distinctions cannot be made (Ting 1966).

Given these limitations, Hansen did note that:

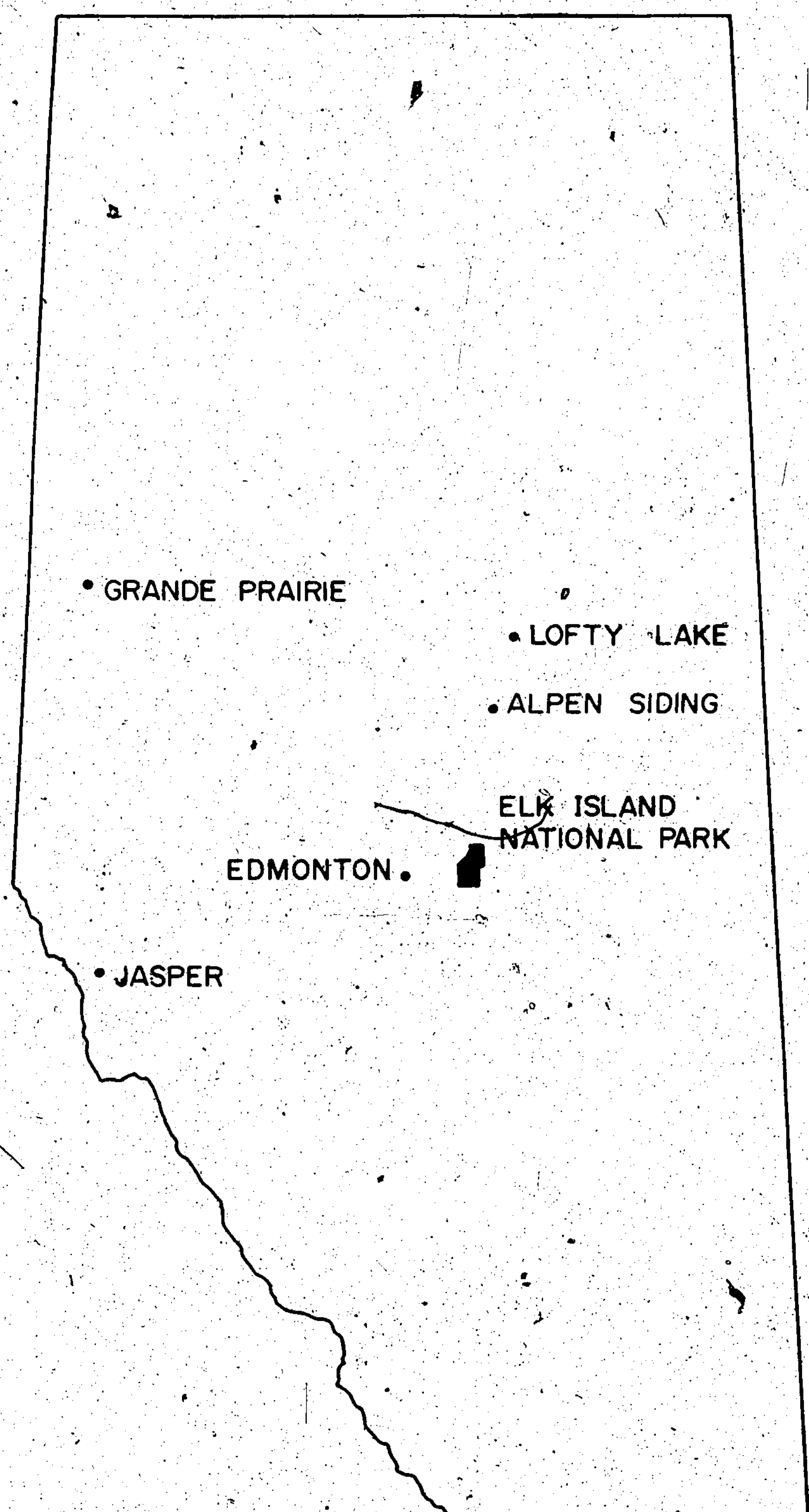
> ....the presence of prairie soil in the Parkland and Poplar areas and podsolized prairie soil in the southern limits of the Boreal Forest suggest that these areas were occupied by grassland for a long time. (Hansen 1949a:60)

He concluded that his palynological data supported the hypothesis of an expanded grassland in central Alberta and theorized that this grassland existed during a warm, dry climatic interval between about 8,000 and 4,000 years ago. Hansen (1952) provided further evidence for this warm, dry climatic interval in the Grande Prairie region but stated that he had no evidence that these concomitant grassland expansions were extensive enough to form one continuous grassland reaching the Grande Prairie region.

Another pioneer worker in Alberta was C.J. Heusser (1956). His palynological research was confined to Jasper National Park and was aimed at documenting recent glacial movements. Unfortunately, his research suffered from many of the same methodological limitations that plagued Hansen's work. Heusser concurred with Hansen in that he felt his data indicated the existence of a warm, dry climatic interval although he estimated the event to have occurred from about 7,000 years ago to 3,000 years ago.

Sigrid Lichti-Federovich has provided interpretations based on data obtained from sediment cores of Lofty Lake (1970) and Alpen Siding (1972). Both sites lie in the Boreal Forest region of Alberta (Figure 1). Lofty Lake is located 50 kilometers east of Athabasca, Alberta, and Alpen Siding is 40 kilometers south-southeast of Athabasca. Both reveal

FIGURE I: Locations of previous paleoecological studies. Present study in Elk Island National Park.



similar pollen sequences.

The earliest pollen zone, radiometrically dated at about 11,000 years B.P., contains extremely high levels (40% - 60%) of *Populus*. This lowermost zone is short-lived and succeeded by a pollen spectrum containing over 40% *Picea*. The *Picea* zone is succeeded by a spectrum dominated by *Betula*. This spectrum contains 30% - 60% *Betula* and exists from 9,000 to 7,000 years B.P. From 7,000 to 3,500 years B.P. the pollen spectrum is high in Gramineae (up to 20%), Chenopodiineae (5%), *Ambrosia* (5%), and Artemisia (10% - 15%), while relatively low in *Picea* (10% - 20%), *Pinus* (20%), *Betula* (15% - 25%), and *Populus* (5% - 20%). From 3,500 years B.P. onwards the pollen record, compared to the previous zone, shows a decrease in Gramineae, Chenopodiineae, *Ambrosia*, and *Artemisia* (all less than 5%) concomitant with a slight increase in *Picea*, *Betula*, and *Alnus*.

Lichti-Federovich (1970) feels that the data indicates a warm, dry period (the Hypsithermal) bracketed by two moister, cooler periods. She goes on to speculate that the northern expansion of the grassland during the Hypsithermal interval spanned a distance of some 80 kilometers. She places the Hypsithermal interval from 7,500 years B.P. to 3,500 years B.P.

Ritchie (1976) has synthesized much of the palynological data from western interior Canada. Although the developmental sequence that Ritchie puts forth for Alberta is based solely on the work of Lichti-Federovich it does provide a regional framework for the Neothermal. In addition, Ritchie does offer some interesting interpretations and also specifies some major problem areas.

Ritchie makes it quite clear that he is attempting merely to outline the apparent vegetative sequence with little offered in the way of causal explanations. In fact, Ritchie states quite clearly that he feels that "differences between phytogeographical speculations will not be resolved until ecologists produce experimental evidence from modern communities" (1976:1815). In other words, Ritchie feels that we must better understand mechanisms of change in modern ecosystems before we can begin to interpret the causes of vegetative changes evident in pollen records. He hints at some form of causal explanation only when he mentions that changes in lake sediments "from late-glacial organic silts to gyttjas to silty clays or sands, suggest lowered lake levels in the early post-glacial, probably in response to a drier climate" (1976:1815). Perhaps he is referring to a Hypsithermal interval? It is evident however, that Ritchie feels the problem of evaluating environmental influences is a difficult and outstanding one.

Besides offering a concise summary of the existing data, Ritchie brings out a number of important problem areas that he feels must be examined. Two of these problems are directly related to this thesis. These problems concern:

(1) The role that fire may have played in shaping the nature of the vegetation of the interior of western Canada.

(2) The nature of the vegetative history of the grass-

land-Aspen Parkland region; a region that has received little attention to date.

What is immediately obvious from this brief review is that our understanding of the vegetative record is very rudimentary. Needless to say, the causal explanations for what is known of the vegetative dynamics are nothing more than mere speculations. It is therefore readily apparent that new research in the area is a necessity.

Archaeology

For the purposes of this review, the province of Alberta is viewed as having three main environmental zones. One zone, the Boreal Forest, occupies the northern half of the province. Immediately south of the Boreal Forest is the Aspen Parkland, while the southeastern corner of Alberta lies within the Great Plains.

(a) The Great Plains

Wormington and Forbis (1965) developed a three phase post-glacial cultural sequence which applied to the Great Plains region of Alberta. This cultural sequence is based on diagnostic projectile point types and is simply stated as the Early, Middle, and Late Prehistoric Periods.

In the Early Prehistoric Period the first recognizable occupation of southern Alberta is characterized by the Clovis complex. The diagnostic projectile point type is a large, lanceolate point which is found contemporaneous with mammoth remains elsewhere in North America and is dated at about 11,000 years ago (Haynes 1964).

This earliest complex is immediately followed by a series of "type" projectile points that are thought to be associated primarily with the communal hunting of buffalo. The Early Prehistoric Period lasted until 7,500 years ago.

The Middle Prehistoric Period and the Late Prehistoric Period span the time from 7,500 to 200 years ago and are distinguished mainly by the size of the projectile points, the Late Prehistoric points being the smaller of the two. The technology is still thought to be associated with the communal hunting of buffalo. This kind of cultural continuity spanning the last 10,000 years is recognized and succinctly pointed out by Reeves. He stated that:

> Because of the nature of the available biomass, subsistence techniques and settlement patterns the basic cultural adaptations have remained essentially unchanged over the past 10,000 years. Similarly, basic adaptations of population and cultural dynamics have probably remained unchanged. (1969:36)

Even though this cultural reconstruction seems to indicate a fairly placid situation, there are nevertheless an array of interesting problems that have been generated from the existing archaeological record. Two such problems have a bearing on this thesis.

The first problem concerns the appearance of artifacts in the southern plains that are thought to be characteristic of more northern peoples. The discovery of microblades synchronous with Plano points on the southern plains was thought to illustrate that "at some remote period makers of microblades had penetrated into Alberta, probably from the north" (Forbis 1970:11). Similarly, Avonlea projectile points in southern Saskatchewan have been suspected to represent the southward movement of Athabascan people (Kehoe 1973). Does the appearance of these artifacts actually indicate a physical movement of peoples, a movement that would mean coping with an entirely new ecological situation? Perhaps we are simply dealing with a transmission of cultural traits across ecological borders? If so, where and how is this transmission of cultural traits carried out? These questions remain unanswered.

Another controversial topic deals with the effect of the Hypsithermal interval on the peoples of the northern Great Plains. A paucity of cultural remains on the plains from 7,500 years B.P. to 4,500 years B.P. has been interpreted by some as a "total abandonment by bison hunting cultures" (Reeves 1973:122); an abandonment presumably brought about by the extremely warm and dry conditions during the Hypsithermal interval. Is this in fact the case or are we simply dealing with a sample bias? On the other hand, if there was indeed a migration of the bison hunting cultures from the Great Plains during this time of enhanced temperature and decreased moisture, where did these people migrate to? The possibility of these people seeking refuge on the prairie fringes has been put forward previously (Wormington and Forbis 1965) however, this notion is mere speculation and along with all the above questions still remains to be satisfactorily answered.

(b) The Boreal Forest

The Boreal Forest region presents special problems to the archaeologist. In addition to the obvious problem of forest cover concealing sites there is also a problem of poor preservation of archaeological remains. Highly acidic soil conditions are common (caused by the decomposition of spruce and pine needles) and this high acidity contributes to high rates of decomposition of bone artifacts. Consequently, it is not surprising that the archaeological record in the Boreal Forest consists only of a scattered documentation of widely separated sites. The cultural history is derived, once again, through a sequence of diagnostic projectile points. Unfortunately, the area has not been summarized in the manner of the Great Plains (for a survey of critical sites and the projectile point sequence of each see Donahue 1976). However, certain aspects of the archaeological record are of particular relevance to this thesis.

The occurrence of projectile points in the Boreal Forest that are characteristic of the Great Plains is of interest. This feature of Boreal Forest cultural assemblages has been noted by many researchers (including Wright 1975, Noble 1971, Pollock 1976) and a variety of hypotheses have been put forth to explain the existence of these projectile points far north of where the technology of their production is thought to have evolved.

It has been suggested that these projectile points represent times when plains cultures inhabited the Boreal Forest (Pollock 1976), either through some unexplained migration or a migration in response to climatic change (Wright 1975). Other explanations take the position that these projectile points represent some sort of seasonal excursion (Minni 1973), possibly simply a movement northward to "capitalize on migrating caribou or stray buffalo" (Noble 1971:107). Considering the distance north that some of these diagnostic projectile points are found, it seems highly unlikely that they would represent simply a seasonal movement. Such a seasonal movement would, in some cases, take longer than the total length of the season itself. Furthermore, the distance northward could not reasonably be accounted for by climatic change since the post-glacial climatic records of western Canada do not indicate ecological shifts of the magnitude necessary to account for these migrations (Lichti-Federovich 1970, Ritchie 1976). It is therefore suggested that the occurrence of plains-like projectile points in the Boreal Forest has not been adequately explained, a situation that is parallel to the problem of accounting for the occurrence of northern cultural traits on the Great Plains.

(c) The Aspen Parkland

The Aspen Parkland of Alberta has been subjected to very little archaeological research. What has been done is, for the most part, confined to piecemeal surveying. The surveys conducted indicate there exists a cultural record that stretches back over the last 8,000 to 10,000 years (Losey 1975). Although the archaeological work is sporadic and cursory it does appear that there is an abundance of sites and that these sites are mainly campsites (ARESCO 1977) located, in the main, around bodies of water (Losey 1975). Many workers mention the importance of modern agricultural techniques as mechanisms of site disturbance. However, even with this disruptive element the initial surveys have recovered elements of each of the three recognized cultural phases of the plains region. This evidence indicates that there may be a complete archaeological sequence available in the area (Losey 1975). However, until more thorough work is completed one may only speculate on the cultural history of the area. Nevertheless, certain relevant questions concerning its cultural history are generated by archaeological research in the surrounding regions.

Considering, (a) the observed north/south distributions of Plains/Forest culture traits far beyond their ecological borders and, (b) the position of the Aspen Parkland between these two distinct environments, it seems logical to question the role that the Aspen Parkland may have played in bringing about these heretofore unexplained distributions. Was the Aspen Parkland an important area of cultural interchange? If it was, one would expect to find a mixture of both Plains and Forest archaeological sites within the Aspen Parkland.

Further questions concern the role that the Aspen Parkland played during the Hypsithermal interval. If in fact the Great Plains were virtually uninhabitable during this time, Plains people would have been forced to move to the fringes of the Great Plains (as suggested by Wedel 1961, Wormington and Forbis 1965) and consequently one would expect to find a proliferation of archaeological sites in the

Aspen Parkland during the time of the Hypsithermal interval. Thorough archaeological investigations are necessary to address this hypothesis.

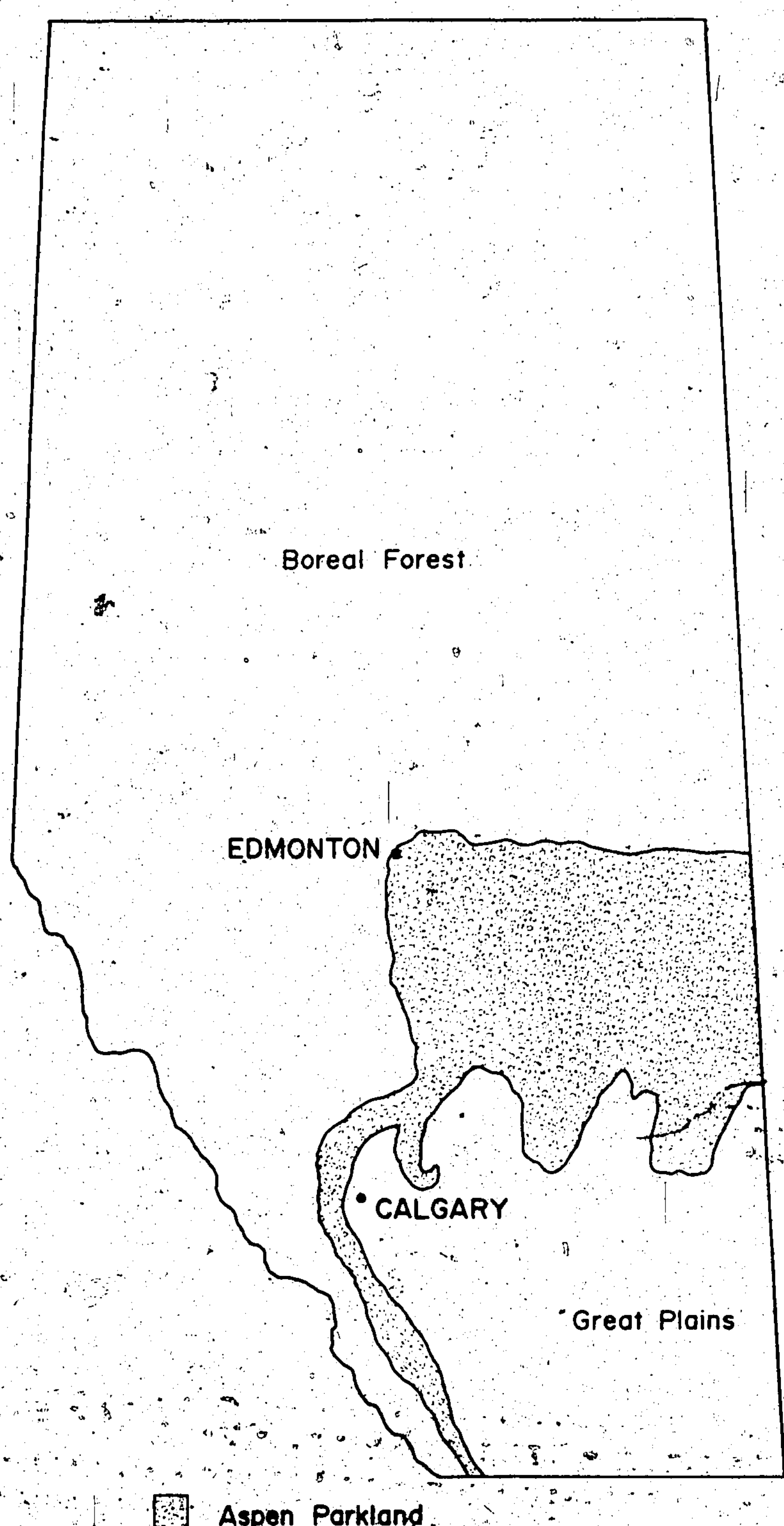
CHAPTER 3 THE ASPEN PARKLAND OF WESTERN CANADA

The Aspen Parkland is a distinct ecological zone that extends across the prairie provinces of Manitoba, Saskatchewan, and Alberta. In Alberta it is bordered by two larger ecological zones, the Boreal Forest and the Great Plains (Figure 2).

The Great Plains region of southeastern Alberta is the characteristic short grass plain which is the northwesternmost extension of the Great Plains of North America. This twelve million acres of the Great Plains is characterized by flat to rolling topography, treelessness, and a semi-arid climate. The dominant short grass species of the area include grama grass (Bouteloua gracilis), needle grass (Stipa comata), wheat grass (Agropyron smithii), and June grass (Koeleria gracilis) (Moss 1955). The region has very low precipitation, somewhere between 30 to 50 centimeters (12-20 inches) per year (Reeves 1969). This low precipitation has been suggested as being the critical climatic factor in the maintenance of the plains region (Dix 1964, Forbis 1970, Reeves 1973). It has also been hypothesized that environmental influences such as fire and trampling by buffalo herds were also powerful agents in creating and maintaining the grassland condition (Wedel 1953).

Directly north of the Aspen Parkland lies the Boreal Forest. The Boreal Forest characteristically has higher annual precipitation and lower average temperatures than the southern plains region (Longley 1967). The rolling

FIGURE 2: Extent of Aspen Parkland in Alberta (after Bird 1961).



topography of the area is typically extensively covered with evergreen species, the only breaks in this forest cover are offered by the numerous lakes and the sporadic occurrence of peat bogs in poorly drained areas.

Certainly the most dominant tree species of the Boreal Forest is white spruce (*Picea glauca*). This species is found on both upland and lowland sites. However, its place may be taken on hydric sites by black spruce (*Picea mariana*) and tamarack (*Larix laricina*); it may be superceded on recently disturbed sites by either aspen (*Populus tremuloides*), lodgepole pine (*Pinus contorta*), or jack pine (*Pinus banksiana*); or it may be succeeded by balsam fir (*Abies balsamea*) (Moss 1953).

Directly between the Boreal Forest and the Great Plains lies the Aspen Parkland. In Alberta, it occupies an area of about 55,000 square kilometers (Moss 1932). It characteristically has rolling topography (kettle and knob topography) with a large number of small lakes and sloughs common in the depressions. The mean annual precipitation of the area is about 45 centimeters (18 inches) in the northwestern fringes and about 40 centimeters (16 inches) in the southeastern portions (Bird and Bird 1967).

The vegetation of the area "may be described as a mosaic of prairie patches and aspen groves, with prairie occupying the drier situations and aspen the more moist sheltered places" (Moss 1955:516). The most dominant tree species is, without a doubt, aspen or white poplar (*Populus tremuloides*). However, this species sometimes gives way to balsam poplar

(*Populus balsamifera*) on the more hydric sites. On some occasions, given that disturbances are minimized for a relatively long time period, white spruce (*Picea glauca*) may succeed the poplar. Presumably this spruce arises from the northern seed source of the Boreal Forest.

The Aspen Parkland exhibits a vegetative type that is a mixture of species from both the Great Plains and the Boreal Forest. Obvious vegetative elements from the north include the sporadic occurrence of the characteristic northern tree species, white spruce (*Picea glauca*) and white birch (*Betula papyrifera*). Less obvious, but no less important, are the common occurrences of herbs and shrubs that are characteristic of the northern Boreal Forest. These include such species as horsetail (*Equisetum* spp.), buffalo berry (*Shepherdia canadensis*), wild roses (*Rosa* spp.), and dogwood (*Cornus stolonifera*). Also common to the Aspen Parkland on xeric sites are the characteristic grasses of the northwestern Great Plains; needle grass (*Stipa comata*), June grass (*Koeleria gracilis*), and grama grass (*Bouteloua gracilis*). As the Aspen Parkland exhibits such a vegetative mixture it is considered to be a zone of transition between the Great Plains and the Boreal Forest. Such zones of transition have been termed as ecotones (Daubenmire 1968) or tension zones (Curtis 1959). Although a great deal of print has been devoted to the discussion of properties of these transition zones, the following will rely heavily on the work of Daubenmire (1968).

Daubenmire (1968) defines an ecotone as simply a zone of intergradation between two plant communities. He goes on to describe two types of ecotones, simple ecotones and complex ecotones. Simple ecotones are distinguished by the fact that they represent a blending of the two contiguous communities; this blending may be very abrupt or may be more gradual and extend over a gradient. A complex ecotone, on the other hand, is a term used to describe a situation in which the two contiguous communities interdigitate rather than merge by degrees. The resulting vegetation is best viewed as a mosaic of the species represented in the bordering communities with the possibility of additional species occurring that are specific to the mosaic itself. Since the Aspen Parkland is a zone that contains groves of aspen (Populus tremuloides) mixed with openings of prairie grassland over a broad areal extent, it is best classified as a complex or mosaic ecotone.

Maintenance of Ecotones

Daubenmire states that mosaic ecotones are common to areas where "climate causes one type of vegetation to give way spatially to another" (1968:23). Since climate is thought to be the ultimate factor in controlling the distribution of vegetation it must be given primary consideration as an agent in the maintenance of an ecotone.

It has been noted that the Aspen Parkland is situated on Chernozemic soils with the characteristic Grey Wooded soils of a forest environment developing on this Chernozemic soil substrate (Bowser et al. 1962). As Chernozemic soils are characteristically formed under heavy grass and herbaceous vegetation (ibid), this development of Grey Wooded soils on Chernozemic soils suggests that the "aspen parkland represents a recent invasion of the aspen upon an area that had been grass for a considerable period" (Bird 1961:2). Since the climatic factor necessary for the maintenance of the grassland condition is a paucity of rainfall (Dix 1964, Forbis 1970, Reeves 1973) and the annual precipitation of the major biotic provinces of Alberta indicates a gradient of increasing precipitation as one moves from southeast to northwest (from 30 centimeters (12 inches) in the southeastern plains region to 40 centimeters (16 inches) near the southern border of the Aspen Parkland to 45 to 50 centimeters (18-20 inches) in the Boreal Forest) (Longley 1967) it would appear that rainfall is an important factor in the maintenance of the Aspen Parkland. One could suggest that the Aspen Parkland occupies a region characterized by an annual amount of precipitation that is near a critical level necessary to support tree growth.

A further climatic consideration is temperature. Bryson (1966) has developed a model of atmospheric circulation based on the mean frontal positions of the major air masses over the North American continent. His model, albeit based on a limited time of observation, shows that the Boreal Forest falls within a climatic province that lies between the mean winter and summer positions of the Arctic front. The correlation of the Boreal Forest/Aspen Parkland boundary and the mean frontal location of the Arctic front is excellent, varying only slightly in the extreme western limits, an area of variation that Bryson claims is due to rapidly increasing elevation as one approaches the Rocky Mountains. This high degree of correlation suggests that the Aspen Parkland's position is determined, at least in part, by an abrupt winter temperature cline.

But climate is not the only factor that must be considered in the discussion of maintenance of a transition zone. There exists an array of ecological factors that may be cited as determinants in the maintenance of the Aspen Parkland. The first, and probably the most important, is fire.

In general, the earliest ecologists tended to grossly underestimate the role of fire in natural environments. This lack of knowledge led to the widespread public view that wildfires were purely destructive. Subsequent efforts to subdue natural fires led to enormous environmental alteration. However, outside this general concensus on the negative influence of fire were a few ecologists who developed differing attitudes on the ecological role of fire. Gleason, in 1922, stated that he felt that North American Indians had greatly expanded the area of grassland through the use of fire. Later, Stewart (1951) pointed out that ecologists have failed to incorporate fire into models of community maintenance and formulation, especially fires created by American Indians. He added that to ignore or to slight consideration of burning might be to nullify conclusions that would otherwise seem justified.

This amended view on the ecological role of fire has led to a whole new conception of community maintenance, a conception that is only now beginning to affect various agencies in present day management policies. Fire is now being looked upon as a necessary ingredient in the maintenance of highly productive, "healthy" ecosystems. This is particularily true of models of grassland community maintenance (Bird 1961, Dix 1964).

It appears that fire was of particular importance in contributing to the determination of the boundary of the Aspen Parkland. Historic references make mention of the fact that fire was a common and widespread characteristic of the prairie environment (Bird 1961, Bird and Bird 1967). North American aboriginal peoples have been known to use fire to drive buffalo herds over jumps or simply to alter the environmental situation so as to bring game into desired hunting areas (Arthur 1975). One writer even notes that natives of the northwest prairies burned areas around trading posts so as to increase the value of the meat they supplied to the traders (Ray 1974). It is easy to conceive of a situation where natural fires combined with man-caused fires occurred at such a rate as to inhibit repeatedly the growth of trees over the large, flat expanse of the Great Plains. It is also easy to visualize a situation in which the combined effect of a slight increase in ground moisture and slight topographic relief (both characteristic of the Aspen Parkland region) could bring a halt to many of the slow burning ground fires, thereby facilitating the growth of some tree species. Obviously a tree well adapted to these ecological constraints, considering its rapid rate of growth, its tendency to colonize open areas, and its ability to regenerate from its own roots, would be aspen (Populus tremuloides). It is also apparent that during times of drought (for example, the Hypsithermal interval), expansion of the grassland could have easily occurred due to the general increase in the numbers of fires and also to the increase in the area burned because of the overall decrease in soil moisture.

Another factor that is of importance to the maintenance of the Aspen Parkland is the damage to trees inflicted by large herbivores such as buffalo (Bison bison) through activities of wallowing or trampling (Wedel 1953). Browsing by elk (Cervus canadensis) and moose (Alces americana andersoni), animals that were reported to be abundant in the Aspen Parkland before settlement (Bird 1961), can also retard the growth of trees and shrubs.

A further consideration in the maintenance of the ecological borders of an ecotone are the activities of European man, especially settlement and agricultural practices. Needless to say, these practices have profound influences on ecosystems and will tend to override other factors. For this reason, the activities of European man will be discussed later under a separate heading.

Properties Exhibited by Ecotones

Associated with the concept of an ecotone are some ecological principles that are of particular relevance to this thesis.

The first principle has to do with the relevance of ecotones to paleoecological research. Since ecotones often lie on the fringes of major biotic provinces, they are generally considered to be more "sensitive" to environmental changes than the surrounding communities. In other words, an ecotone will show rapid and dramatic responses to environmental change. For this reason, ecotones have come to be viewed as ideal situations in which to study the effects of environmental change (Bryson 1966) and therefore obviously are prime candidates for areas of paleoecological research.

In addition to this, a region such as the Aspen Parkland is an area that is particularily good habitat for many game species. Not only is there the higher productivity associated with early seral stages (Loucks 1970) but there is the added effect of the creation of a maximum area of "edge." Edge area occurs at the boundary of any two diverse plant communities. It often contains a greater variety and density of plant species than the surrounding plant communities (Odum 1971). Such a situation provides animal species with concentrations of a variety of food resources, and this consequently attracts a large number and variety of animal species. This concentration of plant and animal species is a phenomenon known as "edge effect." So well known is this principle and its implications that Leopold, the pioneer of game management on this continent, stated unequivocally that "game is a phenomenon of edges" (1933:131).

A mosaic ecotone, with its characteristic "islands" of vegetation housed in a matrix of distinct plant communities, maximizes edge area. The Aspen Parkland, with its groves of trees and shrubs mixed within a grassland environment, provides a classic example of this ecological setting. The diversity and abundance of game species in the Aspen Parkland noted by the earliest Europeans reinforces the application of such ecological principles to this area. Descriptions of vast herds of buffalo (Bison bison) combined with large numbers of antelope (Antilocarpa americana), elk (Cervus canadensis), mule deer (Odocoileus hemionus), moose (Alces americana), black bear (Ursus americanus), timber wolf (Canus lupus griseoalbus), buffalo wolf (Canus lupus nubilis), snowshoe rabbit (Lepus americanus americanus), beaver (Castor canadensis canadensis) and muskrat (Ondatra zibethicus) (Bird 1961) give one the impression of a land of plenty with seemingly endless subsistence opportunities. It would seem logical that such a situation would be ideal for aboriginal populations thereby making the region a prime area of occupation. Is this hypothesis borne out by the available data? To answer this question one must turn to the archaeological and historical records.

Aboriginal Utilization of the Aspen Parkland

(a) Prehistoric Evidence

On the basis of the preceding discussion one would expect to find a great proliferation of evidence of aboriginal utilization of the Aspen Parkland. However, this hypothesis has not been tested in western Canada simply because there is not yet a sufficient data base to carry out the test adequately.

In Alberta the majority of the archaeological work in the

Aspen Parkland has been scattered, cursory survey work. Little has been discerned from the results of this type of work. An archaeological survey along a proposed highway route indicated that the Aspen Parkland contained a greater density of sites than either the Boreal Forest or the western foothill region of Alberta (Losey et al 1975). Other survey reports indicate two important points. Firstly, sites in the Aspen Parkland seem to be most often in close proximity to large bodies of water (Lifeways 1976, Losey 1975, Reeves 1977). This finding is not too surprising as archaeologists have long since recognized the tendency for peoples to prefer such resource-rich areas. In addition to this, the length of time represented by scattered finds in the Aspen Parkland indicate a long record of occupation. Based on the projectile point typologies developed in the Great Plains it appears that the Aspen Parkland region shows evidence of occupation stretching back some 8,000 to 10,000 years (Losey 1975, Reeves 1977).

In terms of actual excavations only two archaeologists have produced detailed reports on sites lying within the Aspen Parkland region of Alberta. The first, the Fullerton site in east central Alberta (Taylor 1969), is an unstratified lookout site that again substantiates the notion that the Aspen Parkland has been occupied for some 10,000 years. Unfortunately, due to the redeposition and disturbances on the site itself, little else may be concluded.

Losey (1978) has excavated three prehistoric sites on the western edge of the Aspen Parkland. The materials recovered span a period of 3,300 years, from 4,450 years B.P. to 1,150 years B.P. The three sites appear to be processing sites with buffalo (Bison bison) being by far the most abundant species represented in the faunal remains. Tentative conclusions indicate that the sites represent the presence of both plains-oriented and forest-oriented peoples in the same spatial proximity. However, Losey does point out the difficulties encountered when trying to discern cultural affiliations from such a paucity of artifacts and ethnographic information. Losey concludes that the sites were winter occupations located within the ecotone specifically to capitalize on herds of wintering buffalo. He also indicates that the possibility of cultural interaction between plains and forest peoples in such a situation would be highly feasible.

Further east, near Saskatoon, Saskatchewan, excavation of a bison hunter's camp in the Aspen Parkland has been completed. Dyck (1977) reports that the site represents a short term occupation (estimated at 21 to 42 days) of a hunting and gathering group. This site (the Harder site) has been radiometrically dated at 3,400 years B.P. Dyck feels that the faunal remains indicate that at the time of occupation the local environment was similar to the existing Aspen Parkland. He does not, however, attempt to describe any cultural affiliations of the inhabitants beyond pointing out that the dominant projectile point recovered belongs to the Oxbow complex. Since the majority of the faunal remains were buffalo (Bison bison bison) Dyck feels that the inhabitants were capitalizing on the abundant buffalo herds in the area, most probably in the winter since it is well known that extreme cold combined with wind will drive buffalo herds into wooded areas for shelter (Fuller 1966).

In Manitoba a great many excavations have been carried out in and around the Aspen Parkland region. Recent work in the area (Syms 1977) has emphasized the fact that this region contains much greater aboriginal diversity than has so far been assumed. Syms adds that the ecotone offers a high resource potential that was recognized and exploited by a great number of diverse peoples. Furthermore, the peoples of the region were characterised by being highly mobile. Syms feels that this mobility was the result of:

> (a) utilization of several environments for different resources on a seasonal basis, (b) shifting from area to area due to tribal conflict, (c) intratribal conflict, and (d) trading with other groups. (*ibid*:38)

It must be pointed out that the area in question was noted in ethnographic times for its diversity in its native populations and their subsistence methods. Also, archaeologists here have the added interpretive aid of ceramic remains. These are reliable aids in interpreting cultural affiliation. Unfortunately, ceramics are virtually absent in western sites of the Aspen Parkland.

Syms' research does provide an interesting model of ecotone utilization, a model that should be examined closely with regard to Alberta's prehistory. Syms' model emphasizes mobility and capitalization on a variety of resources varying in abundance both seasonally and spatially.

(b) Ethnohistoric and Ethnographic Evidence

Ethnohistory, an attempt to glean information from a variety of historical sources, can often provide a great deal of information relevant to archaeological interpretation. Unfortunately, in the case of the western prairies at the time of contact, the native groups occupying the region had not been there for very long. In fact, many of the peoples living in the area had arrived as recently as the early eighteen hundreds. These people had moved westward in response to the decline of fur bearing animal populations in the east (Fisher 1968). This means that the Cree, Assiniboine, and Ojibwa were not the traditional inhabitants of the northwest, contrary to the viewpoint held since the establishment of the fur trade. It is now believed that the original inhabitants were forced westward and northward in the face of the expansion of the better-armed tribes of the eastern forests (ibid). As a consequence, ethnohistoric accounts will not apply to the prehistoric inhabitants.

Recent studies (Losey 1978) indicate that the traditional inhabitants of the northern mixedwood forests of Alberta were the Athapascan speakers, the Beaver, Sarsi, and Sekani. Inhabitants of the grassland region were the Blackfoot. Unfortunately, ethnographic accounts of the traditional life of these peoples, especially the Sarsi and Sekani, are incomplete. What is available states that the Sekani and Sarsi are thought to have been closely related and to have followed the characteristic Boreal Forest subsistence pattern. This pattern involved a seasonal round that captitalized on a variety of big game and fish resources (Jenness 1932). The Beaver, on the other hand, developed a slightly different seasonal round that employed the buffalo hunt in the winter season. The method utilized was driving the buffalo into pounds "after the manner of the plains tribes" (*ibid*:383).

The plains group, the Blackfoot, adopted a subsistence pattern that closely followed the movements of their main source of livelihood, the buffalo. This pattern included the congregation into large camps during the summer and fall months (when the buffalo were in large herds) and the dispersal into smaller units during winter and spring (when the buffalo dispersed). This time of dispersal usually found the Blackfoot occupying sheltered areas, either riverine environments or the wooded areas on the fringes of the prairies (*ibid*).

The westward expansion of the Cree, Assiniboine, and Ojibwa is the first discernible effect of the fur trade on the ecology of the Aspen Parkland. It has been suggested (Ray 1972) that this westward migration is reflected in the archaeological remains of southern Manitoba. The available data indicates that the expansion of the Assiniboine had begun in early protohistoric times. By the mid-eighteenth century the suspected traditional inhabitants of the northwestern Boreal Forest (the Beaver, Sarsi, and Sekani) had been pushed northward by the Cree (advancing mainly through the Boreal Forest) and the Assiniboine (moving through the Aspen Parkland). The interaction of the Cree and Assiniboine during this period of the fur trade provides an intriguing model of aboriginal utilization.

According to Ray (1972, 1974) the roots for the basis of this mode of utilization lie in the cyclical nature of game abundance in the Aspen Parkland and the Boreal Forest. In the Boreal Forest, game was relatively abundant during the summer and fall. At these times big game could be easily hunted, the fisheries yielded their best results, and waterfowl was abundant. However, in the winter, the fisheries declined in productivity since the fish sought out warmer, deeper water and the waterfowl migrated out of the area. Therefore, during the later months of the winter the inhabitants of the Boreal Forest (at this time the Cree) were faced with a decline in the availability of their food resources.

In the Aspen Parkland the Assiniboine were faced with similar cycles of resource availability. Summer and fall were again times of high productivity; the fisheries and waterfowl were plentiful. However, the winter did not produce the same sort of scarcity because of one critical difference; the buffalo herds migrated into the shelter of the Aspen Parkland during the harsher weather. This migration of the buffalo into the Aspen Parkland had a profound influence on Cree-Assiniboine relations.

The abundance of buffalo stimulated the winter movement of the Cree into the Aspen Parkland. Ray states that "it is clear that there was a general winter movement of Indian populations out of the forests of Saskatchewan into the parklands" (1974:45). This meant that during winter months there were two distinct aboriginal groups occupying the relatively small area of the Aspen Parkland. Interactions occurred, as reports exist of Cree and Assiniboine peoples working the same bison pounds from the same camps (ibid). The role played by the ecology of the Aspen Parkland in stimulating this interaction is clear. The question that immediately comes to mind is whether this sort of interaction among groups of grassland and forest dwellers could have occurred in prehistory.

Utilization of the Aspen Parkland Region by European Peoples

With the decline of the populations of fur bearing animals in western Canada came the subsequent decline of the fur trade. The Indian peoples, many of whom having prospered as trappers and middlemen in the fur trade, were of little economic importance to the now dominant white society. In fact, they came to be viewed as somewhat of a hindrance to the rapidly expanding numbers of European settlers arriving on the scene. With the near extinction of the buffalo during the late nineteenth century the aboriginal populations had no choice but to sign land title treaties with the Canadian government. These treaties relegated the Indians to the small, scattered reserve areas designated by the government.

With the decimation of the buffalo and the restriction of Indian activities (more specifically, restriction of their burning activities), two of the major environmental factors of boundary determination of the Aspen Parkland became inoperative. In addition, the settlers, who initially may have caused an increase in the numbers of fires in the area (Nyland 1969), began actively to suppress fires. This factor added to the conditions already established that would lead to the expansion of the Aspen Parkland.

Other factors came into operation with the advent of widespread mechanized agriculture. Many species of game populations were reduced. Land clearing increased the effects of wind and water erosion. New plant and animal species were introduced, and herbicides and insecticides altered the ecological situation. In fact, the results of these activities have created conditions which preclude the existence of any area of the Aspen Parkland that remains in the condition described in the early fur trade (Bird 1961). However, in the face of these powerful and disruptive elements it has been noted that the Aspen Parkland, as it now exists, is increasing its area on the southern boundary, mainly because of the disappearance of the buffalo herds and fire, two of the major limiting factors on its expansion in prehistoric times (Bird and Bird 1967).

Summary

The Aspen Parkland may best be described as a mosaic ecotone. As such, it exhibits properties that are of importance to this thesis. Firstly, because they are situated on fringe areas of major climatic and environmental zones, ecotones respond dramatically and quickly to environmental changes. Secondly, because they often possess greater edge area than the surrounding biotic provinces, ecotones attract a large number and variety of game species. Presumably this high productivity of game species would serve to attract aboriginal populations. Therefore, considering the above properties, the Aspen Parkland is an ideal location in which to examine the nature of man/land relationships relevant to cultural ecology.

Modern ecological studies combined with data from historical documents reveal that the extent and location of the Aspen Parkland is determined by the interaction of an array of factors. Climate (particularily rainfall and winter temperatures), fire, activities of game species, and land-use patterns by man are important determinants. It is the dynamic relationships of these factors that determine the boundaries of the Aspen Parkland.

Archaeological studies in the Aspen Parkland are, in general, scattered and cursory. Only in areas east of Alberta have a number of detailed archaeological investigations been carried out. This understandably restricts the analysis of prehistoric culture change. However, ethnographic studies reveal important seasonal cycles centered around the Aspen Parkland that brought together diverse cultures during the harsher climates of winter months. This land-use pattern facilitates the opportunity for cultural exchange and such an exchange would have important implications on the interpretation of Alberta's archaeological record.

CHAPTER 4 METHODS OF STUDY

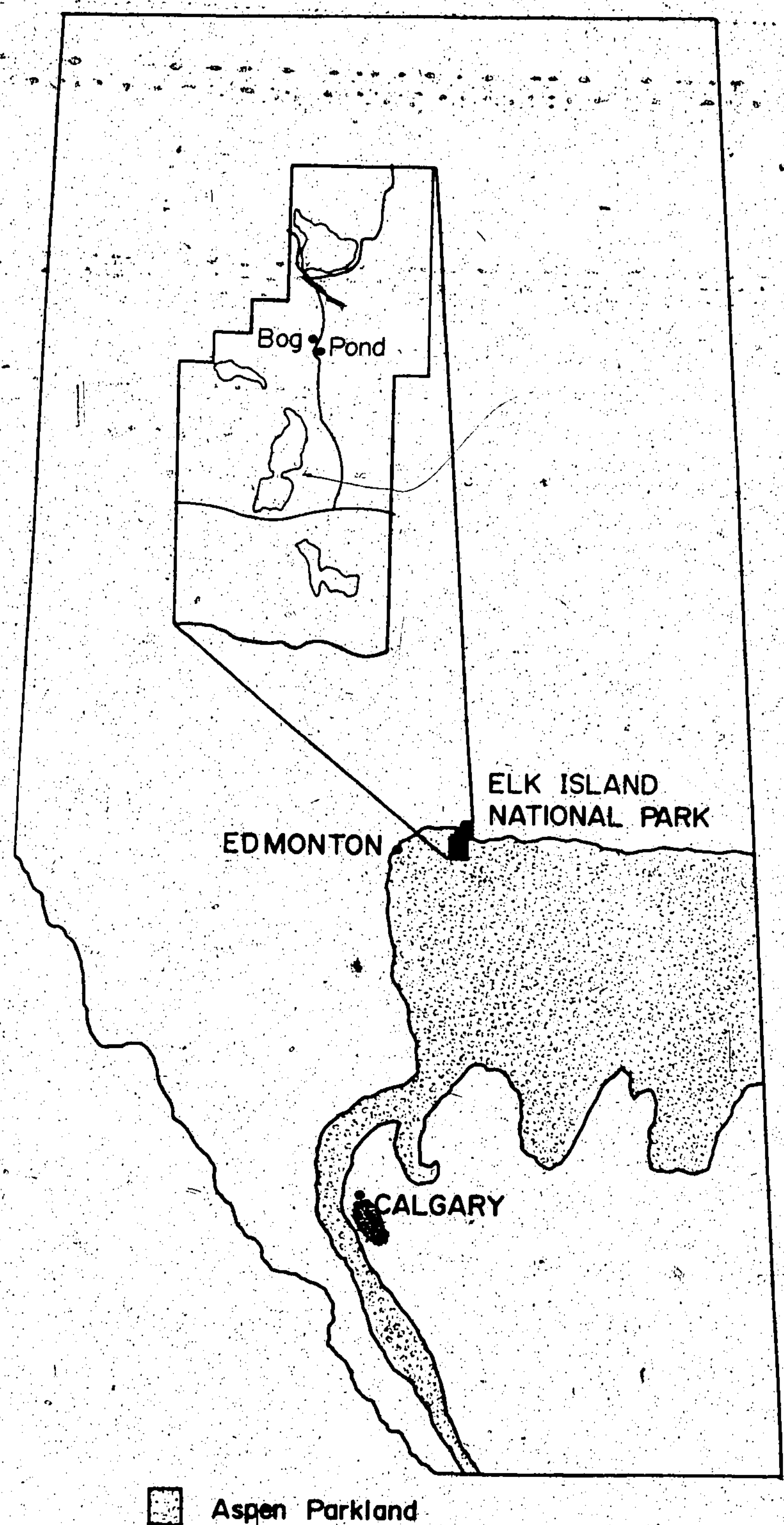
Site Location and Description

In order to establish a paleoecological sequence for the Aspen Parkland region in central Alberta a palynological investigation was initiated in a bog and a small pond within the confines of Elk Island National Park. These sites were chosen because they yielded sediments suitable for analysis and also because they offered easy access. This ease of access was necessary to accomodate an interpretive program that Parks Canada was to develop from this study. The sites are located within Township 54, Range 20 at 53° 38' N, 112° 51' W (Figure 3).

Elk Island National Park lies on an area of slight topographic relief known as the Beaver Hills. The Beaver Hills rise some 30 to 60 meters (100-200 feet) above the surrounding plains, reaching a maximum elevation of 820 meters (2,700 feet) above sea level (Lang 1974). However, Elk Island National Park lies on the slightly lower northern portion of the Beaver Hills, the maximum elevation within the Park being about 755 meters (2,475 feet) above sea level (ibid).

Geological studies reveal that the underlying bedrock of the region is made up of Precambrian rocks. On this base a variety of sedimentary rocks have formed over the past 70 million years, mainly results of "flooding by shallow seas and subsequent up-lifts throughout the Paleozoic and part of the Mesozoic eras" (Seace et al 1976). More recently, the

FIGURE 3: Location of coring sites, Elk Island National Park.



surficial geology of the Beaver Hills region has been shaped by the interaction of lake and glacial deposits associated with several glaciations. These glacial advances occurred at various times throughout the Pleistocene and terminated with a final glacial recession marking the beginning of the Neothermal.

The retreat of glacial ice in central Alberta involved a process of melting isolated, stagnant blocks of ice. This melting of ice in blocks (rather than the whole mass of ice) produced a hummocky topography commonly known as "kettle and knob" topography. It is within these "kettles" (depressions) that the two coring locations are situated.

The bog coring site is best described as a typical northern bowl bog. The organic mat that forms the floor of the bog is completely covered with Sphagnum mosses. Laborador tea (Ledum groenlandicum) and cranberries (Vaccinium vitis-idaea) form a thick low shrub cover while black spruce (Picea mariana) is scattered over the floor of the bog. Directly adjacent to the bog is a vegetative community dominated by a dense stand of willows (Salix sp.). This community is ringed by the typical Aspen forest upland community of the Aspen Parkland.

The adjacent pond is ringed by four distinct vegetative communities. The open water is surrounded by a dense ring of cattails (Typha latifolia). This vegetative community gives way to one dominated by sedges (Cyperaceae) which in turn is surrounded by a dense willow (Salix sp.) thicket. The willow thicket gives way to the ubiquitous Aspen forest community.

Coring

Both sites were cored using a modified Livingston piston sampler (Cushing and Wright 1965). This operation was carried out in the bog during the fall of 1975 and on the pond during the winter of 1976. The common problem of compression and subsequent loss of the uppermost sediments in the bog core was compensated for by digging a soil pit and collecting the samples for the first meter directly from the pit. In the pond the uppermost portion of the core was also lost due to the soft nature of the sediment near the sediment-water interface. In order to overcome this sediment loss a method known as the "frozen-finger" or "frigid-finger" (Shapiro 1958) was employed. Replicate cores were extracted from each site and once secured they were frozen for storage. Over the course of the research these cores were thawed and sampled.

Vegetative Analysis

In an effort to determine the vegetative composition of each site and its immediate surroundings a vegetative study was initiated that included the following steps:

(1) Mapping of the vegetative communities on and bordering the coring sites. This was accomplished by locating community boundaries along a series of line transects.

(2) Collection of quantitative data to determine the composition of the vegetation. This was done by locating a maximum of twenty random sample points within each vegetative community. At each sample point a series of measurements were made:

(a) By utilizing the quarter point method (Cottam and Curtis 1956) data was collected concerning the relative frequency, density and dominance of trees, shrubs, and seedlings (less than 1 m in height) on the site.

(b) A one square meter plot was laid out and the occurrence of herbs and low shrubs (less than 20 cm in height) was noted. Percentage occurrence for each species was determined by the no. of quadrats it occurred in/total no. of quadrats X 100. Also, the percentage cover of each life form represented was estimated.

(c) At every sample point a "pinch" of ground cover was sampled. This sample was collected for pollen analysis. The analysis of this sample provides information on the modern pollen rain, that is, the pollen spectrum that the existing vegetation sheds.

(3) A line transect was run across each coring site to measure the percentage leaf area of each species of herbs and low shrubs (Daubenmire 1968). This was accomplished by measuring leaf coverage of each individual along a 50 m tape. Linear measures were then summed for each species and expressed as a percentage of total linear coverage of all species.

In addition to the vegetative analysis a series of tests were carried out to characterize the soils and soil water of each vegetative community. Decomposition of the organic soils was determined by the Von Post rating (Von Post 1924) and depth to water was measured. A water sample was collected from each community and analyzed for pH and calcium content. Calcium content was determined by the EDTA titration method (Taras 1971).

Pollen Analysis

(a) Sampling

Each core was described according to the types of sediments represented and various physical properties they exhibited. The cores were zoned and described by their characteristic appearance according to the Munsell color chart. Organic sections were further classified through the Von Post decomposition rating (Von Post 1924).

The lowermost five centimeters of the replicate cores were removed for radiocarbon dating. Additional radiocarbon dates were acquired from (a) a five centimeter slice from the middle (95-100 cm) of the pond core and, (b) a root fragment (probably _Picea mariana_) retrieved from a depth of 60 centimeters from the bog. All sediment samples were pretreated to remove carbonates and humic acids. The root fragment was examined under a microscope to ensure no obvious impurities existed and then was pretreated for humic acid removal.

The bog core was sampled every five centimeters by removing a one centimeter slice. Care was taken to sample only from the central portion of the core so as to avoid the possible contaminants on the exterior surface of the core. To sample the pond core, a one cubic centimeter spoon was used. At two centimeter intervals, one cubic centimeter of sediment was taken as a sample.

(b) Processing

Processing followed the standard procedure outlined by Faegri and Iverson (1964). Since the sediment had a high silt content a one hour boiling in HF was used to remove silicates. This treatment was followed by three minutes of acetolysis. Each sample was stained with methyl red hydrochloride and mounted in glycerol for counting.

In the case of the sample material from the pond two Stockmarr pills (Batch no. 212 761) were added to each sample before processing. These pills contain a known number of acetolyzed Lycopodium spores and are used to compute absolute pollen influx following the method outlined by Maher (1977).

Samples collected for the analysis of modern pollen rain were treated with the standard washings (Faegri and Iverson 1964), acetolyzed for three minutes, and mounted in glycerol for counting.

(c) Counting

All samples were counted at 400 power on a Leitz SM-Lux microscope. For each sample a total of 200 pollen grains were counted. Identifications were verified using the reference collection located in the Paleoenvironmental Studies

Laboratory at the University of Alberta. Traverses during counting were split equally between the margin and the center of the slide so as to avoid a possible bias brought about by differences in pollen grain size (Maher 1977).

In addition to the pollen counted, charcoal fragments over 15 microns in size were also tabulated. During the counting of the charcoal fragments, it was observed that many of the alleged charcoal fragments were opaque, regular spheres. Upon closer inspection, it was decided that these spheres were not charcoal, but in fact most likely pyrite spherules (Vallentyne 1963). Unfortunately, chemical determinations were not carried out to confirm their exact composition although it was clear they were not charcoal. The spherules were also counted for each sample.

Surface samples collected for the analysis of modern pollen rain were counted by the methods listed above. However, in addition to the counts described above a further step was taken. Due to the notoriously poor preservation of Populus pollen grains (Sangster and Dale 1961) a second count was made on all surface samples that excluded Populus pollen from the pollen sum. This second count is thought to be a more realistic figure for comparison to fossil pollen rains.

In the samples prepared from the pond sediment the Lycopodium contaminants were counted along with the pollen. This statistic is necessary to compute absolute pollen influx (Maher 1977).

Treatment of Data

(a) Vegetative Data

Data collected from the quantitative vegetative study were summarized as relative density, relative dominance and relative frequency according to the method outlined by Cottam and Curtis (1956) where; relative density = no. of individuals of the species/no. of individuals of all species X 100, relative dominance = total basal area of the species/total basal area of all species X 100 and relative frequency = no. of sample quadrats the species occurred in/total no. of quadrats X 100. An importance value for each species is then determined simply by summing relative density, relative dominance and relative frequency. Basal area of shrubs and seedlings was not measured therefore seedling and shrub data is restricted to relative density and relative frequency.

(b) Pollen Data

The pollen sum for all samples counted was 200. This sum includes all upland and aquatic pollen taxa. Spores, charcoal fragments, and spherules were counted outside the pollen sum.

Sample counts from the bog, the pond, and the surface sample were expressed as a percentage of the pollen sum. In addition to the percentile values, absolute pollen influx was calculated for the samples from the pond according to the equation:

Influx of taxon x in grains/cm/yr. = MSR/V; where M is the number of Lycopodium contaminants added to the sample, S is the sample's sedimentation rate in cm/yr., R is the ratio of the number of grains of taxon x to the number of Lycopodium contaminants, and V is the volume of raw sediment in cm^3 (Maher 1977).

Spores counted in the samples were treated as a raw number per 200 pollen grains. Spherules and charcoal fragments were expressed as a raw number per 100 pollen grains.

CHAPTER 5 RESULTS

Modern Vegetation

(a) Bog

The bowl-shaped bog site possesses a characteristic raised bog floor brought about by peat accumulation. The bog floor itself supports five vegetative communities while a further two vegetative communities were recognized on the immediate boundaries of the bog (Figure 4). Each vegetative community was named according to its major vegetative components. Communities present on the bog floor are: *Picea-Ledum*, *Larix-Ledum*, *Betula*-Gramineae, *Betula-Ledum*, and *Picea-Pinus*. An analysis of environmental parameters (Figure 5) and quantitative vegetative data (Table 1) serve to illustrate the uniqueness of each vegetative community.

Bog community no. 1, the *Picea-Ledum* community, covers an extensive area of the bog floor. *Picea mariana* is the only tree species present and its cover is very sparse (basal area of 265 sq cm/hectare). *Ledum groenlandicum* is the dominant low shrub (less than 20 cm in height) and it occurs extensively throughout the community. Of the high shrubs, *Betula pumila* var. *glandulifera* is the only one present and has a scattered occurrence of only 3 stems/hectare. *Picea mariana* is the most successful reproducer although a few *Pinus banksiana* seedlings were noted.

Environmental measures reveal that the *Picea-Ledum* community is an extremely acidic environment (pH = 4.0) and has

FIGURE 4: Bog vegetative community distribution.

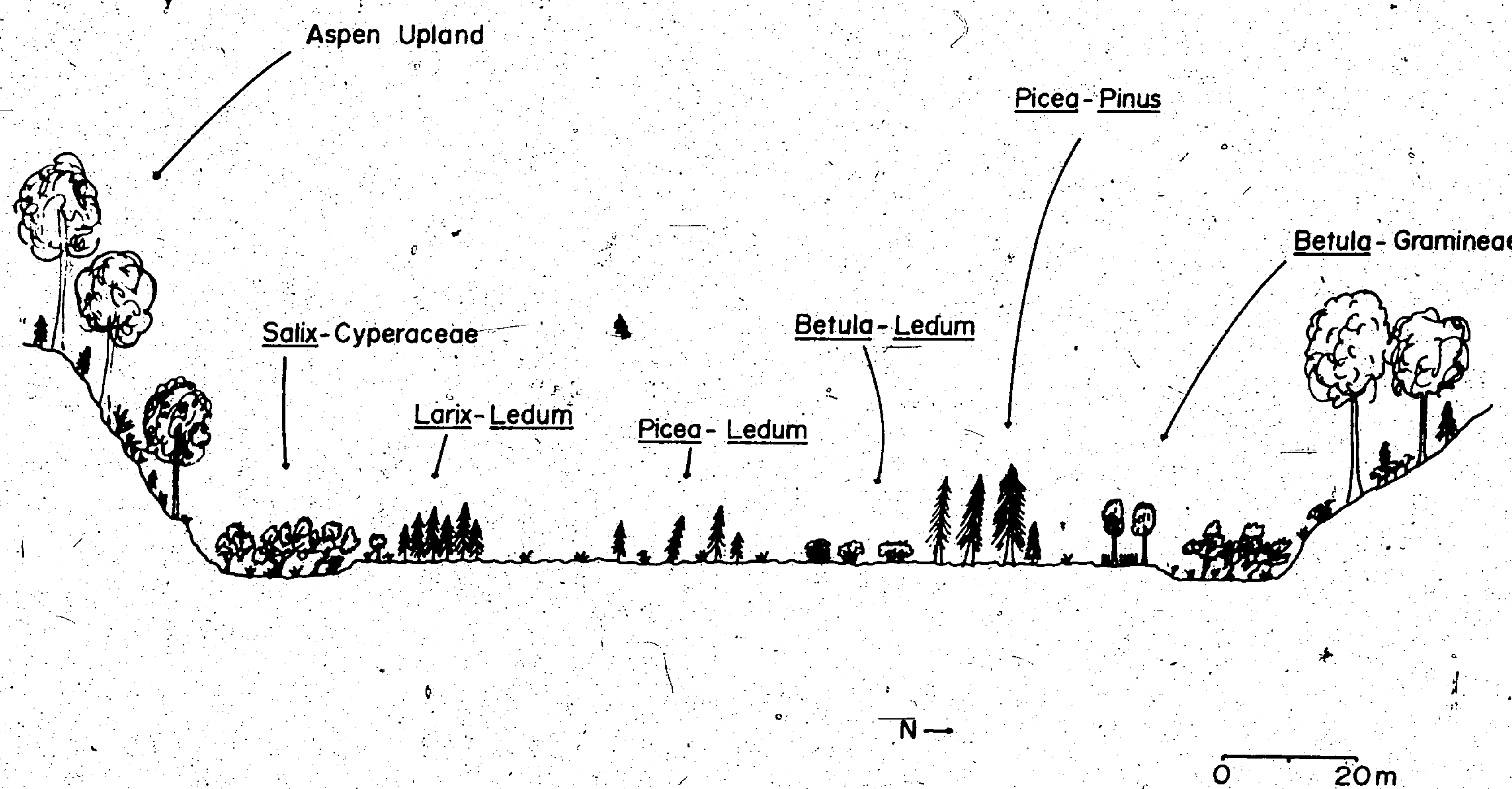


FIGURE 5: Bog community distribution and environmental data.

Number	Community
1	*Picea* - *Ledum*
2	*Salix* - Cyperaceae
3	Aspen Upland
4	*Larix* - *Ledum*
5	*Betula* - Gramineae
6	*Betula* - *Ledum*
7	*Picea* - *Pinus*

Number	pH	Calcium (p.p.m.)	Depth to H_2O
1	4	5.2	20 cm
2	5.2	14.0	4 cm
3	-	-	-
4	4.3	12.0	22 cm
5	3.9	8.0	20 cm
6	4.1	12.8	17 cm
7	4.2	9.2	24 cm

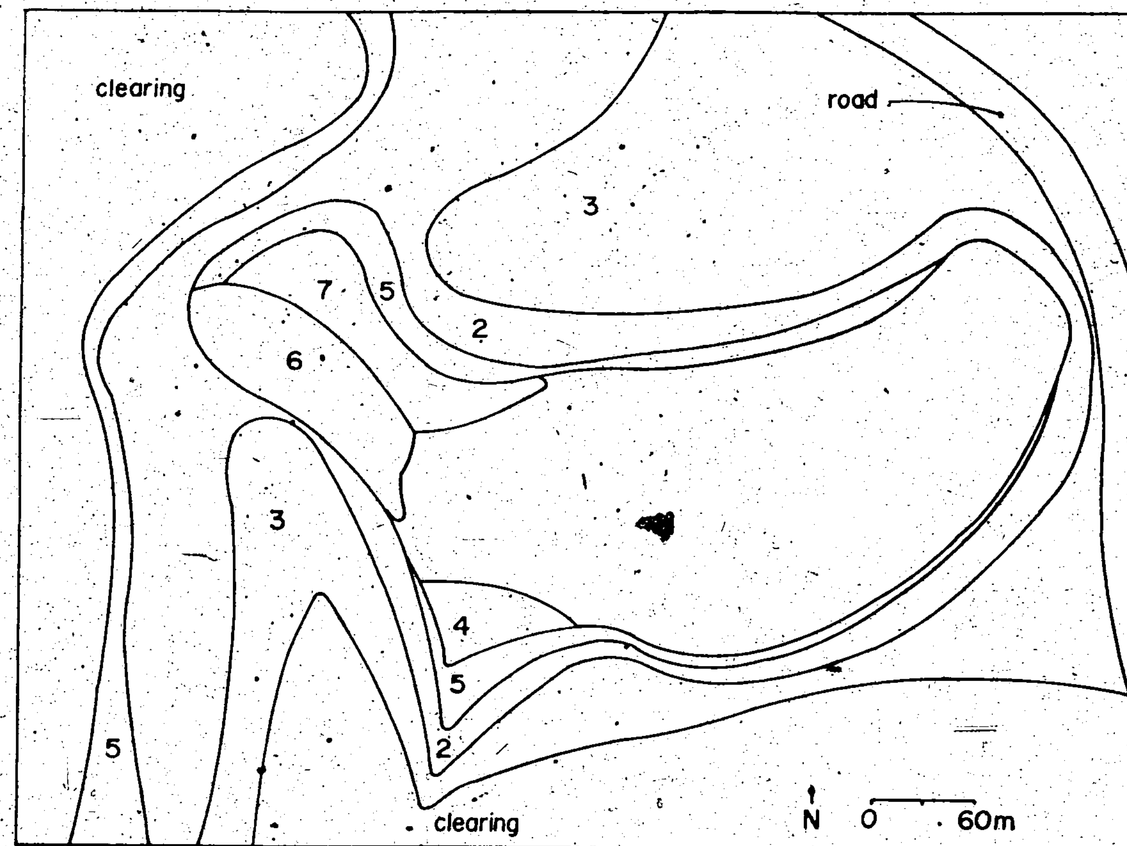


Table 1: Vegetative composition data: bog

Species	TREES % Frequency	% Density	% Dominance	Importance Value
COMM. #1				
Picea mariana	100	100	100	300
	basal area/hectare = 265 sq cm			
COMM. #2				
Betula papyrifera	71.42	68.75	51.98	192.16
Populus tremuloides	28.57	31.25	48.02	107.84
	basal area/hectare = 8136 sq cm			
COMM. #3				
Populus tremuloides	60.71	64.55	64.34	189.06
Populus balsamifera	35.71	34.18	35.47	105.36
Betula papyrifera	3.57	1.27	0.18	5.02
	basal area/hectare = 14272 sq cm			
COMM. #4				
Larix laricina	100	100	100	300
	basal area/hectare = 300 sq cm			
COMM. #5				
Betula papyrifera	90.48	92.11	88.07	270.66
Picea mariana	9.52	7.89	11.93	29.43
	basal area/hectare = 1065 sq cm			
COMM. #7				
Picea mariana	92.31	97.83	98.72	288.86
Pinus banksiana	7.69	2.17	1.28	11.14
	basal area/hectare = 874 sq cm			

Table 1: Vegetative composition data: bog - Continued

Species	SHRUBS % Frequency	SHRUBS % Density	SEEDLINGS % Frequency	SEEDLINGS % Density
COMM. #1				
Betula pumila var. *glandulifera*	100	100		
Betula papyrifera			29.63	23.75
Picea mariana			66.67	75.00
Pinus banksiana			3.70	1.25
	3 stems/hectare		119 stems/hectare	
COMM. #2				
Salix sp.	42.42	48.10		
Ribes hudsonianum	12.12	10.13		
Rosa acicularis	6.06	2.53		
Alnus sp.	9.09	5.06		
Ribes sp.	24.24	29.11		
Rubus strigosus	6.06	5.06		
Betula papyrifera			81.25	87.50
Populus tremuloides			18.75	12.50
	1208 stems/hectare		168 stems/hectare	
COMM. #3				
Rosa acicularis	17.65	18.75		
Ribes sp.	3.92	2.50		
Rubus strigosus	15.69	11.25		
Viburnum edule	5.88	5.00		
Salix sp.	1.96	1.25		
Symphoricarpus occidentalis	13.73	11.25		
Lonicera involucrata	7.84	8.75		
Corylus cornuta	17.65	25.00		
Amelanchier alnifolia	15.69	16.25		

Table 1: Vegetative composition data: bog - Continued

Species	SHRUBS % Frequency	SHRUBS % Density	SEEDLINGS % Frequency	SEEDLINGS % Density
COMM. #3 - Continued				
Populus tremuloides			53.13	62.50
Betula papyrifera			34.37	30.00
Populus balsamifera			9.37	6.25
Prunus sp.			3.13	1.25
	7716 stems/hectare		416 stems/hectare	
COMM. #4				
Betula pumila var. *glandulifera*	88.89	96.67		
Salix sp.	11.11	3.33		
Larix laricina			41.18	43.75
Picea mariana			17.65	12.50
Betula papyrifera			41.18	43.75
	65 stems/hectare		565 stems/hectare	
COMM. #5				
Salix sp.	37.14	47.46		
Betula pumila var. *glandulifera*	20.00	18.64		
Ribes hudsonianum	8.57	10.17		
Lonicera involucrata	2.86	1.69		
Amelanchier alnifolia	8.57	5.08		
Vaccinium myrtilloides	11.43	10.17		
Alnus sp.	2.86	1.69		
Rosa acicularis	2.86	1.69		
Ribes sp.	5.71	3.39		
Betula papyrifera			71.43	88.31
Picea mariana			21.43	9.00
Larix laricina			3.57	1.30

Table 1: Vegetative composition data: bog - Continued

Species	SHRUBS		SEEDLINGS	
	% Frequency	% Density	% Frequency	% Density
COMM. #5 - Continued				
Populus tremuloides			3.57	1.30
	135 stems/hectare		630 stems/hectare	
COMM. #6				
Betula pumila var. *glandulifera*	100	100		
Picea mariana			55.55	71.67
Betula papyrifera			40.74	1.67
Larix laricina			3.70	1.67
	71 stems/hectare		196 stems/hectare	
COMM. #7				
Betula pumila var. *glandulifera*	100	100		
Picea mariana			50.00	66.67
Betula papyrifera			41.67	27.08
Pinus banksiana			8.33	6.25
	23 stems/hectare		503 stems/hectare	

a high water table (depth to water is 20 cm). Calcium content is the lowest of any vegetative community analyzed at 5.2 p.p.m. (parts per million).

Another plant community located on the bog floor is community no. 4, the Larix-Ledum community. Occupying only a small south-central portion of the bog floor, the Larix-Ledum community has a slightly more basic ground water (pH = 4.3), a slightly lower water table (22 cm), and a higher calcium content (12.0 p.p.m.) than the Picea-Ledum community. Larix laricina is the only tree species present in community no. 4, but none reach a substantial size as basal area/hectar is low (300 sq cm). Ledum groenlandicum is again the dominant low shrub while both Betula pumila var. glandulifera and Salix sp. are also present, albeit in small amounts (65 stems/hectare). Betula papyrifera, Larix laricina and Picea mariana produce a relatively dense seedling population (565 stems/hectare).

Bog community no. 5, the Betula-Gramineae community, occupies a narrow band of the bog floor that nearly encircles the coring site. With a pH of 3.9, the ground water of community no. 5 is the most acidic tested. Calcium content is also the lowest recorded (8.0 p.p.m.). It is 20 cm to ground water.

Betula papyrifera together with Picea mariana form a scattered tree cover on bog community no. 5. Considered together these tree species have a basal area of 1,065 sq cm/hectare. Betula papyrifera and Picea mariana are also the most successful reproducers although Larix laricina and

Populus tremuloides seedlings do occur occasionally (together they occur at a relative frequency of 7%). The highest density of seedlings (630 stems/hectare) on the entire bog coring site is recorded in this vegetative community.

The Betula-Ledum community (bog community no. 6) is located in the western corner of the bog floor. This vegetative community is dominated by the low shrub Ledum groenlandicum and the high shrub Betula pumila var. glandulifera. There are no trees present in bog community no. 6 however, Picea mariana, Betula papyrifera and Larix laricina seedlings are present in moderate amounts (196 stems/hectare).

Bog community no. 6 has acidic ground water (pH = 4.1) at a depth of 17 cm. Calcium content is relatively high at 12.8 p.p.m.

Community no. 7, the Picea-Pinus community, also occupies an area of the bog floor. Located adjacent to the Betula-Ledum community, the Picea-Pinus community contains Picea mariana and Pinus banksiana making a relatively dense tree cover of 874 sq cm of basal area/hectare. These two species, together with Betula papyrifera are the major reproducers, (503 stems/hectare) although Pinus banksiana is not contributing a great many seedlings (a relative frequency of 8%). The dominant high shrub in bog community no. 7 is Betula pumila var. glandulifera, although this species occurs only sparsely (23 stems/hectare).

Depth to ground water is the greatest of all in bog community no. 7 (24 cm) while its pH (4.2) and calcium content

(9.2 p.p.m.) are comparable to other communities on the bog floor.

In addition to the plant communities on the bog floor two communities adjacent to the bog were identified and quantitatively described. These communities were named *Salix*-Cyperaceae and Aspen Upland.

The *Salix*-Cyperaceae community (bog community no. 2) forms a continuous ring around the bog floor. This vegetative community occurs in a trough around the raised platform of the bog. Drainage is poor, as reflected by the extremely high water table (4 cm depth to water). Calcium content (14.0 p.p.m.) and pH (5.2) are distinctly higher than all communities on the bog floor.

Betula papyrifera and *Populus tremuloides* are scattered throughout bog community no. 2 and have a relatively high basal area of 8,136 sq cm/hectare. These tree species are the only ones noted in the scattered occurrence of seedlings (168 stems/hectare) in bog community no. 2. The *Salix*-Cyperaceae community has large numbers of shrubs (1208 stems/hectare) dominated by *Salix* sp. and *Ribes* spp.

The entire bog coring site is surrounded by the Aspen Upland vegetative community. *Populus tremuloides* and *Populus balsamifera* (with a few *Betula papyrifera* individuals) form a dense tree cover (basal area = 14,272 sq cm/hectare). The ground cover is made up of a dense, varied shrub layer (7,716 stems/hectare). Common shrub species include *Rosa acicularis*, *Rubus strigosus*, *Symphoricarpus occidentalis*, *Corylus cornuta* and *Amelanchier alnifolia*.

(b) Pond

Vegetative communities of the pond coring site were also mapped and analyzed. The open water of the pond is encircled by a narrow, dense band of cattails (Typha latifolia). This community was named Typha-Cyperaceae (pond community no. 1). Immediately adjacent to and encircling pond community no. 1 is the Cyperaceae meadow community (pond community no. 2). Adjacent to pond community no. 2 is the Salix-Cyperaceae community (pond community no. 3) which is in turn surrounded by the Aspen Upland community (pond community no. 4). These vegetative communities (1 to 4) were mapped (Figure 6), measured in terms of critical environmental parameters (Figure 7), and quantitatively described (Table 2). Pond community no. 5, the disturbed area of the road allowance, was simply mapped while pond community no. 6, the aquatic community, was mapped and described.

Pond community no. 1, the Typha-Cyperaceae community, was named after the extensive and dense coverage of both these herbs. There is also however, a relatively dense (359 stems/hectare) coverage of Salix sp. shrubs. No trees are present in pond community no. 1. This plant community is covered by 80 cm of slightly acidic (pH =6.1) water that has a calcium content of 13.6 p.p.m.

The Cyperaceae meadow community (pond community no. 2) is covered by 15 cm of water. Water pH is 6.1 with 14.0 p.p.m. of calcium. In addition to the dense sedge coverage, pond community no. 2 possesses a sparse (83 stems/hectare) shrub cover made up of Salix sp. and Alnus sp. Also noted were a

FIGURE 6: Pond vegetative community distribution.

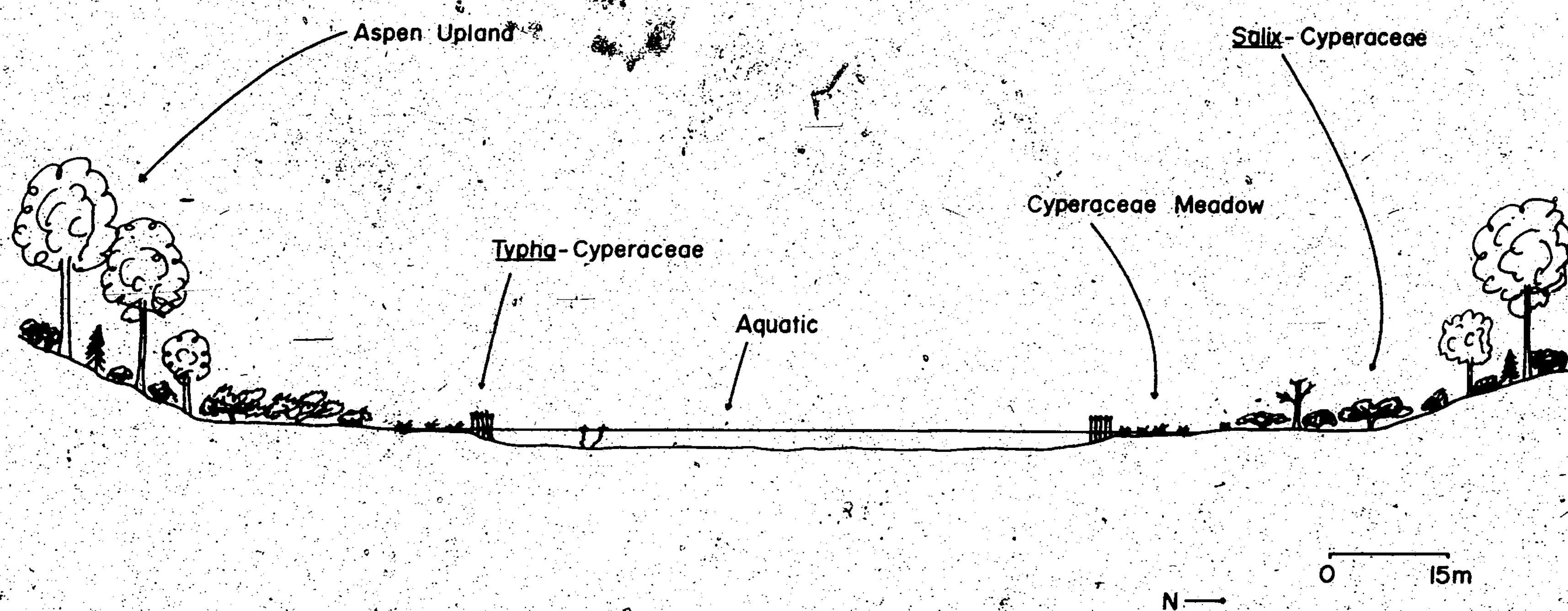


FIGURE 7: Pond vegetative distribution and environmental data.

Number	Community
1	*Typha* - Cyperaceae
2	Cyperaceae Meadow
3	*Salix* - Cyperaceae
4	Aspen Upland
5	Disturbed Area
6	Aquatic

Number	pH	Calcium (p.p.m.)	Depth to H_2O
1	6.1	13.6	-80 cm
2	6.1	14.0	-15 cm
3	5.7	20.0	5 cm
4	-	-	-
5	-	-	-
6	6.75	12.4	-250 cm

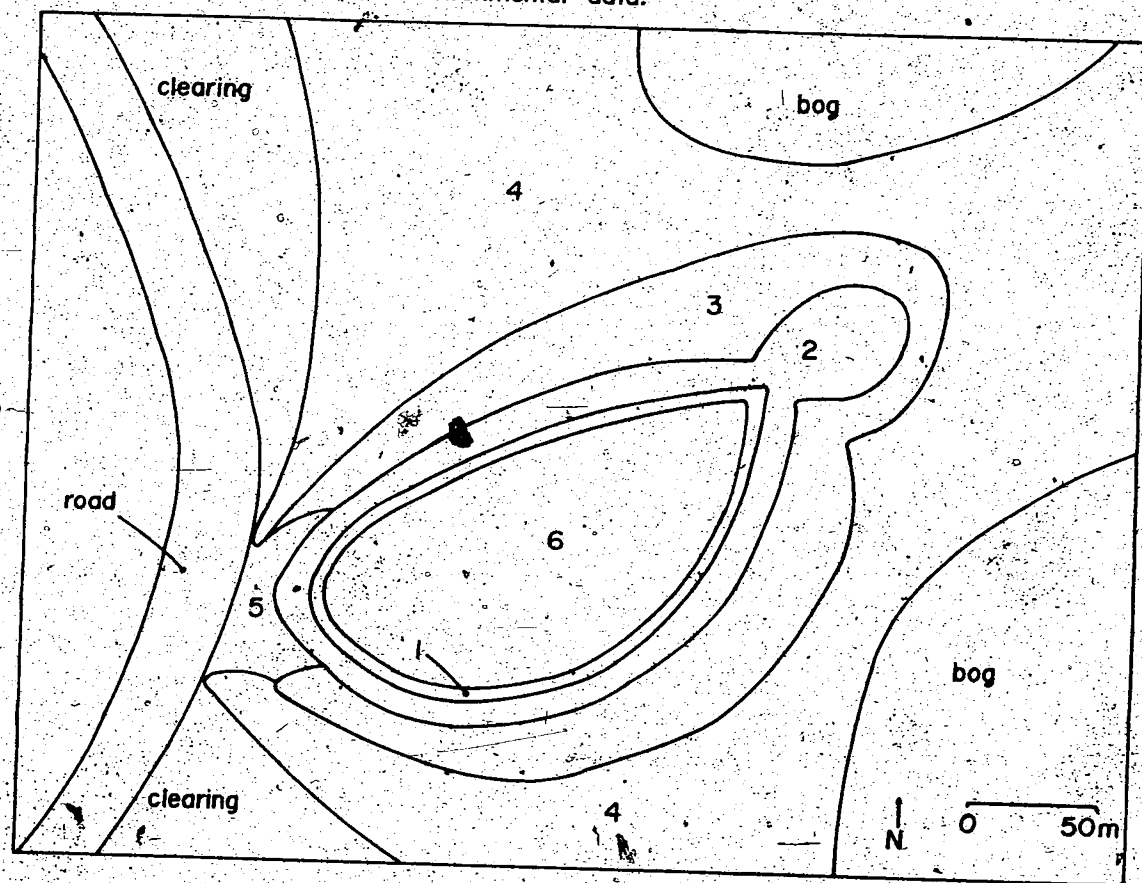


Table 2: Vegetation composition data: pond

Species	TREES % Frequency	% Density	% Dominance	Importance Value
COMM. #3				
Betula papyrifera	18.18	11.11	1.41	30.70
Populus balsamifera	63.63	66.67	48.40	178.70
Populus tremuloides	18.18	22.22	50.19	90.59
	basal area/hectare = 3158 sq cm			
COMM. #4				
Populus tremuloides	55.56	56.25	67.93	179.74
Populus balsamifera	44.44	43.75	32.07	120.26
	basal area/hectare = 16831 sq cm			

Species	SHRUBS % Frequency	% Density	SEEDLINGS % Frequency	% Density
COMM. #1				
Salix sp.	100	100		
	359 stems/hectare			
COMM. #2				
Salix sp.	95.25	98.41		
Alnus sp.	4.76	1.59		
Betula papyrifera			100	100
	83 stems/hectare		42 stems/hectare	

Table 2: Vegetative composition data: pond - Continued

Species	SHRUBS % Frequency	SHRUBS % Density	SEEDLINGS % Frequency	SEEDLINGS % Density
COMM. #3				
Salix sp.	50.00	68.35		
Lonicera involucrata	7.89	5.06		
Alnus sp.	13.15	12.66		
Ribes hudsonianum	10.53	5.06		
Ribes sp.	5.26	2.53		
Rubus strigosus	10.53	5.06		
Rosa acicularis	2.63	1.27		
Betula papyrifera			64.29	80.65
Populus tremuloides			25.00	14.51
Populus balsamifera			10.71	4.84
	122 stems/hectare		23 stems/hectare	
COMM. #4				
Rosa acicularis	30.00	36.25		
Rubus strigosus	22.00	22.50		
Shepherdia canadensis	2.00	1.25		
Symphoricarpus occidentalis	10.00	8.75		
Ribes hudsonianum	2.00	1.25		
Lonicera involucrata	2.00	1.25		
Viburnum edule	12.00	8.75		
Corylus cornuta	14.00	16.25		
Amelanchier alnifolia	6.00	3.75		
Prunus sp.			11.43	7.50
Populus tremuloides			54.29	63.75
Betula papyrifera			20.00	17.50
Populus balsamifera			14.29	11.25
	5050 stems/hectare		248 stems/hectare	

few (42 stems/hectare) Betula papyrifera seedlings. No fully grown tree species exist in pond community no. 2.

Pond community no. 3, the Salix-Cyperaceae community, has a moderately dense (122 stems/hectare) shrub cover made up mainly of Salix sp., Alnus sp., Ribes hudsonianum and Rubus strigosus. Tree cover consists mainly of Populus balsamifera (relative frequency of 63.6%) supplemented by equal amounts of Betula papyrifera and Populus tremuloides. Considered together these tree species contribute 3,158 sq cm of basal area/hectare. Also of note in this vegetative community was the existence of several large Betula papyrifera stumps.

Betula papyrifera, Populus tremuloides and Populus balsamifera seedlings were noted in pond community no. 3 at a density of 23 stems/hectare. Ground water was encountered at a depth of 5 cm; this ground water was found to be slightly less acidic (pH = 5.7) and had a higher calcium content (20.0 p.p.m.) than the standing water in pond communities no. 1 and 2.

The Aspen Upland community surrounding the pond coring site is actually an extension of the Aspen Upland community of the bog site. Similarities in structure and composition are apparent.

Like the Aspen Upland community described on the bog site, pond community no. 4 has a dense tree cover of Populus tremuloides and Populus balsamifera (basal area = 16,831 sq cm/hectare). The shrub cover is dense (5,050 stems/hectare) and varied with Rosa acicularis, Rubus strigosus, Corylus cornuta, Viburnum edule and Symphoricarpus occidentalis being the most dominant species. Dense regeneration (248 stems/hectare) was observed with *Populus tremuloides*, *Betula papyrifera*, *Populus balsamifera* and *Prunus* sp. making up the seedling population.

Pond community no. 6, the Aquatic community, has a maximum water depth of 2.5 meters. Water pH is 6.75 with a calcium content of 12.4 p.p.m. Species noted in pond community no. 6 include *Sagittaria cuneata*, *Lemna minor*, *Lemna trisulca* and *Potamogeton* sp.

Percent frequency of occurrence of herbs and low shrubs in all bog and pond vegetative communities is summarized in Appendix 1. Appendix 2 contains results of the line transect in each coring site. The line transects measure leaf area coverage of herbs and shrubs.

Modern Pollen Rain

Pollen analysis of surface samples from the two coring sites yielded results listed on Table 3 and Table 4. An examination of the representation of each pollen taxon in each vegetative community reveals several noteworthy relationships.

Pinus is consistently high in its representation in nearly all plant communities. Even though *Pinus* occurs only very sporadically in the local vegetation (only 8% frequency of occurrence in one community, bog community no. 7) it contributes over 10% of the pollen in nearly every community. The only cases where *Pinus* representation

Table 3: Percentage pollen composition in modern surface samples (bog)

Bog Comm.	#1	#2	#3	#4	#5	#6	#7	$\bar{M}$
Pinus	19(5)	3(1)	23(7)	18(4)	7(0)	20(5)	13(3)	15(4)
Picea	11(5)	3(0)	19(5)	9(3)	5(0)	10(1)	18(5)	11(3)
Betula	9(3)	5(0)	9(3)	7(3)	52(6)	16(2)	5(1)	15(3)
Populus	24	5	21	27	7	14	10	15
Alnus	6(1)	0(0)	2(0)	4(1)	1(0)	5(1)	2(1)	3(1)
Salix	11(3)	79(4)	13(3)	21(9)	15(1)	13(3)	25(0)	25(3)
Corylus	3(0)	1(0)	2(0)	1(0)	4(0)	1(0)	4(0)	3(0)
Ericaceae	10(3)	0(0)	0(0)	5(3)	1(0)	7(1)	9(1)	5(1)
Gramineae	1(0)	1(0)	1(0)	1(1)	1(0)	3(0)	2(1)	1(0)
Compositae	0(0)	0(0)	0(0)	0(0)	1(0)	1(0)	1(0)	0(0)
Artemisia	2(1)	0(1)	1(0)	1(1)	1(0)	0(1)	2(0)	1(0)
Cheno-Am	1(0)	0(0)	1(0)	0(1)	0(0)	1(0)	1(1)	1(0)
Cyperaceae	1(0)	1(1)	1(1)	3(1)	4(0)	7(0)	4(0)	3(0)
Typha	0(0)	0(0)	1(0)	0(0)	0(0)	0(0)	0(0)	1(0)
Other	2(6)	2(0)	8(2)	5(1)	1(0)	2(1)	3(0)	3(1)
Total counts for:								
Trilete spores	72(0)	0(0)	0(0)	21(6)	11(0)	64(12)	18(0)	27(3)
Charcoal frags.	36	9	71	26	10	50	76	40

Pollen sum = 200

() = Additional pollen counted after *Populus* counted outside pollen sum.

Table 4: Percentage pollen composition in modern surface samples (pond)

Pond Comm. Species:	#1	#2	#3	#4	M̄
Pinus	12(0)	13(1)	13(0)	10(19)	12(3)
Picea	11(0)	5(0)	7(1)	5(9)	7(3)
Betula	5(0)	2(0)	5(0)	3(2)	4(1)
Populus	1	4	5	49	15
Alnus	2(0)	3(0)	1(0)	5(3)	3(1)
Salix	3(0)	5(1)	30(1)	10(5)	11(2)
Corylus	0(0)	0(0)	0(0)	1(1)	0(0)
Gramineae	2(0)	2(0)	9(1)	0(1)	3(0)
Compositae	1(0)	1(0)	7(0)	1(1)	2(0)
Artemisia	0(0)	0(0)	1(1)	1(0)	1(1)
Cheno-Am	0(0)	1(0)	0(0)	0(1)	0(0)
Cyperaceae	24(0)	50(2)	22(1)	6(4)	25(2)
Typha	39(1)	26(1)	1(1)	1(0)	16(1)
Potamogeton	5(0)	1(0)	1(0)	0(0)	2(0)
Other	0(0)	1(0)	1(0)	8(3)	1(1)
Total counts for:					
Trilete spores	0(0)	0(0)	0(0)	2(0)	1(0)
Charcoal frags.	9	24	26	59	29

Pollen sum = 200

() = Additional pollen counted after Populus counted outside pollen sum.

drops below 10% is in bog community no. 2 (Salix-Cyperaceae) and bog community no. 5 (Betula-Gramineae). In either case this decreased representation of Pinus is concurrent with uncharacteristically heavy representation by other pollen taxa (in bog community no. 2 Salix pollen accounts for 79% of all pollen while in bog community no. 5 Betula accounts for 52%).

Picea also contributes consistently large amounts of pollen to the surface samples. Although not usually as high as Pinus, Picea never contributes less than 3% nor more than 19% of the total pollen rain. Lowest Picea representation is in bog community no. 2 (where, like Pinus, it is overshadowed by high amounts of Salix pollen) while highest representation occurs in bog community no. 3, the Aspen Upland.

Betula is another pollen taxon that shows relatively high representation although it is not as consistently high as Pinus or Picea. Betula pollen representation is extremely varied, from a low of 2% (pond community no. 2) to a high of 52% (bog community no. 5). Betula pollen percentages are high only in those vegetative communities that have a significant amount of Betula growing in them. Specifically, these vegetative communities are bog community no. 5 (where Betula papyrifera has a relative frequency of 90%) and bog community no. 6 (where Betula pumila var. glandulifera has a relative frequency of 100%).

Populus pollen also occasionally contributes significant amounts of pollen but, like Betula, its pollen representation is very sporadic. In pond community no. 1 (Typha-Cyperaceae) Populus contributes only 1% of the total pollen rain. On the other hand, Populus pollen makes up 49% of the total pollen rain in the Aspen Upland community (community no. 4) around the pond site. This is an extremely high range of variation and is especially difficult to account for when the high rates of decomposition of Populus pollen grains (Sangster and Dale 1961) are considered.

Salix pollen also shows an extremely high degree of variability. Maximum pollen percentage occurs in bog community no. 2 (79%) while a minimum of 3% occurs in pond community no. 1.

Ericaceae pollen is generally represented in very small amounts, if present at all. However, notable exceptions to this do occur. In bog communities no. 1, 4, 6, and 7 Ericaceae pollen is well represented. These communities all occur on the floor of the bog coring site.

Gramineae and Compositae pollen show poorly with only one exception, pond community no. 3. Here Gramineae and Compositae pollen reach values of 9% and 7% respectively.

Cyperaceae pollen reaches high percentages (up to 50%) in the vegetative communities around the perimeter of the pond (pond communities no. 1, 2, and 3). Similarly, Typha pollen reaches high percentages in pond communities no. 1 and 2 (39% and 26% respectively). Potamogeton pollen reaches its highest value (5%) in pond community no. 1, directly adjacent to the pond.

Notable in its absence is Larix pollen. This is especially noteworthy in bog community no. 4 where Larix laricina is the major tree species in the vegetation (relative frequency of 100%).

Also of significance are the values recorded in surface samples for trilete spores and charcoal fragments. Trilete spores are recorded in significant amounts only in vegetative communities on the floor of the bog. Bog community no. 1 has 72 trilete spores/200 pollen grains, bog community no. 4 has 21, bog community 5 has 11, bog community no. 6 has 64, and bog community no. 7 has 18. In all other vegetative communities the number of trilete spores recorded never exceeded 2/200 pollen grains. In addition to this, charcoal fragments counted showed a range of variation from 5 to 91/100 pollen grains (mean = 36/100 pollen grains).

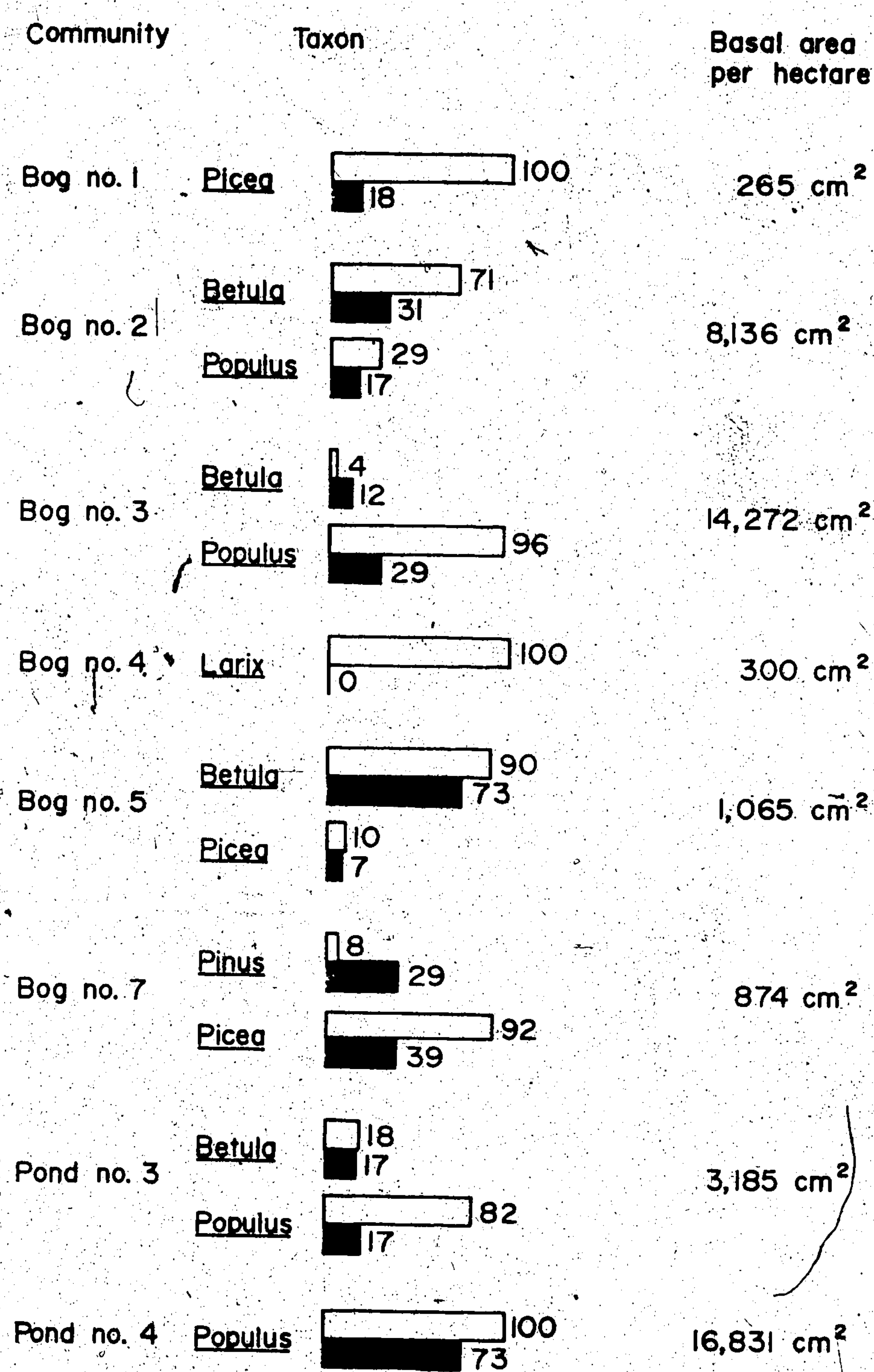
This data on modern pollen rain from the surface samples is made more meaningful when compared directly to the quantitative vegetative data. Figures were prepared that compared pollen frequency to relative frequency of occurrence for the major vegetative taxa on the two coring sites.

Of the tree species (Figure 8) Larix is undoubtedly the taxon most poorly represented in the modern pollen rain. In bog community no. 4, where Larix has a relative frequency of occurrence of 100%, not one Larix pollen grain was tabulated.

Of the remaining tree taxa, Pinus is the only one to show a greater pollen percentage than its frequency of occurrence. This over-representation is apparent in bog community no. 7 where Pinus has a pollen frequency of 29% with a frequency of occurrence in the existing vegetation of only 8%.

Betula pollen percentages show that this taxon has a high

FIGURE 8: Pollen frequency and stand composition (tree taxa).



White bar = frequency of occurrence (%) in vegetation
Black bar = pollen frequency (% of all tree taxa)

degree of representation. In one instance (bog community no. 3) its pollen percent frequency actually exceeds its percent frequency of occurrence. In all other cases (bog community no. 5 and pond community no. 3) Betula pollen representation shows a high degree of correlation with its frequency of occurrence.

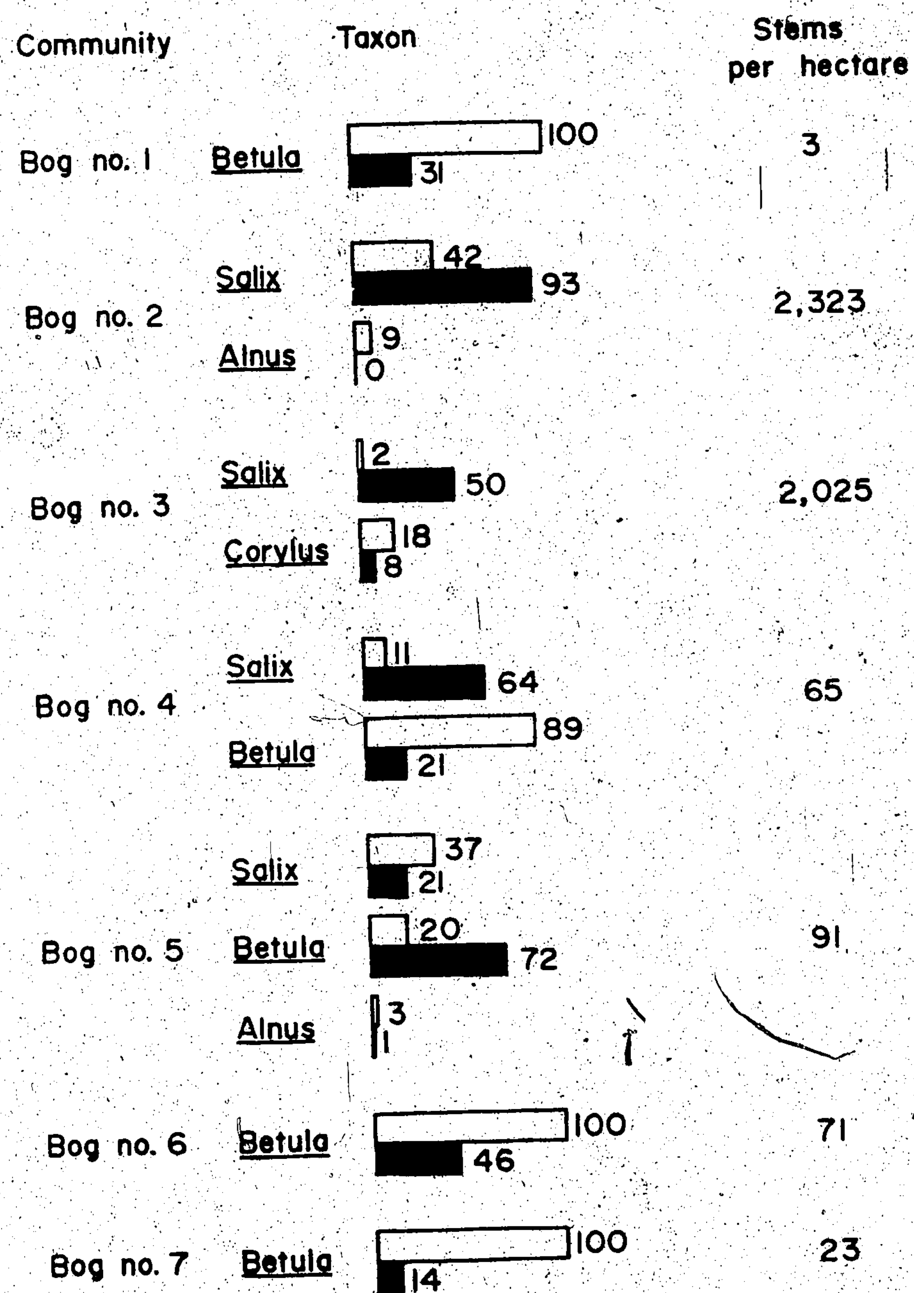
Populus is also a well represented tree species in the modern pollen rain. In bog community no. 2 Populus pollen shows a frequency of 17% compared to a frequency of occurrence in the existing vegetation of 29%. Bog community no. 3, pond community no. 3 and pond community no. 4 show a similar relationship. Although Populus pollen representation does not equal its frequency of occurrence in the existing vegetation, it certainly does contribute significant amounts to the modern pollen rain.

Picea pollen percentages are not as representative of the existing vegetation as Betula and Populus are. This is most apparent in bog community no. 1 where Picea has a frequency of occurrence of 100% but a pollen frequency of only 18%. Since Picea mariana is the dominant tree species here this low pollen frequency is none too surprising as Picea mariana is well known for its ability to regenerate asexually (Hosie 1973).

The modern pollen rain of the shrub taxa (Figure 9) shows similar ranges of representation as observed for the tree taxa. Salix and Betula are well represented in the modern pollen rain while Alnus and Corylus show poorly.

Salix is undoubtedly the best represented shrub taxon. As a matter of fact, Salix is over-represented in the pollen rain in bog community no. 2, bog community no. 3, bog community no. 4 and pond community no. 3. In the remaining vegetative communities in which Salix is present in the existing

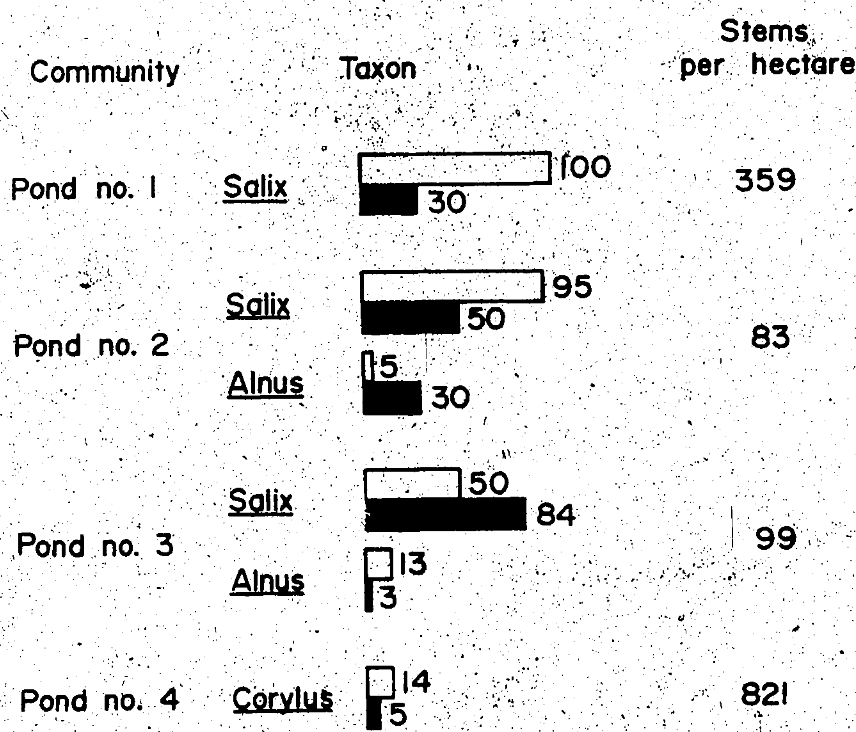
FIGURE 9: Pollen frequency and stand composition (shrub taxa).



White bar = frequency of occurrence (%) in vegetation

Black bar = pollen frequency (% of all shrub taxa)

FIGURE 9 (cont'd): Pollen frequency and stand composition (shrub taxa).



White bar = frequency of occurrence (%) in vegetation

Black bar = pollen frequency (% of all shrub taxa) flora it shows as a major pollen contributor, never having a pollen frequency of less than 21%.

Betula is also a consistent contributor of substantial amounts of pollen. It shows a high degree of over-representation in the pollen rain of bog community no. 5 (a pollen frequency of 72% compared to a frequency of occurrence of 20%) and in all other vegetative communities Betula counts are high (never less than 14%). However, these statistics must be viewed with caution as it is impossible to accurately delineate Betula shrub pollen from Betula tree pollen (Ives 1977). Consequently, pollen counts only reflect total amounts of Betula (species indeterminate) and therefore this value is an unavoidably inadequate one to compare with modern distributions of known Betula tree and shrub species. Regardless, Betula is well represented in the pollen rain whether all its pollen is considered to be from tree or shrub species.

Alnus and Corylus are usually under-represented in the modern pollen rain, the only exception being pond community no. 2 where Alnus pollen makes up 30% of the shrub pollen rain while only showing a frequency of occurrence of 5%. Outside of this isolated case, Alnus and Corylus pollen frequency is never greater than 8%.

While it is possible to generalize on pollen frequencies in the modern surface samples, it is obvious from the preceding discussion that pollen distribution varies greatly from one vegetative community to another. This strong local bias in pollen representation makes it difficult to decipher the nature of the regional pollen rain. In an effort to overcome this local bias, all data on tree and shrub pollen frequency and frequency of occurrence were averaged for each taxon. The averaged values appear in Figure 10.

Clearly, taxa that are over-represented in the regional pollen rain are <u>Pinus</u>, <u>Salix</u>, and <u>Alnus</u>. <u>Betula</u>, <u>Populus</u>, and <u>Picea</u> are well represented in the modern pollen rain while both <u>Corylus</u> and <u>Larix</u> are under-represented. These observations are useful to refer to when interpreting fossil pollen rain.

Sediment Description

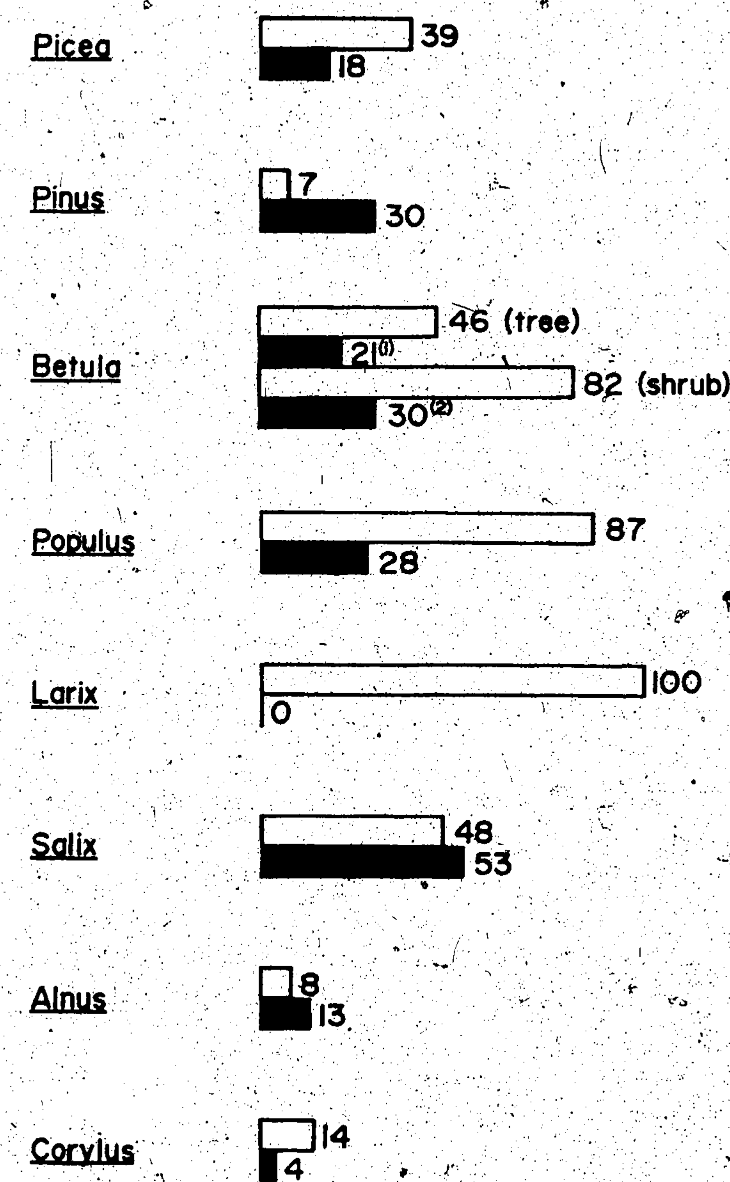
(a) Bog

The majority of the sediment column obtained from the bog is made up of organic matter in varying stages of decomposition. The least decomposed sediments (from 190 cm to the surface) contain remains of <u>Carex</u> spp. and mosses. Below this point, sediments are more decomposed and plant remains are indistinguishable. A stratigraphic break is noted near the bottom (235 cm) of this sediment column. At this point, organic sediments are succeded by silty-clay sediments.

(b) Pond

Sediments obtained from the pond were classified as silty gyttja. The uppermost 10 cm (those samples collected by the "frozen-finger" method) are readily distinguished from the remainder of the core because of their high water content. The sediment column from the pond has only one discernable stratigraphic break. This occurs near the bottom of the

FIGURE 10: Pollen frequency and stand composition (averages).



White bar = $\overline{M}$ frequency of occurrence (%) in vegetation

Black bar = $\overline{M}$ pollen frequency (% of total tree or shrub pollen)

(1) when all Betula pollen considered as tree pollen

(2) when all Betula pollen considered as shrub pollen

column (lowermost 15 cm) where silt content increases. There are present, however, two areas with high concentrations of Lymnaea shells (117 - 124 cm and 141 - 153 cm).

Radiocarbon Dates and Sedimentation Rates

Radiometric analysis of samples submitted from the bog and pond appear in Table 5. In order to date events occurring at points in the cores other than those points sampled a simple extrapolation from these radiocarbon dates was made.

Table 5: Radiocarbon determinations of samples from Elk Island National Park

Location	Level (cm)	Laboratory dating number	Radiocarbon date
Bog	233-240	DIC 625	4,180 ± 70 yrs B.P.
Bog	65	DIC 626	1,190 ± 55 yrs B.P.
Pond	165-170	DIC 627	3,970 ± 170 yrs B.P.
Pond	95-100	DIC 628	1,740 ± 85 yrs B.P.

Of major concern in the calculation of pollen influx values was the determination of the rate of sedimentation in the pond at each sample level. Only two radiocarbon dates were available from the pond cores. When these dates were plotted against depth (Figure 11) an important and somewhat distressing relationship was noted. Figure 11 indicates that the deposition rate has changed rather dramatically. The location of this abrupt change in sedimentation rate is no doubt an artifact of the arbitrarily placed date at the 100 cm level.

In order to determine rates of deposition integrated over the entire core, the following method was used. The slope of both distinct portions of the sedimentation rate curve (Figure 11) were plotted as a straight line (Figure 12). The resulting graph provided a constant transition of sedimentation rates throughout the entire core. From this graph sedimentation rates may be read for each depth analyzed. Only by dating more portions of the core could a more accurate rate of deposition be established.

Fossil Pollen Rain

(a) Relative Percent Pollen Diagram - Bog

Results of the samples analyzed for pollen content from the bog site appear in Figure 13. For the purpose of this discussion, the pollen diagram was divided into four descriptive levels.

Level 1 (240 cm - 195 cm):

This lowermost level of the diagram has a pollen spectrum containing the highest proportions of Gramineae (19%), Compositae (7%) and Chenopodiaceae (7.5%) recorded in the entire diagram. The upland vegetation summary column clearly

FIGURE 11: Pond sedimentation rates based on radiocarbon dates. (assume 0 depth = 0 years)

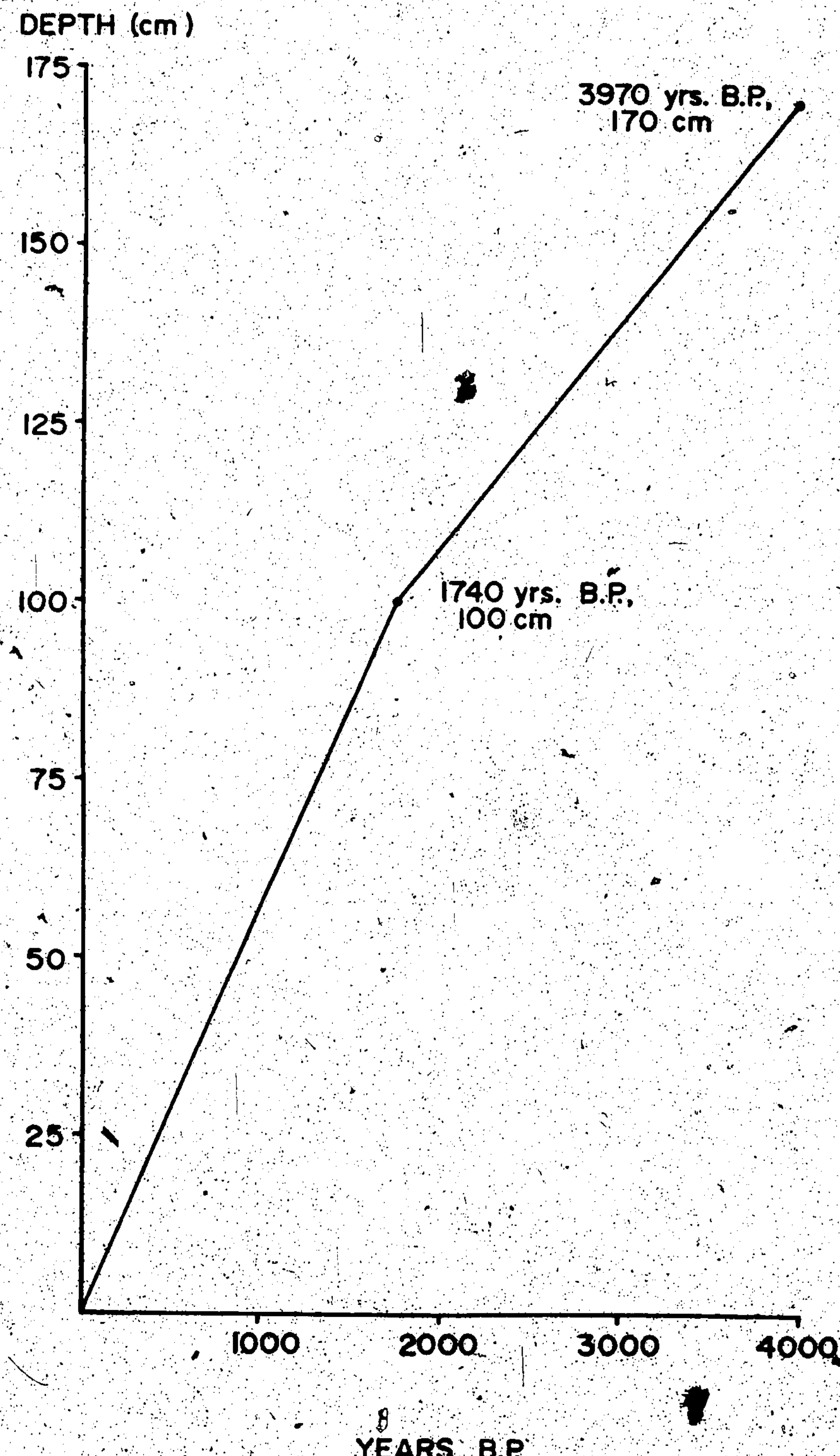


FIGURE 12: Pond sedimentation rate.
(depth vs. slope from fig. 11)

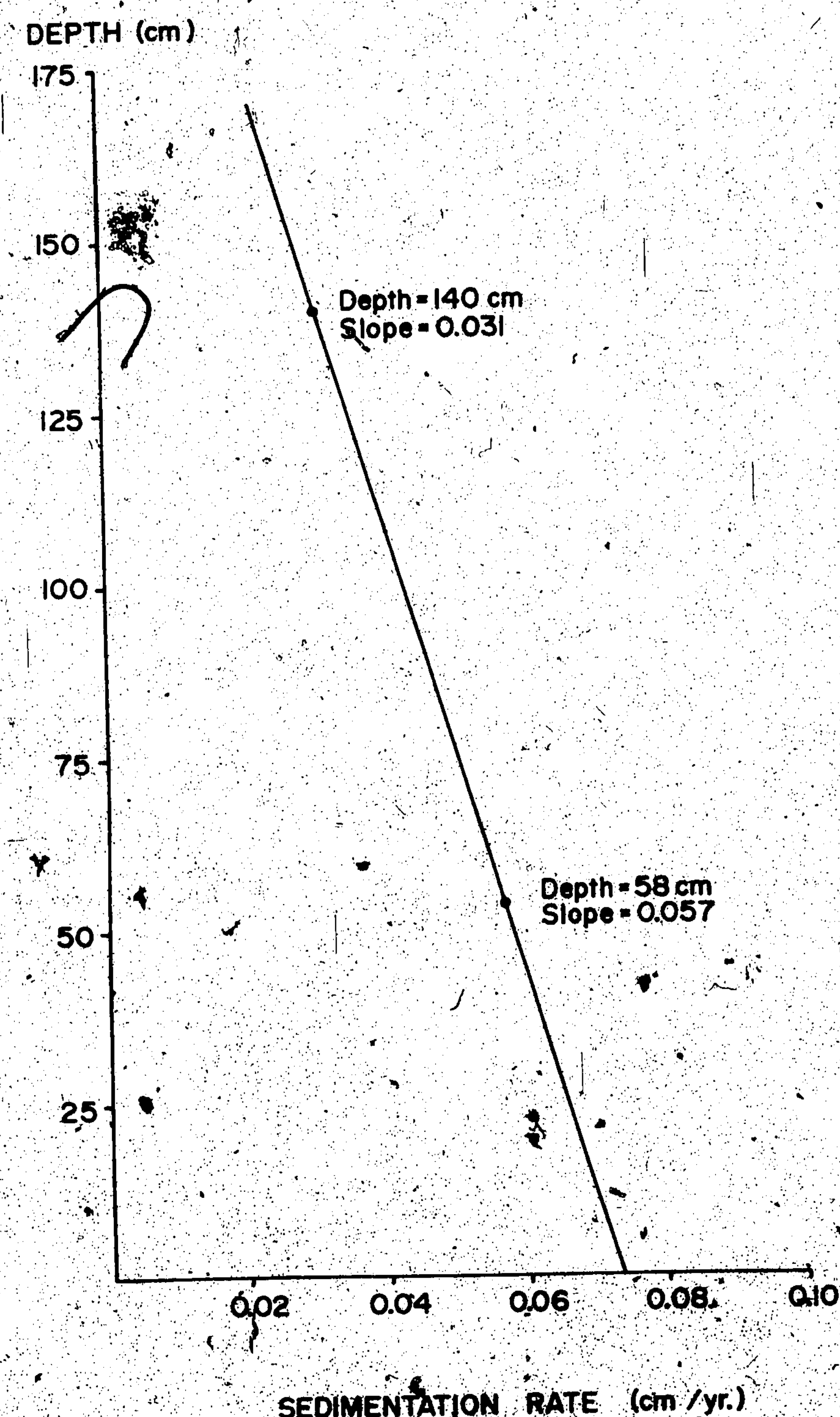
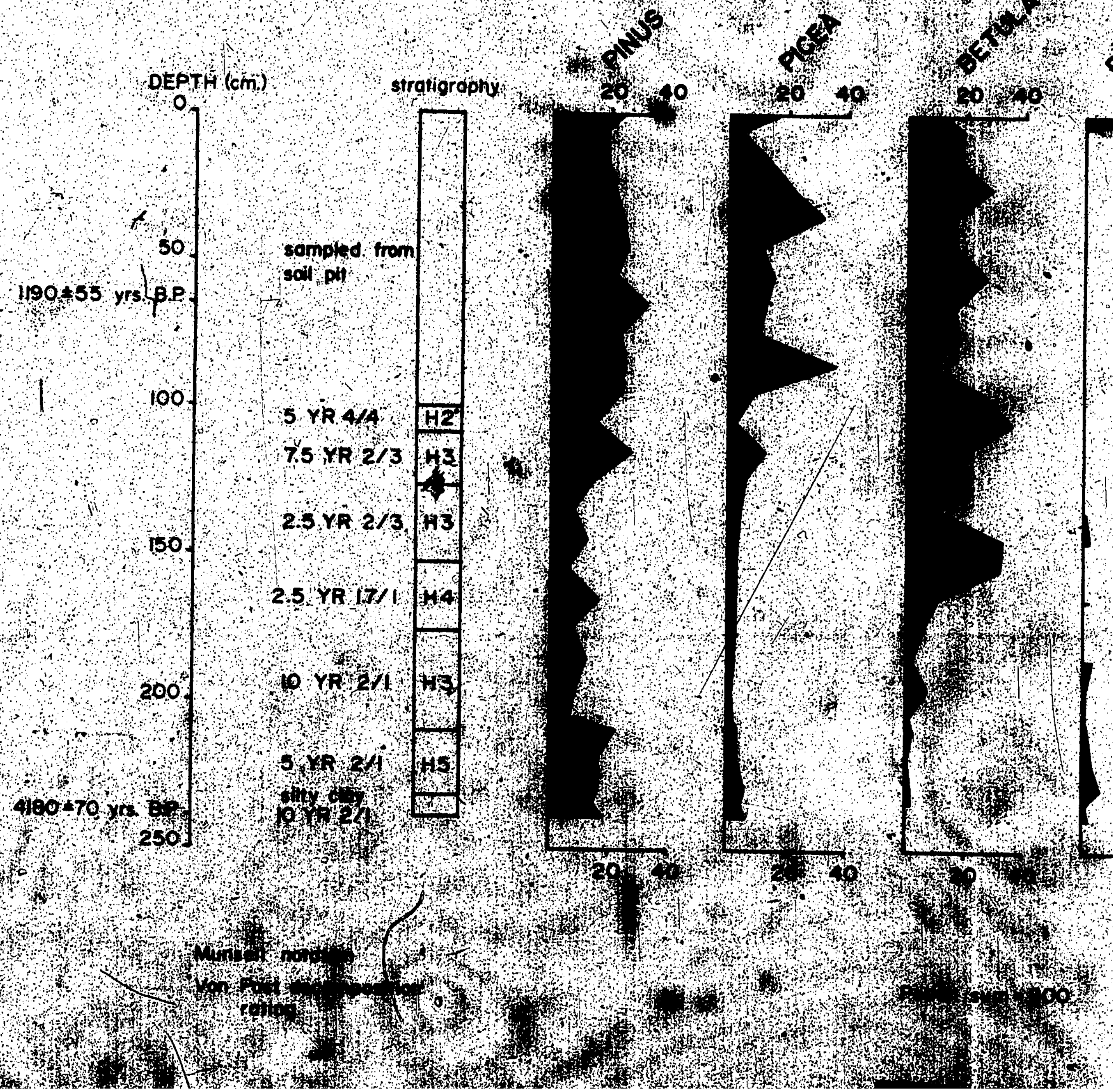
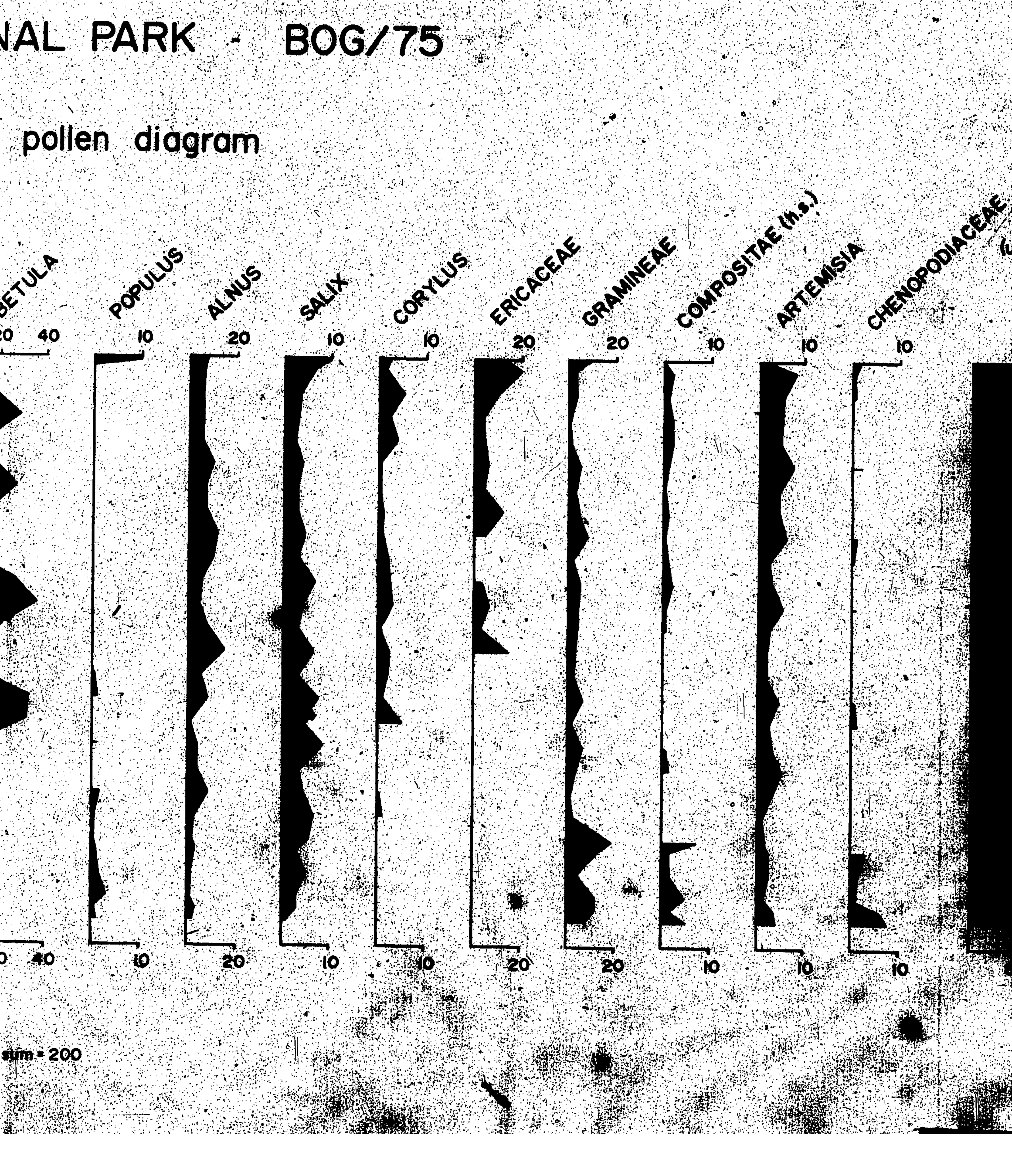


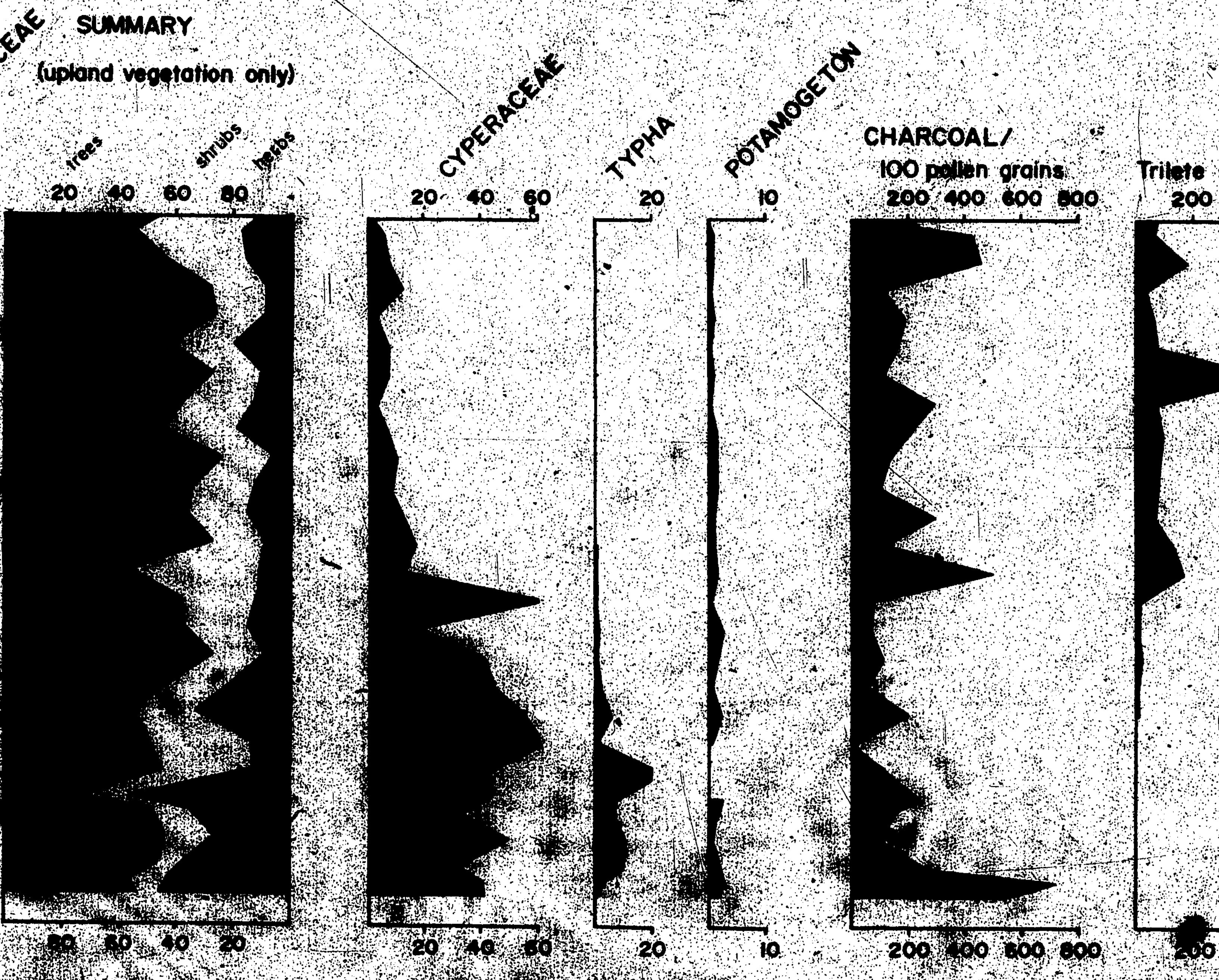
Figure 13: Relative percent pollen diagram - bog

ELK ISLAND NATIONAL P

relative percent pollen




NAL PARK - BOG/75
pollen diagram
BETULA
POPULUS
ALNUS
SALIX
CORYLUS
ERICACEAE
GRAMINEAE
COMPOSITAE (n.s.)
ARTEMISIA
CHENOPODIACEAE
20 40
10
20
10
10
20
20
10
10
10
sum = 200



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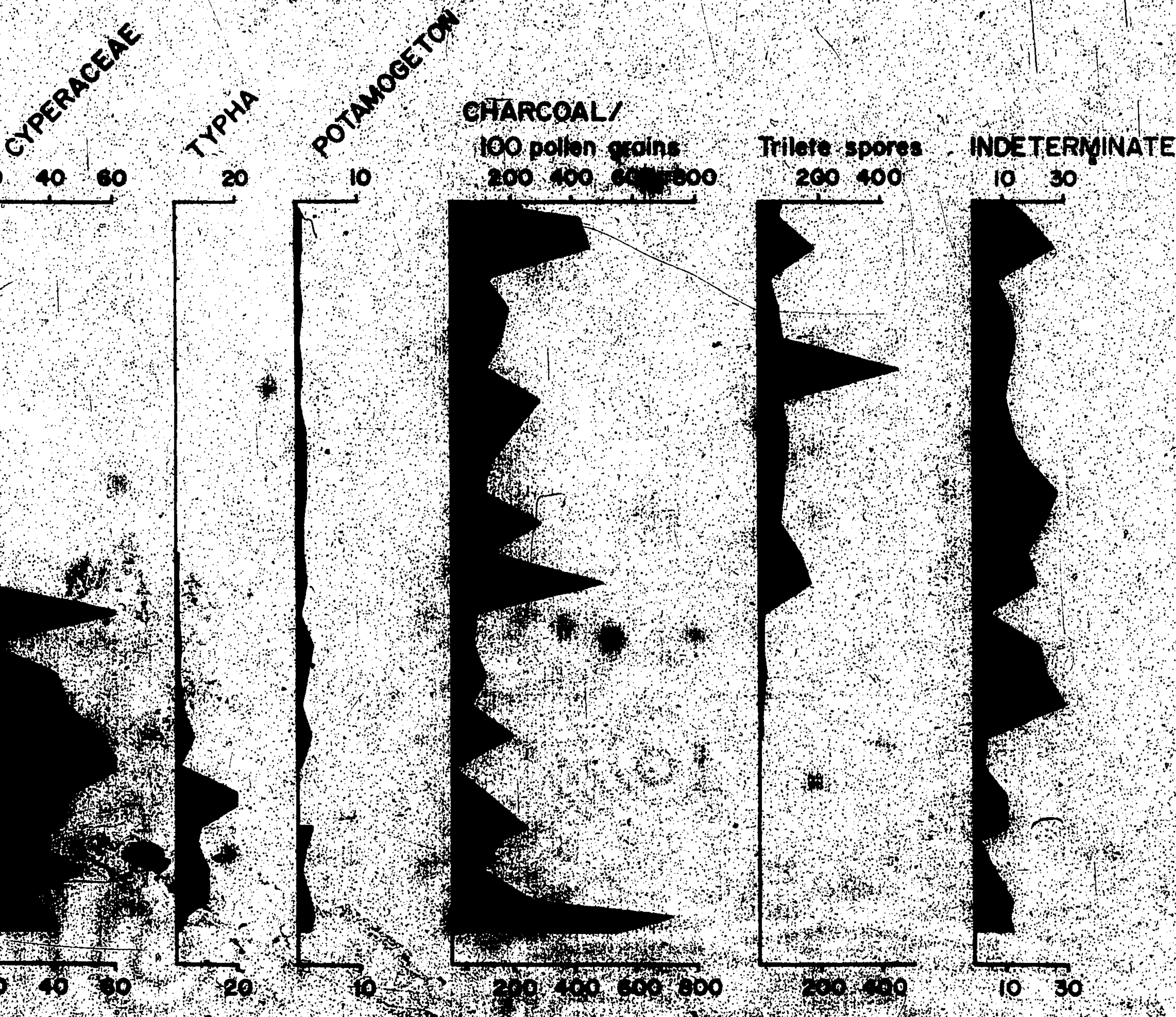

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shows this dominance of herbs in level 1.

Tree taxa contribute relatively small amounts of pollen in level 1. *Pinus* contributes approximately 20%, *Picea* less than 10% and *Betula* less than 5%. On the other hand, Cyperaceae contributes large amounts of pollen (up to 49.5%) while *Typha* also contributes significant amounts (up to 10%).

Charcoal fragments are extremely dense (720 fragments/100 pollen grains) in level 1 while trilete spores are non-existant. Level 1 lasts from 4,180 years B.P. to 3,485 years B.P. and is terminated by the sharp decline of Gramineae to values below 5%.

Level 2 (195 cm to 160 cm):

The pollen spectrum in Level 2 is dominated by aquatic and semi-aquatic pollen taxa. Exceedingly high levels of Cyperaceae (55%) and *Typha* (24%) are recorded. Upland taxa contribute only minor amounts of pollen with *Artemisia* (5%) and *Salix* (8.5%) being the most prominent recorded. Tree taxa contribute insignificant amounts.

Charcoal density has dramatically decreased (58-196 fragments/100 pollen grains) from level 1 while trilete spores appear in level 2 but only in small amounts (1-17 spores/200 pollen grains). This pollen spectrum lasts from 3,485 years B.P. to 2,860 years B.P. and terminates when *Betula* pollen representation rises rapidly and exceeds 20%.

Level 3 (160 cm - 5 cm):

The pollen record for level 3 is dominated by upland pollen taxa. *Pinus* reaches its highest values (32.5%) along with *Picea* (35%) and *Betula* (36%). Shrub taxa such as *Corylus* and Ericaceae make their appearance in level 3 and reach 5% and 15% respectively. Cyperaceae drops to less than 20% while Potamogeton and Typha representation is reduced to below 5%.

Level 3 charcoal density varies considerably (67-485 fragments/100 pollen grains). Trilete spores reach their highest values (451 spores/200 pollen grains) in level 3. This pollen spectrum is terminated at the 5 cm level with the rapid rise in Populus pollen frequency.

Level 4 (5 cm to surface):

The upper 5 cm of the relative percent pollen diagram are distinct from the previous levels in that Populus pollen becomes a significant factor (10%) while charcoal density, after reaching high values (420 fragments/100 pollen grains) directly below the 5 cm mark, drops to less than 50 fragments/ 100 pollen grains in level 4.

(b) Relative Percent Pollen Diagram - Pond

The relative percent pollen diagram derived from the pond core appears in Figure 14. Three distinct levels are recognized for the purposes of this description.

Level 1 (170 cm - 135 cm):

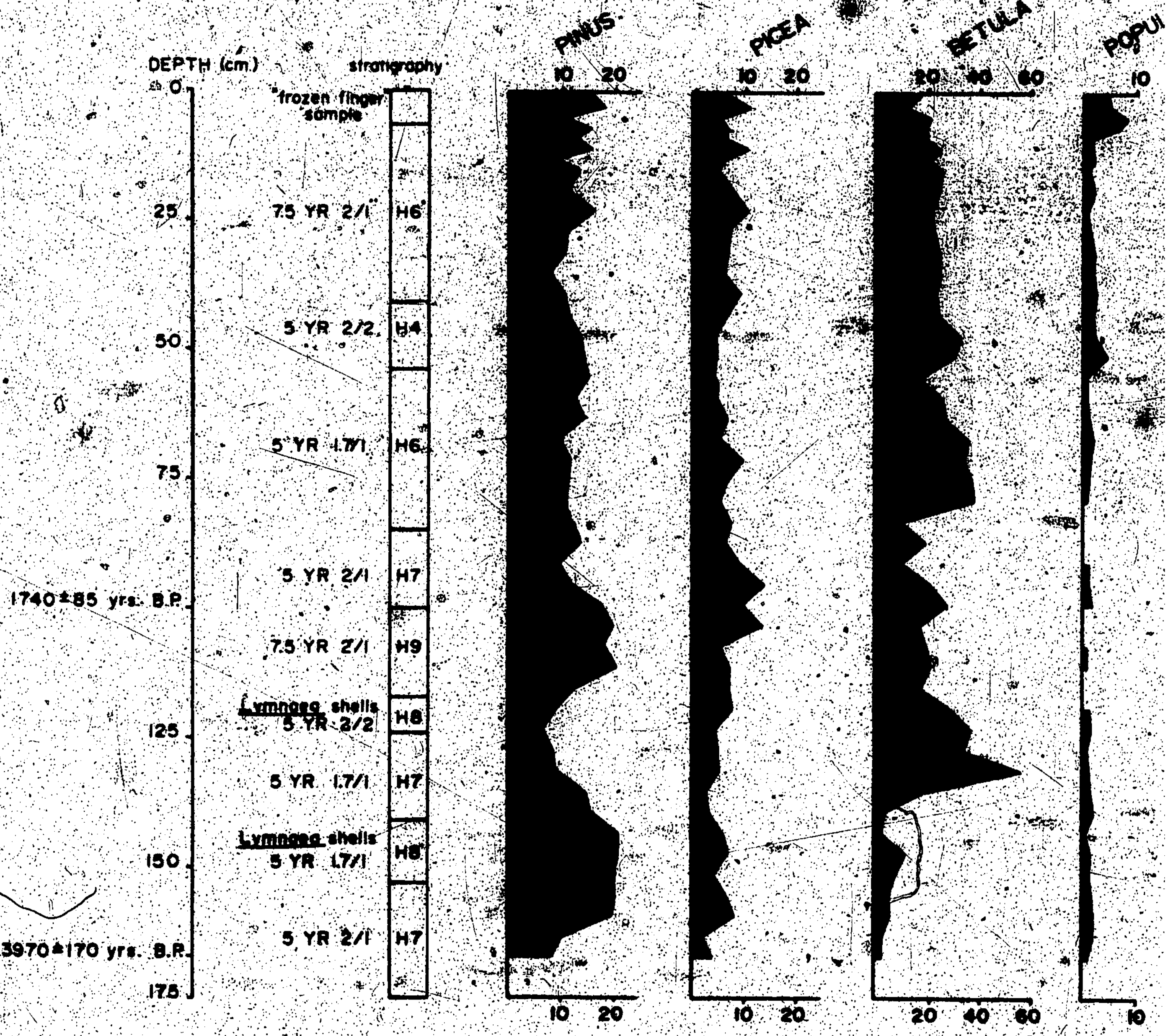
This lowermost portion of the diagram contains the highest proportions of Gramineae (41.5%) recorded in the entire diagram. The impact of these high Gramineae values are apparent in the summary of upland vegetation column. In the lower portions of level 1 herbs make up over 60% of the total upland pollen rain.

Tree taxa are poorly represented in level 1 as Pinus (20%),

Figure 14: Relative percent pollen diagram - pond

ELK ISLAND NATIONAL PARK

relative percent pollen



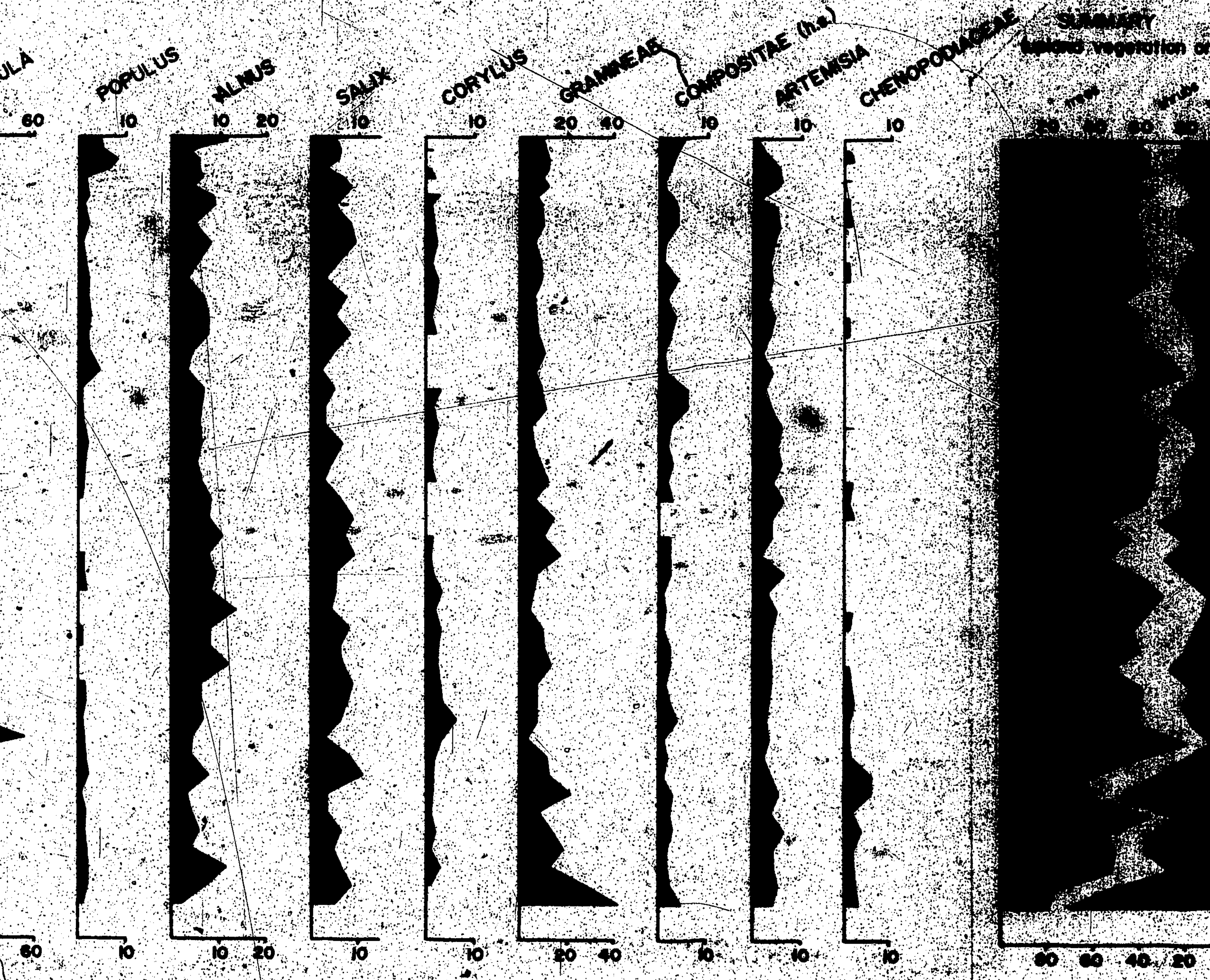
" Munsell notation

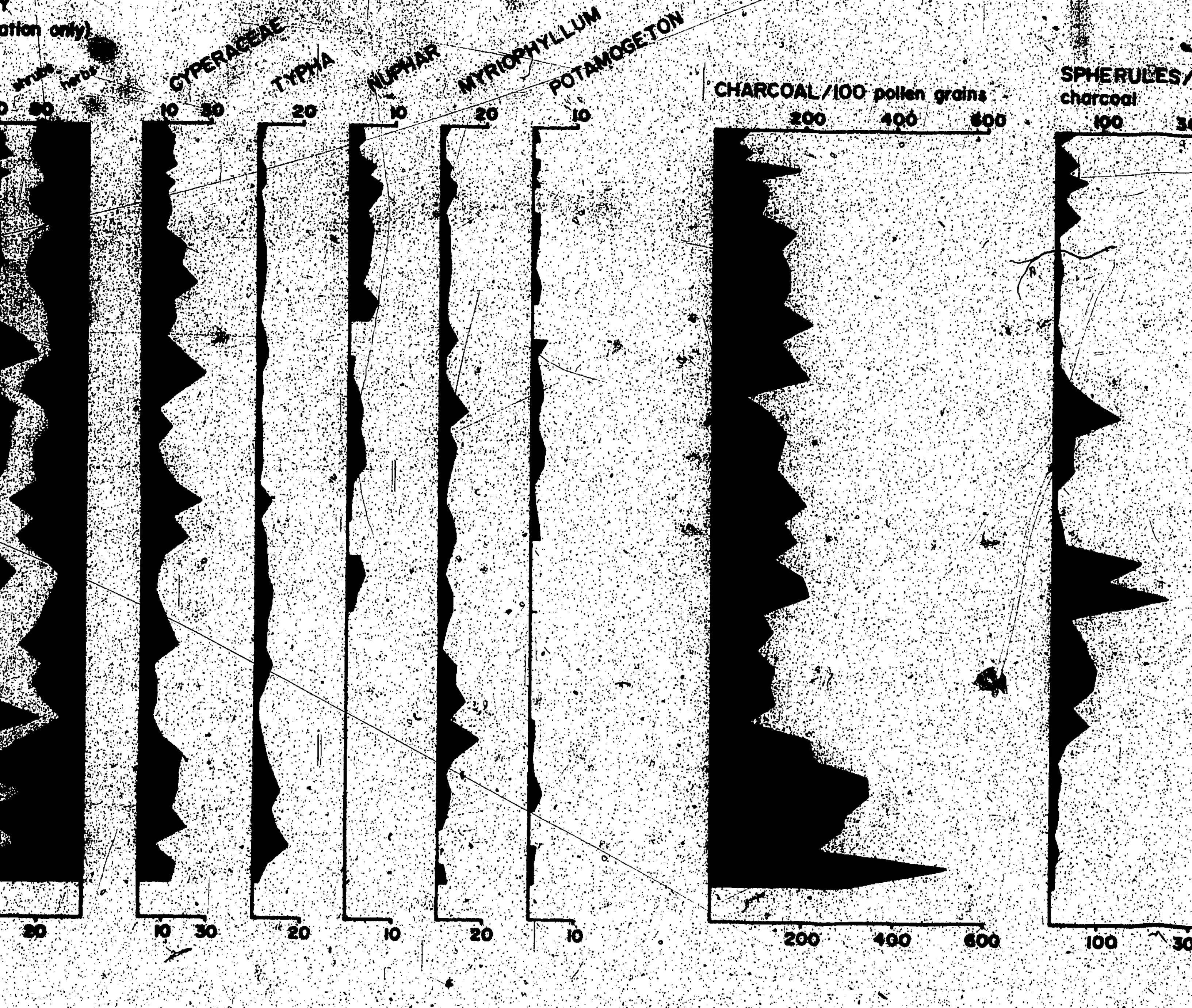
' Von Post decomposition rating

Pollen sum = 200

PARK POND/76

ent pollen diagram





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Picea (less than 10%), *Betula* (less than 11.5%), and *Populus* (less than 5%) contribute only minor amounts to the pollen spectrum. Conversely, Cyperaceae (20%) and *Typha* (15%) contribute the highest values recorded in the entire diagram for these two taxa.

Charcoal attains its highest densities (518 fragments/100 pollen grains) in level 1 while spherules are present, albeit in small amounts (less than 20/100 pollen grains). Level 1 terminates with the decline of Gramineae pollen below 10% concomitant with the rise in *Betula* pollen to values exceeding 20%. It spans a time period from 3,970 yrs. B.P. to 2,725 yrs. B.P.

Level 2 (135 cm to 5 cm):

Level 2 is dominated by *Pinus* (up to 20.75%), *Picea* (up to 13.75%), and *Betula* (up to 55.5%). *Nuphar* makes its first appearance at 105 cm and from this point upwards makes a significant contribution (up to 7%) to the pollen spectrum. All other pollen taxa remain relatively static throughout level 2.

Charcoal fragment density makes a significant drop from level 1 and remains relatively stable at about 100-200 fragments/100 pollen grains. Spherules reach their highest density (251/200 pollen grains) in the lower portions of level 2 but decline to less than 10 spherules/200 pollen grains in the upper portions of level 2. Level 2 terminates with the rise of *Populus* pollen to values greater than 5%.

Level 3 (5 cm to surface):

The uppermost 5 cm reveal a significant drop in charcoal density (68 fragments/100 pollen grains) concomitant with a rise in Populus representation and a rapid rise in Alnus pollen to its highest values (11.5%).

(c) Pollen Influx Diagram - Pond

The pollen influx diagram (Figure 15) shows a sequence of events similar to the relative percent pollen diagram from the pond, further substantiating the notion that the pollen record from the pond actually reflects vegetative change.

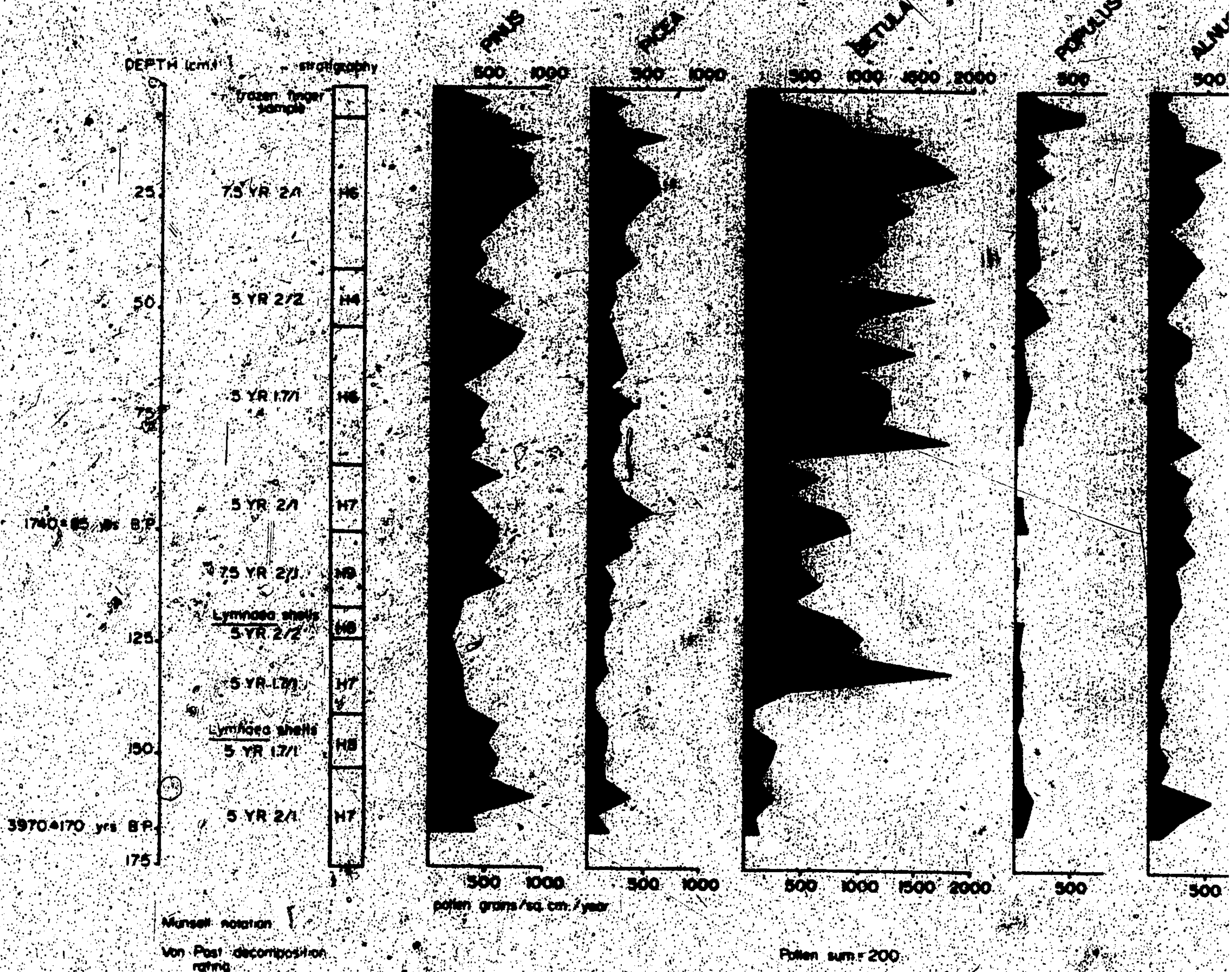
The pollen influx diagram illustrates just how dramatic the Gramineae peak in level 1 is. Further, the sharp rise in Betula pollen representation (135 cm) is again graphically illustrated in pollen influx diagram.

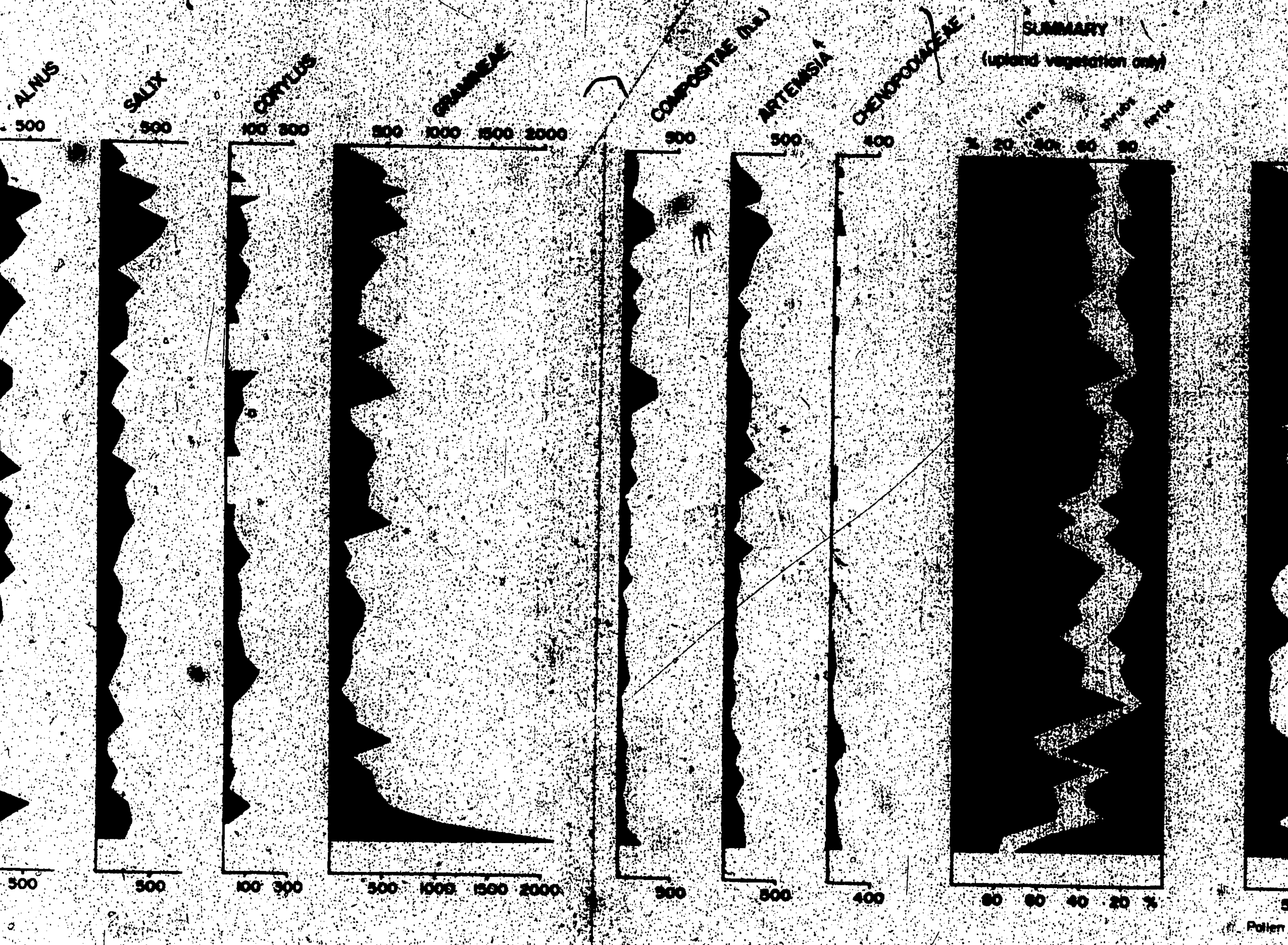
Total pollen influx reaches 5,116 pollen grains/cm^2/yr at 167 cm. From this high value in the lowermost sediments total pollen influx drops to 2,057 pollen grains/cm^2/yr at 135 cm. From this point upwards it makes a relatively steady climb to a high of 6,524 pollen grains/cm^2/yr at 27 cm. This high is followed by a rapid decline in total pollen influx that terminates with an influx value of 1,478 pollen grains/cm^2/yr at the surface of the pond core.

Figure 15: Pollen influx diagram - pond

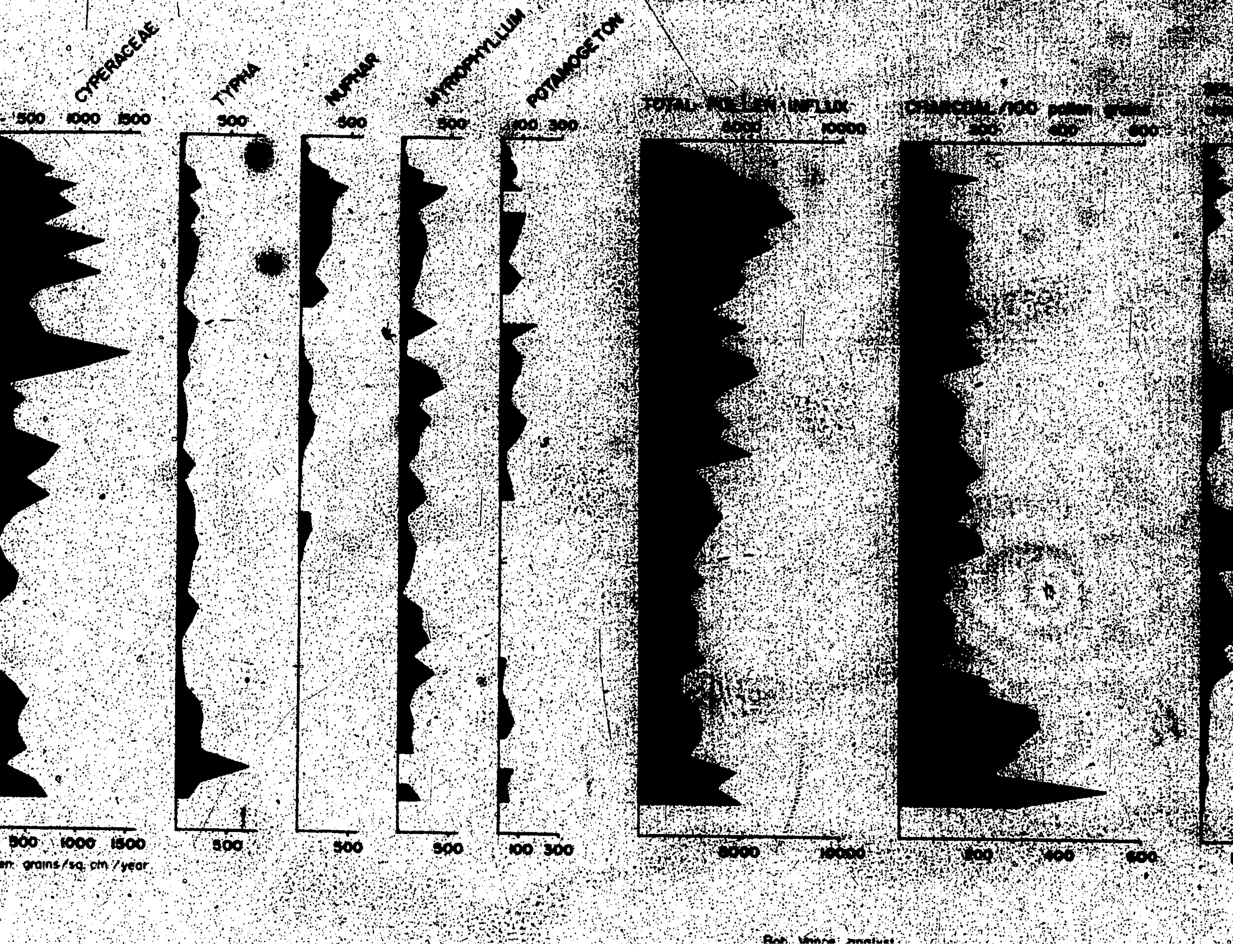
ELK ISLAND NATIONAL PARK POND/76

pollen influx diagram

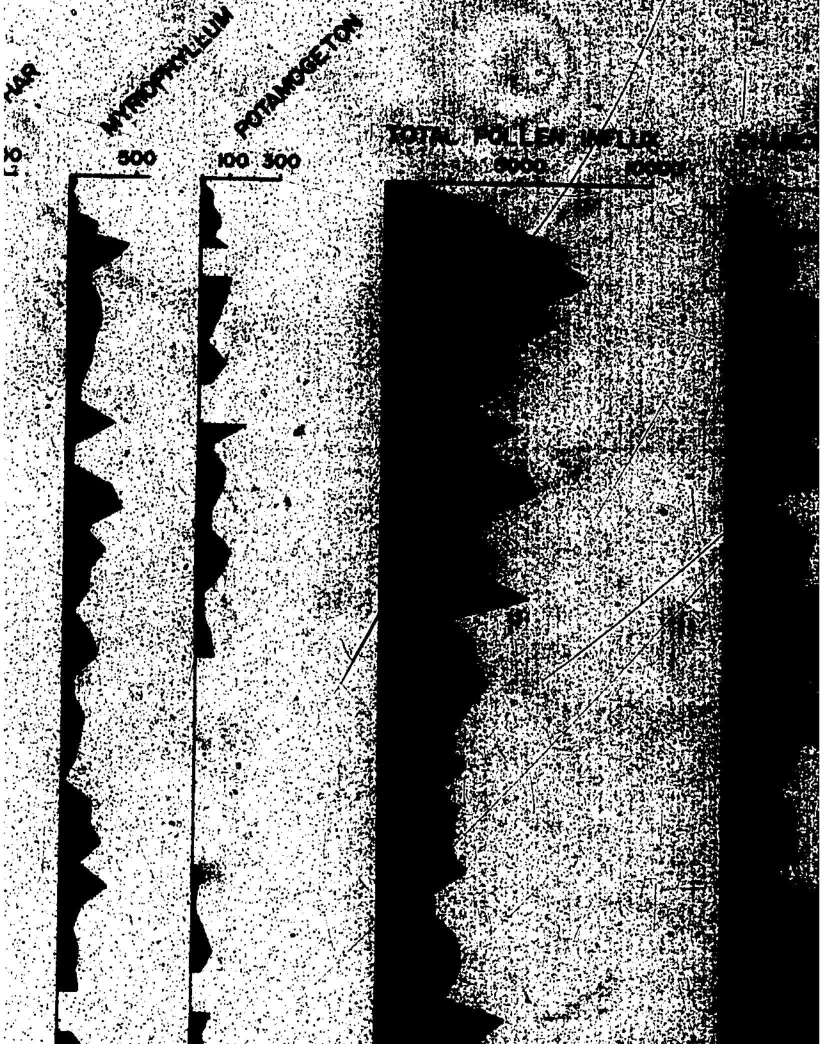




ALNUS
500
SALIX
500
CORYLUS
100 300
GRAMINEAE
500 1000 1500 2000
COMPOSITAE
500
ARTEMISIA
500
CHENOPODIACEAE
400
SUMMARY
(upland vegetation only)
trees
shrubs
herbs
% 20 40 60 80
80 60 40 20 %



CYPERACEAE
TYPHA
NUPHAR
MYRIOPHYLLUM
POTAMOGETON
TOTAL POLLEN INFLUX
CHARCOAL/100 pollen grains
500 1000 1500
500
500
500
100 300
5000 10000
200 400 600
grains/sq. cm/year



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CHAPTER 6 INTERPRETATIONS AND CONCLUSIONS

The Local Record

In order to interpret pollen diagrams correctly the analyst must first distinguish "local" pollen rain from "regional" pollen rain. "Local" pollen rain refers to the changes occurring in the vegetation on the coring site itself, whether these changes are a result of succession or other factors of environmental alteration. The "regional" pollen rain refers to vegetative changes occurring over a much wider area than the coring site itself. Since some pollen grains may be transported upwards of hundreds of kilometers (Faegri and Iverson 1964) the regional record, at its greatest extent, may represent an area of several thousand square kilometers. Distinguishing these aspects of the pollen rain is essential.

What sort of local successional changes may one expect from the locations sampled? Bog-lake succession has been documented by many workers; one such description is offered by Loucks (1970). His developmental sequence involves the infilling of a basin that developed during glacial recession. The initial vegetative community would be an open pond environment with little plant and animal life. Through time, a mat of vegetation would form around the edge of the pond. This mat usually consists of sedges (Cyperaceae) and peat mosses (*Sphagnum* spp.). Subsequently the growth of this organic mat continues and ultimately reaches a stage where it completely fills in the pond. At this time, the organic mat is stable enough to allow the establishment of shrub species, oftentimes initially those of the heath family (Ericaceae). As the establishment of shrubs continues the surface becomes increasingly more stable, eventually reaching a state of stability that allows the establishment of tree species. Typical tree taxa on such a surface include black spruce (Picea mariana) and larch (Larix spp.).

An examination of the relative percent pollen diagram from the bog (Figure 13) reveals an excellent record of precisely such a successional process. The lowermost portion of the diagram (240 cm - 150 cm) exhibits a pollen spectrum with large amounts of Cyperaceae (30% - 60%), Typha (5% - 20%), and Potamogeton (5%). Upland pollen taxa contribute small amounts of pollen to these lower sediment levels. Such a pollen rain is reminiscent of the modern pollen rain from pond environments. Table 4 shows that modern samples from ponds are dominated by Cyperaceae (24% - 52%), Typha (27% - 40%), and Potamogeton (5%). The similarity of these pollen rains shows clearly that the bog pollen record reflects the existence of a pond environment from 4,180 years B.P. to 2,680 years B.P. Furthermore, this pond may well have been slightly larger than the pond in existence now as Typha percentages are slightly lower in the fossil samples, a probable result of an expanded shoreline.

Directly above 150 cm changes in the pollen spectrum indicate successional changes on the ancient pond. Cyperaceae representation drops to below 20% while Typha and Potamogeton become insignificant contributors (less than 5% each).

Concurrent with reductions in these aquatic and semi-aquatic taxa are abrupt increases in pollen representation of Corylus (8%) and Ericaceae (15%). Similarily, trilete spore counts rise dramatically to 200 spores/200 pollen grains. Modern pollen rain from bog environments (Table 3) contain high percentages of Ericaceae (8% - 4%). Also, these modern surface samples show that the presence of substantial amounts of trilete spores (11-72/200 pollen grains) is indicative of a bog environment. Since the fossil pollen rain exhibits these characteristics from 150 cm to the surface it is apparent that bog conditions prevailed.

A more precise successional sequence may be postulated. Indications of the development of sphagnum peat begin with the occurrence of small numbers of trilete spores at 160 cm (2,860 years B.P.). With the establishment of a more stable peat surface shrubs begin growth at 2,230 years B.P. (an event marked by the appearance of large amounts of Ericaceae pollen at 125 cm). Later, with the further stabilization of the peat surface, Picea mariana becomes established on the bog surface. This is recorded by the rise of Picea pollen representation to values greater than 20% at 100 cm (1,785 years B.P.).

Few changes in the relative percent pollen diagram from the pond (Figure 4) may be attributed to successional changes. In fact, it appears that the pond has remained in quite a static condition throughout its 4,000 year history. The appearance of Nuphar in the pollen record at 2,410 years B.P. (110 cm) could be a result of an adjustment of water levels in the pond to a depth conducive to the establishment of a bottom rooted aquatic such as *Nuphar*. This adjustment is suggested to have been an increase in water depth considering the concomitant decrease in *Typha* representation, a probable result of shoreline expansion.

The pollen influx diagram from the pond (Figure 15) shows a sequence similar to the pond relative percent pollen diagram (Figure 14). As the pollen influx diagram is derived by a method designed to remove constraints imposed by percentage calculations, the similarity of this record to the relative percent pond record serves to support the notion that changes in the pollen record from the pond reflect actual changes in the plant community.

The Regional Record

With the identification of local pollen rain in the pollen records it is possible to describe changes of regional significance. Three major events are evident in the pollen diagrams that may be considered a reflection of changes in the regional vegetation.

Firstly, in the lowermost portions of all three diagrams grasses (Gramineae) reach their highest values (41.5%, 2,123 grains/cm^2/year). Coupled with these high Gramineae values are high amounts of Compositae (5%), *Artemisia* (6%), and Chenopodiaceae (7.5%). These lower sediment levels also consistently yield the highest charcoal counts (720 fragments/100 pollen grains) recorded.

Although surface samples from Alberta grasslands were not analyzed in this study, data is available from surface collections in Manitoba grasslands (Lichti-Federovich and Ritchie 1965). These surface collections show that Manitoba grasslands yield a pollen rain typified by a high proportion of herbs (60% - 70%) when Populus and Cyperaceae are excluded from the pollen sum. Chief components in the herb dominated spectrum are Gramineae, Chenopodiaceae, Artemisia, and Ambrosieae.

If pollen percentages in the lowest sediment levels of the pond diagram from Elk Island National Park are calculated excluding Populus and Cyperaceae from the pollen sum the relevant pollen percentages become: Gramineae 56%, Compositae 6%, Artemisia 5%, and Chenopodiaceae 5%. The total proportion of herbs in the upland vegetation is equal to 72%. Based on a comparison with surface samples collected in Manitoba it appears that the lower sediment levels in this pollen diagram are indicative of a grassland environment. However, in the bog diagram the herb proportion reaches a maximum of only 50% at the bottom of the core. Although this value is not indicative of a true grassland (as defined in Manitoba) it certainly indicates a preponderance of herbs. At the very least such a pollen spectrum is a reflection of a very sparsely treed environment. High charcoal densities in both pollen records attest to the common occurrence of fire, a point that further supports the interpretation of an almost treeless environment. Certainly these lower sediments and the pollen spectrum they yield are representative of an open grassland environment. This grassland environment existed at 4,000 years B.P. but is short lived. The pollen record indicates that tree and shrub species gradually become a more integral part of the vegetation even though a Gramineae dominated pollen spectrum persists for almost 1,000 years.

Subsequent to the Gramineae dominated pollen spectrum there appears, on all three diagrams, a sharp and dramatic increase of Betula pollen at 2,800 years B.P. (125 cm on Figure 14 and Figure 15, 165 cm on Figure 13). What could account for such a dramatic rise? To answer this it is necessary to consider some aspects of the autecology of species within this taxon.

Both tree and shrub species of Betula are colonizers of open habitat, and tree species are especially adept at sucking from roots after fire (Hosie 1973). Also, some tree and shrub species of this taxon have a preference for hydric habitat (ibid).

Charcoal counts are extremely high in the pond diagrams (Figures 14 and 15) immediately preceding the Betula rise. This intimates that the abrupt increase in Betula pollen is a result of the expansion of individuals in this taxon into recently burned areas. However, similarly located high charcoal counts are not recorded in the bog diagram (Figure 13).

All three pollen records show that the Betula rise follows immediately after a drop in Typha pollen representation. In the case of the pond, this drop in Typha pollen may be a result of the expansion in the size of the pond. This suggests that the subsequent increase in Betula pollen may be a result of an increased area of hydric habitat, habitat that is ideal for colonization by Betula. In the case of the bog, the drop in Typha pollen representation coupled with the increased density of trileté spores is probably a result of a reduction in pond size due to accumulation of organic matter. In this situation wetland habitat created on the bog surface would provide ideal habitat for Betula growth. These interpretations suggest that the rise in Betula pollen is a result of either local succession (as in the bog diagram) or an increase in precipitation (as indicated by increased water levels in the pond), a regional climatic factor.

Further support for the regional climatic explanation comes from an unpublished pollen diagram from Smallboy Lake, 90 kilometers west of Elk Island National Park (Paleoenvironmental Studies Laboratory, University of Alberta). The Smallboy Lake pollen record also shows a dramatic rise in Betula pollen representation, although at a slightly earlier date (3,700 years B.P.) than at Elk Island National Park (Habgood, personal communication). Increased precipitation certainly offers the best explanation for this widespread creation of Betula habitat although the question is far from being resolved. Whatever the cause, the addition of substantial amounts of Betula pollen to the pollen rain transforms the pollen spectrum into one most reminiscent of the modern pollen spectrum from the Aspen Parkland. Therefore, the present-day vegetation around Elk Island Park was established by 2,800 years B.P. This date may well represent the establishment of the Aspen Parkland in its present position. Such a date agrees with the observations of Ritchie (1976).

A final regional change in the pollen record occurs in the upper 5 cm. The uppermost portion of the pollen record represents the agricultural period.

It is documented that in 1894-95 a series of fires swept over the Beaver Hills area (an area which includes Elk Island National Park) and destroyed the forest of the region (Nyland 1969). These large fires have left their mark in the sediments as a pronounced charcoal peak evident in the upper portions of all three diagrams. As such, these charcoal peaks provide an excellent time marker. They may well be considered as a marker for the beginning of the agricultural period as the first settlers in the Beaver Hills area arrived only two years previously, in 1892 (*ibid*).

Immediately above this pronounced peak the charcoal levels drop dramatically, eventually reaching levels that are near the lowest recorded on the entire diagrams. These low levels are undoubtedly a reflection of European land management policies, policies that include the active suppression of fires.

An examination of the pollen record from the agricultural period reveals that the most dramatic change is the rise in *Populus* representation (to 10%). Although *Populus* does show occasionally throughout all the diagrams it is not until the very recent time periods that it is consistently represented. Its sporadic record may largely be attributed to differential preservation of pollen grains. Sangster and Dale (1961) have shown that there are differences in preservation success among different pollen taxa. Furthermore, their research has revealed that Populus pollen grains are rapidly degraded in bog and pond environments. This fact accounts for the relatively high percentages of Populus in recent times, while its scattered occurrence throughout the record may simply be a result of varying chemical conditions in the depositional surface.

A general trend during the agricultural period is for most pollen taxa to show a reduction in their abundance. This fact is readily apparent in the pollen influx diagram for the pond. Total pollen influx decreases consistently through the agricultural period reaching a low of 1,478 pollen grains/cm^2/year at the sediment surface. What would cause such an overall decrease in pollen representation? This decrease, in many of the pollen taxa, may simply be a result regional agricultural activities. Such practices have brought about a vast reduction of the forested regions in the area. This replacement of forested lands by agricultural lands would bring about a reduction in pollen influx since, in general, (a) forested regions produce large numbers of pollen grains (Davis 1969) and, (b) cultigens produce much larger, and therefore poorly transportable, pollen grains. A further indication of the overall increase in the area of deforested lands is provided by the slight increases in the representation of such taxa as Gramineae, Chenopodiaceae, and Compositae. However, overall decreases in pollen abundance here may simply be due to increased water content. These uppermost sediments are less compacted and would not be expected to contain as high amounts of pollen as the lower, more compacted sediments.

Environmental Interpretations

At a date of 4,000 years B.P. depressions in the Beaver Hills area began infilling as a result of a regional climatic chnage. This date is near the end of the warm, dry Hypsithermal interval and marks the beginning of cooler, moister conditions. The vegetation around the Beaver Hills at this time was an open grassland reminiscent of that existing now in the plains region of southern Alberta. Fire was a common occurrence in this environment, and it served to maintain the grassland condition.

Over the course of the next 4,000 years a series of local and regional vegetative changes occurred at and around these ponds. One pond (the pond that did not have an active drainage system) began accumulating organic matter which led to a gradual infilling of the pond. This process led to the development of the now existing bog. The second pond, due to an open drainage system, did not undergo this process of organic accumulation but did in fact experience a gradual increase in the amount of water contained within its basin.

By 2,800 years B.P. the cool, moist climatic regime brought about the establishment of the Aspen Parkland region in its present position. This establishment is marked the appearance of large amounts of <u>Betula</u> in the pollen records. Its appearance in the appropriate amounts gives the overall pollen spectra of that time an appearance very reminiscent of the existing pollen rain.

From 2,800 years B.P. to 55 years B.P. the environment remained relatively static. It is not until 1895, soon after the arrival of the first white settlers, that any major changes in the regional environment are apparent in the pollen record. With the advent of agriculture regional changes occurred in response to specific causes. Displacement of Indian people, deforestation, and fire suppression combined with modern agricultural activities brought about both a reduction in the forested area of the region as well as an expansion of the southern boundary of the Aspen Parkland. Of these changes the elimination of fires should not be underestimated as a powerful agent of environmental alteration. Charcoal fragments are apparent throughout the pollen records and their presence indicates that fire was an integral part of the ecology of the area. It is not until very recent times that fire has been reduced and the effects of this reduction may not yet be apparent. The exclusion of this agent of vegetative maintenance and succession obviously affects vegetative distribution and is also important in nutrient cycles and animal distribution (Odum 1971). Since fires have been a part of the prehistoric situation, no land management scheme will minimize long term environmental alterations unless fire and its effects are compensated for. The exclusion of fire from the Aspen Parkland environment will upset the ecological balance of the region and can only be viewed as being detrimental to the maintenance of a "healthy", viable ecosystem.

Effect on Human Populations

The stated objectives of this thesis included addressing some questions relevant to human occupation of the Aspen Parkland. Although it was recognized that palynological research alone cannot directly solve these sorts of questions it was hoped that such research, combined with a thorough literature review, could add useful insights.

As has previously been pointed out, the archaeological record for Alberta is far from complete. What little exists seems to indicate that the Aspen Parkland region of Alberta has had long term occupation (Losey 1975, Reeves 1977) with a relatively high density of sites (Losey 1975).

However, 4,000 years ago the region presently occupied by the Aspen Parkland was in fact an open grassland environment. At this time, it seems reasonable to assume that there was a northward shift of the Aspen Parkland, a shift of the type apparent for the northern treeline during the Hypsithermal interval (Nichols 1967). Certainly a northern migration of 80 kilometers, as suggested by Lichti-Federovich (1970), does not seem unreasonable. As a result, a simple northward shift of aboriginal activities would accomodate a continuous habitation of the Aspen Parkland.

What sort of aboriginal activities were carried out in the Aspen Parkland? Based on historic records (Ray 1974) it appears as though the Aspen Parkland served an important and central role in the lives of the aboriginal inhabitants. It is universally recognized that the winter months in northern regions place the greatest stress on survival of aboriginal populations. As well, the role that the buffalo played in supporting northwestern North American aboriginal peoples cannot be underestimated. Since the buffalo sought the shelter of the Aspen Parkland region during harsh weather it would therefore seem logical that human populations would be attracted from the plains to the Aspen Parkland during the winter months not only for the shelter offered but also to captialize on the herds of buffalo holding there. As well, the northern forest dwellers would obviously be attracted to such an abundant food resource of buffalo in the Aspen Parkland. As a result, both plains-oriented and forest-oriented peoples would occupy the Aspen Parkland simultaneously during the winter months. This situation would effectively create an opportunity for social interaction and cultural exchange between these groups. In fact, it is not unreasonable to assume that this cultural exchange accounts for the widespread distribution of both plains artifacts well into the Boreal Forest (Wright 1975, Noble 1971, Pollock 1976) and the southern extension of Boreal Forest artifacts well into the Great Plains (Forbis 1970, Kehoe 1973).

The palynological study at hand indicates that the Aspen Parkland has occupied its present position since 2,800 years B.P. This does not mean that cultural exchanges of the type described above did not occur prior to 2,800 years B.P. The exploitation of the Aspen Parkland did not cease during the Hypsithermal interval, but the scene of this activity shifted further north in accord with the northward movement of the Aspen Parkland.

In summary then, it is suggested that in prehistoric times the Aspen Parkland region played a crucial role in not only the survival of aboriginal peoples but also in the distribution of "diagnostic" artifacts throughout Alberta. In fact, the Aspen Parkland could be considered the primary zone of cultural interaction in Alberta.

During historic times it is more appropriate to describe the effect of human populations on the Aspen Parkland rather than vice versa. With the near extinction of the buffalo, the wholesale restriction of aboriginal activities, the introduction of widespread agriculture, and the suppression of fires, the ecology of the Aspen Parkland was dramatically altered. The overall vegetative structure and distribution has changed. Boundaries have been altered and these adjustments are still continuing. The most obvious of these adjustments that is ongoing is the southern expansion of the Aspen Parkland (Bird and Bird 1967). This continuing alteration serves to remind one of the dynamic nature of not only the Aspen Parkland but of all vegetative communities.

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APPENDIX 1

RELATIVE FREQUENCY OF OCCURRENCE OF MOSSES, HERBS, AND LOW SHRUBS

Bog: Percent Frequency (Occurrence) of Herbs and Low Shrubs by Community.

	Community No.						
	1	4	5	6	7	2	3
Sphagnum sp.	100	100	80	100	92	65	20
Cyperaceae sp.	---	12	40	60	17	35	70
Smilacina trifolia	60	88	70	53	58	5	---
Eriophorum angustifolim	10	25	10	87	50	---	---
Vaccinium vitis-idaea	100	100	80	93	100	---	---
Oxycoccus microcarpus	90	63	10	47	8	---	---
Rubus chamaemorus	65	100	80	93	83	---	---
Ledum groenlandicum	100	100	100	100	---	100	---
Cladonia sp.	100	---	---	27	92	---	---
Vaccinium myrtilloides	---	12	15	8	---	---	---
Polytrichum juniperinum	---	100	45	100	100	---	---
Lycopodium annotinum	---	---	5	---	---	---	---
Pleurozium sp.	---	---	---	---	67	---	---
Dicranum sp.	20	25	15	---	50	---	---
Gramineae sp.	---	---	90	---	7	95	70
Cornus canadensis	---	---	35	---	---	15	60
Epilobium angustifolium	---	---	25	---	---	25	25
Rosa acicularis	---	---	5	---	---	10	85
Caryophyllaceae sp.	---	---	5	---	---	40	---
Ribes hudsonianum	---	---	5	---	---	20	---
Ribes sp.	---	---	10	---	---	40	45
Equisetum sp.	---	---	50	---	---	75	20
Lonicera involucrata	---	---	5	---	---	10	55
Rubus acaulis	---	---	35	---	---	---	80
Amelanchier alnifolia	---	---	15	---	---	---	45
Urtica gracilis	---	---	---	---	---	10	---
Viola sp.	---	---	---	---	---	75	25
Epilobium sp.	---	---	---	---	---	65	---
Caltha palustris	---	---	---	---	---	20	---
Thalictrum sp.	---	---	---	---	---	5	40
Lathyrus sp.	---	---	---	---	---	5	85
Rubus strigosus	---	---	---	---	---	20	80
Petasites sp.	---	---	---	---	---	35	39
Aralia nudicaulis	---	---	---	---	---	5	75
Geum macrophyllum	---	---	---	---	---	5	---
Potentilla palustris	---	---	---	---	---	35	---
Galium trifidum	---	---	---	---	---	20	---
Trientalis europaea	---	---	---	---	---	5	---
Labiateae sp.	---	---	---	---	---	20	---
Mnium sp.	---	---	---	---	---	5	---
Polypodiaceae sp.	---	---	---	---	---	5	---

Appendix 1 (Bog) - Continued

	Community No.						
	1	4	5	6	7	2	3
Symphoricarpus occidentalis	---	---	---	---	---	---	75
Viola rugulosa	---	---	---	---	---	---	65
Aster sp.	---	---	---	---	---	---	65
Disporum trachycarpum	---	---	---	---	---	---	30
Shepherdia canadensis	---	---	---	---	---	---	25
Sanicula sp.	---	---	---	---	---	---	40
Galium boreale	---	---	---	---	---	---	65
Mertensia sp.	---	---	---	---	---	---	40
Viburnum sp.	---	---	---	---	---	---	55
Maianthemum sp.	---	---	---	---	---	---	5
Vicia sp.	---	---	---	---	---	---	50
Actaea sp.	---	---	---	---	---	---	40
Solidago sp.	---	---	---	---	---	---	40
Fragaria sp.	---	---	---	---	---	---	30
Corylus cornuta	---	---	---	---	---	---	50
Lonicera dioicia	---	---	---	---	---	---	15
Heracleum lanatum	---	---	---	---	---	---	5
Pyrola sp.	---	---	---	---	---	---	30

Pond: Per Cent Frequency (Occurrence) of Herbs and Low Shrubs per Community.

	Community No. 1	2	3	4
Typha latifolia	100	15	---	---
Cyperaceae sp.	100	100	95	10
Caryophyllaceae sp.	15	5	20	---
Rumex sp.	10	---	---	---
Galium trifidum	100	95	70	---
Epilobium sp.	75	---	75	---
Cicuta bulbifera	40	---	---	---
Cicuta sp.	---	15	10	---
Ranunculus gmelinii	15	5	---	---
Potentilla palustris	10	45	---	---
Bidens cernua	10	---	---	---
Epilobium palustre	25	5	---	---
Lonicera involucrata	---	30	5	35
Mnium sp.	---	15	40	---
Utricularia vulgaris	---	5	---	---
Potentilla norvegica	---	5	---	---
Gramineae sp.	---	---	40	35
Ribes hudsonianum	---	---	15	---
Equisetum sp.	---	---	15	35
Petasites sp.	---	---	15	20
Ribes sp.	---	---	10	---
Lysimachia thyrsiflora	---	---	40	---
Labiateae sp.	---	---	5	---
Sphagnum sp.	---	---	85	---
Aralia nudicaulis	---	---	---	65
Cornus canadensis	---	---	---	85
Pyrola sp.	---	---	---	30
Rubus acaulis	---	---	---	70
Lathyrus sp.	---	---	---	85
Viola rugulosa	---	---	---	60
Aster sp.	---	---	---	80
Disporum trachycarpum	---	---	---	55
Sanicula sp.	---	---	---	75
Galium boreale	---	---	---	80
Thalictrum sp.	---	---	---	40
Mertensia sp.	---	---	---	35
Maianthemum sp.	---	---	---	60
Vicia sp.	---	---	---	65
Actaea sp.	---	---	---	35
Mitella sp.	---	---	---	15
Solidago sp.	---	---	---	55
Frageria sp.	---	---	---	75
Viola sp.	---	---	---	20
Heracleum lanatum	---	---	---	5
Symphoricarpus occidentalis	---	---	---	85
Rosa acicularis	---	---	---	95
Shepherdia canadensis	---	---	---	25

Appendix 1 (Pond) - Continued

	Community No. 1	2	3	4
Viburnun edule	---	---	---	55
Rubus strigosus	---	---	---	85
Corylus sp.	---	---	---	35
Amelanchier alnifolia	---	---	---	45

APPENDIX 2

LINE TRANSECT (PERCENT GROUND COVER OF LEAF AREA)

	% COVER	
	Pond	Bog
Achillea sp.	---	0.01
Actea sp.	0.16	0.06
Amelanchier alnifolia	1.13	2.07
Andromeda polifolia	---	0.21
Aralia nudicaulis	3.84	2.07
Aster sp.	1.49	0.82
Betula pumila var. glandulifera	---	0.31
Bidens cernua	0.40	---
Caltha palustris	---	0.08
Caryophyllaceae sp.	0.47	0.06
Cicuta bulbifera	0.20	---
Cladonia sp.	---	1.64
Cornus canadensis	0.93	0.51
Corylus cornuta	4.74	3.39
Cyperaceae sp.	37.08	0.67
Dicranum sp.	---	0.14
Disporum trachycarpum	0.59	0.09
Epilobium angustifolium	0.19	0.22
Epilobium sp.	0.30	0.06
Equisetum sp.	3.21	0.63
Eriophorum sp.	---	0.33
Fragaria sp.	0.36	0.17
Galium boreale	0.32	0.27
Galium trifidum	1.53	---
Galium triflorum	0.18	0.02
Geum allepicum	0.01	---
Gramineae sp.	5.87	5.30
Heracleum lanatum	0.25	0.07
Labiateae sp.	0.98	0.06
Lathyrus sp.	2.53	0.64
Ledum groenlandicum	---	20.03

Appendix 2 - Continued

	% COVER Pond	Bog
Lonicera dioicia	0.13	0.04
Lonicera involucrata	1.75	0.68
Maianthemum canadense	---	0.01
Mertensia sp.	0.40	0.24
Mitella sp.	0.01	---
Mnium sp.	---	0.89
Oxycoccus microcarpus	---	0.51
Petasites sp.	0.54	0.24
Pleurozium sp.	---	0.04
Potentilla palustris	0.09	0.15
Polypodiaceae sp.	---	0.06
Polytrichum juniperinum	---	2.16
Pyrola sp.	0.16	0.07
Ribes hudsonianum	0.01	0.02
Ribes sp.	0.11	0.42
Rosa acicularis	5.69	2.84
Rubus acaulis	0.64	1.03
Rubus chamaemorus	---	5.54
Rubus strigosus	2.59	1.09
Sanicula marilandica	0.55	0.37
Shepherdia canadensis	3.27	0.67
Smilacina trifolia	---	1.22
Solidago sp.	1.97	0.31
Sphagnum sp.	---	33.98
Symphoricarpus occidentalis	1.05	0.78
Thalictrum sp.	---	0.12
Typha latifolia	9.42	---
Utricularia vulgaris	0.45	---
Vaccinium myrtilloides	---	1.46
Vaccinium vitis-idaea	---	2.07
Viburnum sp.	0.53	1.47
Vicia sp.	0.71	0.23
Viola rugulosa	0.09	0.13

Appendix 2 - Continued

	% COVER	
	Pond	Bog
Viola sp.	0.26	0.60
unknown herbs	0.14	0.09
unknown mosses	2.42	0.47