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Paul A. Delcourt

P. A. Delcourt, Major Professor

We have read this thesis
and recommend its acceptance:

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Thomas L. Crawhead

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LATE-QUATERNARY VEGETATIONAL HISTORY AT JACKSON POND LARUE COUNTY, KENTUCKY

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Gary R. Wilkins

March 1985

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ABSTRACT

A 6.2 meter core of lacustrine sediment from Jackson Pond, Larue County, Kentucky represents the first continuous sequence from Kentucky permitting the vegetational reconstruction for the full-glacial through late-Holocene intervals. Jackson Pond is a spring-fed pond situated within a karst-collapse basin underlain by Ste. Genevieve and St. Louis limestone of Mississippian age. The site is located at 37°27'N, 85° 30'W, 190 km south of the full-glacial limit of the Laurentide Ice Sheet. Six sediment samples submitted for radiocarbon analysis provide an absolute chronology for the site for the last 20,460 years.

From 20,460 yr B.P. to 20,330 yr B.P. the forest community consisted of a jack pine (Pinus banksiana) dominated boreal forest with a spruce (Picea) subdominant. The remainder of the full-glacial interval, from 20,330 yr B.P. to 16,800 yr B.P., is marked by a co-dominance of jack pine and spruce, and a limited population of the temperate species oak (Quercus), black ash (Fraxinus nigra), elm (Ulmus), sugar maple (Acer saccharum), and hornbeam (Ostrya/Carpinus). A spruce dominated open woodland represents the late-glacial interval, with pine remaining a subdominant. The late glacial is marked by a number of rapid biotic changes in which oak, spruce, and black ash have a co-dominance of the arboreal taxa. The early Holocene, from 10,040 yr B.P. to 7300 yr B.P., is characterized by a mesic northern hardwood-conifer open woodland with spruce, elm, hornbeam, oak, basswood (Tilia), beech (Fagus grandifolia), and hemlock (Tsuga). The remainder of the

Holocene is represented by an open oak savannah. Near the pond a suite of warm temperate arboreal taxa, sweetgum (Liquidambar styraciflua), blackgum (Nyssa), and red maple (Acer rubrum) are established along with a swamp shrubbery of buttonbush (Cephalanthus occidentalis), blackberry (Rubus), and virginia willow (Itea virginica).

Full-glacial climatic extremes reduced temperate taxa to near elimination, with only a few cold-hardy species able to maintain sparse populations 190 km from the maximum ice front. Late-glacial climatic amelioration is marked by a decline in boreal taxa density, but without any significant replacement by deciduous taxa. During the Holocene an open oak savannah predominated, producing the "Barrens" observed by early Euro-American settlers. Distributions of plant taxa are suggested to be dependent upon the environmental parameters established by major air mass systems. The changing positions of the Maritime Tropical, Pacific, and Arctic Air Masses determined the nature of vegetation around Jackson Pond.

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I. INTRODUCTION

The question of the vegetation composition of eastern United States south of the glacial boundary during the Wisconsinan glaciation has been an extensively debated issue in American phytogeography (Braun, 1950, 1955; Cain, 1943; Davis, 1976, 1981; Deevey, 1949; H. Delcourt, 1979; Watts, 1979, 1983). Palynological evidence now documents that during the last full-glacial interval (23,000 to 16,500 yr B.P.) boreal forests occurred as far south as Missouri, Tennessee, Georgia and the Carolinas (H. Delcourt, 1979; Delcourt et al., 1980; King, 1973; Smith, 1984; Watts, 1970; Whitehead, 1981). Major questions remain, however, concerning the vegetation patterns during full-glacial times near the ice front boundary.

This is primarily because few palynological sites with records that extend to peak-glacial times (between 18,000 to 20,000 yr B.P.) have been investigated west of the Appalachian Mountains (Wright, 1981). Most palynological sites near the ice front (Figure 1) have been within deglaciated terrain and are therefore not indicative of full-glacial conditions (King, 1981; Ogden, 1966; Shane, 1975, 1976; Williams, 1974). Full-glacial sites that have been studied within the unglaciated portion of southeastern North America (H. Delcourt, 1979; P. Delcourt, 1980; Delcourt et al., 1980; Smith, 1984; Watts, 1970, 1980a; Whitehead, 1981) all are at least 300 km south of the glacial boundary at its maximum extent (Figure 1). Only one full-glacial site with continuous sedimentation, Pittsburg Basin, Illinois, is located near the ice front

Figure 1. Location map for eastern United States Quaternary pollen sites and the maximum extent of any Wisconsinan ice 18,000 years ago. The area within the dotted line encompasses the Interior Low Plateau physiographic province. Captions are identified as follows; JP=Jackson Pond, GS=Goshen Springs (P. Delcourt, 1980), WP=White Pond (Watts, 1980a), NC=Nonconnah Creek (Delcourt et al., 1980), AP=Anderson Pond (H. Delcourt, 1979), CP=Cupola Pond (Smith, 1984), PB=Pittsburg Basin (Gruger, 1972a, 1972b), CG=Cranberry Glades (Darlington, 1943; Watts, 1979), CB=Chatsworth Bog (King, 1981), C=Carter (Shane, 1975), S=Stotzel Leis (Shane, 1975), SL=Silver Lake Ogden,(1966), PL=Pretty Lake (Williams, 1974), BG=Battaglia Bog (Shane, 1976), RB=Rockyhock Bay (Whitehead, 1981), BP=Bartow County Ponds (Watts, 1970), BS=Boney Springs (King, 1973), L=Longswamp (Watts, 1979), and BU=Buckles Bog (Maxwell and Davis, 1972).

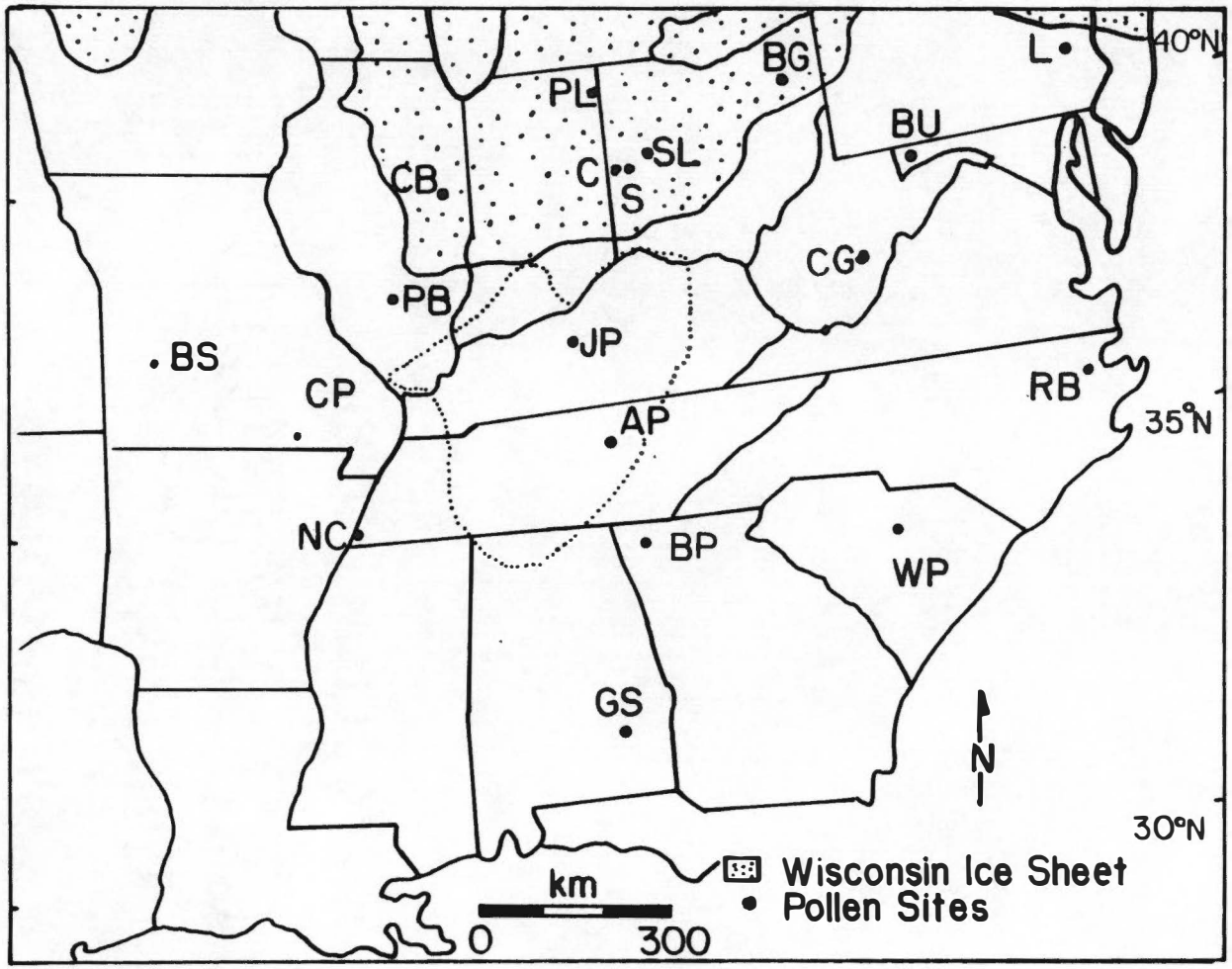

40°N
BG
L
PL
BU
SL
CB
C
S
CG
PB
JP
BS
CP
RB
35°N
AP
NC
BP
WP
GS
N
30°N
km
0
300
Wisconsin Ice Sheet
Pollen Sites

Figure 1

(within 60 km), and the radiocarbon chronology there is ambiguous (Grüger, 1972a, 1972b).

The paucity of late-Quaternary paleoecological information between the ice boundary and known southeastern sites has led to considerable controversy concerning the nature of full-glacial vegetation within 300 km of the glacial maximum. Three differing interpretations of the sparse paleoecological data have been proposed in recent years. Wright (1977, 1981) has suggested that periglacial tundra was generally absent from Ohio to South Dakota during the period of ice advance. He suggested that ice lobes advanced so far into the area primarily because of the region's low elevation, within a climatic regime not as severely cold as tundra vegetation would require. Wright (1981), however, did postulate that a tundra fringe could have developed within northern Indiana and Wisconsin because conditions would have been colder in more northerly latitudes. Sites farther to the south such as Chatsworth Bog in central Illinois (King, 1981) may have been in a warmer climatic regime and therefore have lacked tundra environments. Wright (1977) envisioned that the full-glacial and late-glacial boreal forest was markedly different in composition from that of today, with a glacial-age spruce forest predominating and populations of deciduous trees such as oak (Quercus), elm (Ulmus), and black ash (Fraxinus nigra) remaining in favored locations. A predominately boreal forest of spruce and some northern pines is projected by Wright (1981) as extending from known southeastern sites to the ice front itself.

Grüger (1972a, 1972b) has suggested that the pollen record from

Pittsburg Basin indicated that temperate deciduous forest was the dominant vegetation during the full-glacial interval within 60 km of the ice front in central Illinois. Grüger's paleoecological interpretation included spruce populations as occupying only local areas.

A third view (P. Delcourt and H. Delcourt, 1979; King, 1981; Martin, 1958; Maxwell and Davis, 1972; Whitehead, 1973) is that tundra was present along the southern flank of the Laurentide Ice Sheet both east and west of the Appalachian Mountains. Evidence for this interpretation consisted of periglacial geomorphic features associated with permafrost within 150 km of the full-glacial ice margin (Pewe, 1983), low pollen influx, and presence of tundra indicator species in full-glacial and late-glacial sediments. Estimates of the distribution of full-glacial tundra range from a discontinuous tundra belt (P. Delcourt and H. Delcourt, 1979, 1981) to a broad band of tundra 100 km wide south of the ice front (Martin, 1958).

Simple southward displacement of present-day vegetational zones, however, was unlikely (Maxwell and Davis, 1972; Whitehead, 1973). The dynamic climatic systems found during full-glacial and late-glacial times were different from those of today (P. Delcourt and H. Delcourt, 1984). The individual responses of plant taxa to climatic change may have resulted in full-glacial and late-glacial plant communities considerably different in composition from those found today.

In the Mid-South region, between Tennessee and southern Ohio-Indiana-Illinois, only sparse late-Quaternary paleoecological data are available. In September of 1981, I identified a full-glacial palynological site,

Jackson Pond, near the town of Magnolia in Larue County, Kentucky (37° 27'N, 85°30'W, Magnolia 7.5' U.S.G.S. topographic quadrangle). The site is a lacustrine pond approximately 75 km northeast of Mammoth Cave and 190 km south of the full-glacial ice boundary. The site is located within the Interior Low Plateau (Fenneman, 1938), near the boundary between two of its physiographic subdivisions, the Pennyroyal and the Western Coal Field (McFarlan, 1943). Local relief is approximately 20 meters; the surface area of the pond covering approximately 3 ha. Jackson Pond provides the first continuous palynological record spanning the last 20,000 years of full-glacial through Holocene times in a location between the former ice front boundary and mid-latitudinal southeastern sites (Figure 1). Paleoecological analyses from Jackson Pond therefore provide critical new data on full-glacial vegetation composition and plant species migrations in response to dynamic climatic change during the late Quaternary within this relatively unstudied region.

II. ENVIRONMENTAL SETTING

Jackson Pond is a spring-fed sinkhole located within a karst region, underlain by Mississippian-age Ste. Genevieve and St. Louis limestones (Moore, 1975). The pond lies one kilometer northwest of the crest of the Dripping Springs Escarpment (Figure 2), a prominent physiographic feature marking the border between the Western Coal Field and the Pennyroyal (McFarlan, 1943). The Dripping Springs Escarpment is situated generally along an east-west trending fault and forms a well-developed continuous ridge stretching from the Ohio River southwest in an arcuate pattern to the area of southwestern Kentucky west of the Tennessee River. The escarpment, noted for its deeply dissected cliff-bordered valleys, large sinks and dismembered drainage systems, consists of limestone knobs capped by sandstone. The region to the immediate north-northwest of the escarpment is noted for its wealth of karst basins and contains the famous Mammoth Cave complex.

Jackson Pond lies near the transition between the Mississippian Pennyroyal to the east, with its gently rolling karsted plains, and the adjoining Pennsylvanian sandstone and conglomerate of the maturely dissected Western Coal Field plateau to the west. Jackson Pond's location is therefore within a diverse physiographic region where landscape elements of both the Pennyroyal and the Western Coal Field are evident. The Dripping Springs Escarpment provides a steady reservoir for spring-fed recharge of collapse basins at the base of the ridgeline (Brown, 1973; Jillson, 1927; Moore, 1975). Many of the deepest sinkholes are located at the heads of limestone valleys where they meet the

Figure 2. Location map for Jackson Pond and surrounding drainage. (Magnolia 7.5' U. S. G. S. topographic quadrangle).

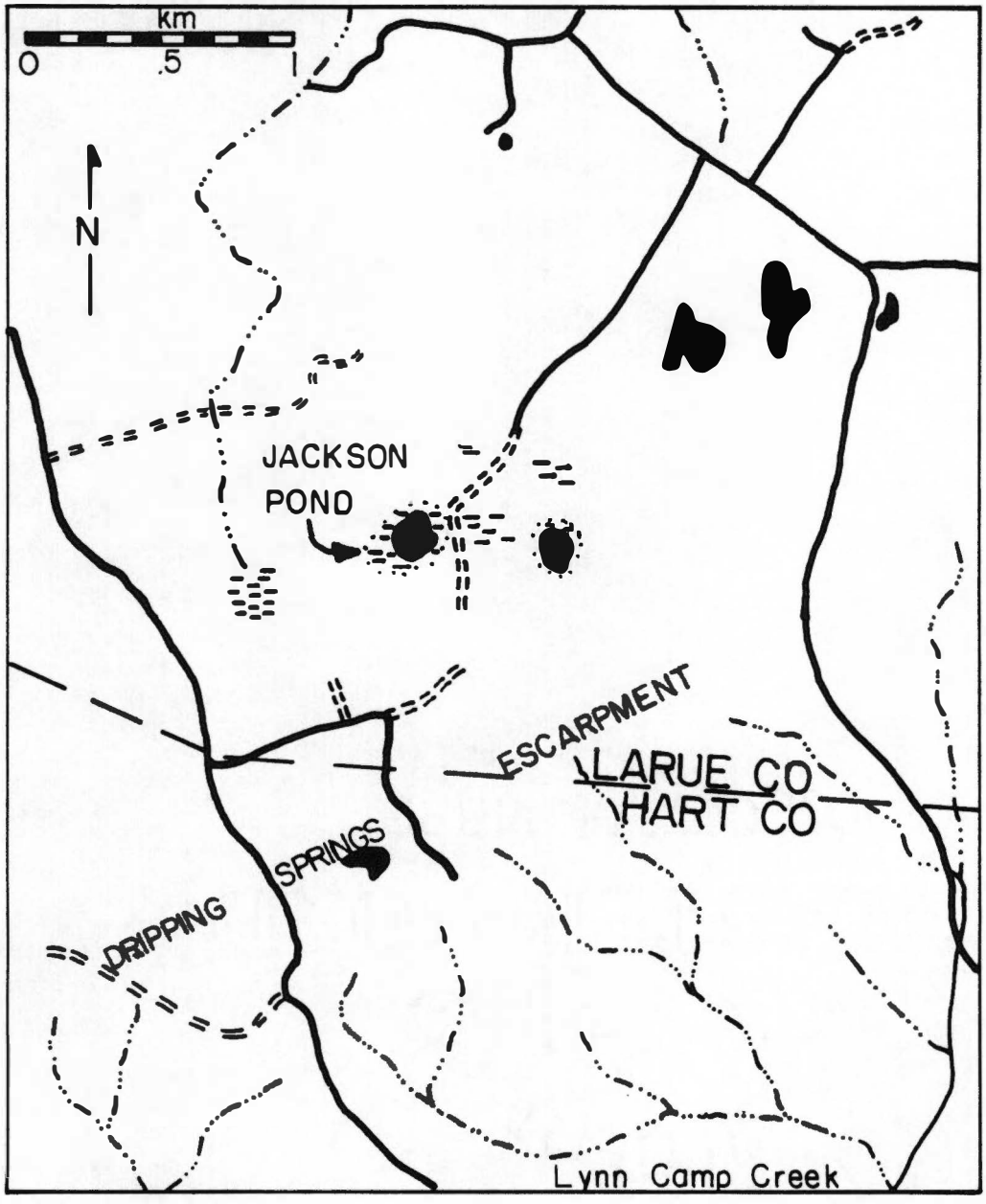

km
0
.5
1
N
JACKSON
POND
ESCARPMENT
LARUE CO
HART CO
SPRINGS
DRIPPING
Lynn Camp Creek

Figure 2

Dripping Springs Escarpment. Lower groundwater recharge is enhanced by development of sinkholes, as well as the tendency for sinking streams to flow into the escarpment (Brown, 1973). Also, slumping sandstone, shale, and conglomerate from either the escarpment-capping Cypress Sandstone or nearby Pottsville Group provide a source of material for clogging nearby sink-collapse basins. The drainage area encompassing Jackson Pond is typical in this respect because the regolith represents a surficial veneer of slumped rock debris of sandstone, shale, or conglomerates mixed with residual clayey soil derived from weathered limestone. The Ste. Genevieve and St. Louis formations provide a major source of ground water for springs (Moore, 1975; Otton, 1948).

Although many karst basins are found along the Dripping Springs Escarpment, Jackson Pond has particular attributes which have contributed to its long permanence. It lies within a large basin in which numerous sinkhole depressions are found. The large basin is bounded on all sides by low rolling hills or the escarpment itself. This is an ideal location for the development of deep karst basins (Brown, 1973). This topographic position has provided the basin with a steady supply of surface recharge from the Dripping Springs Escarpment, surface runoff from the surrounding hills, and the abundance of water within the Ste. Genevieve and St. Louis limestones have combined to provide a steady and reliable source of water for the development of a permanent pond.

The vegetation of the Interior Low Plateau region was characterized by Braun (1950) as Western Mesophytic Forest. This region includes a mosaic of vegetational types rather than a single type of climax

vegetation, and is a transitional area between the true Mixed Mesophytic Forest to the east and the Oak-Hickory Forest region to the west. Vegetation composition is strongly influenced by local environmental conditions such as soil fertility, depth to the ground water table, mineralogic composition of the underlying bedrock, and topography, as well as by regional climatic controls. Mixed mesophytic forests are particularly prominent in the eastern portion of the study region. Forests dominated by oak and hickory (Carya) are more prevalent in the west.

Oak and oak-hickory forests were dominant in the presettlement forest of the Western Coal Field plateau. This oak-hickory forest type was also present on upper slopes of the adjacent border region bounded by the Dripping Springs Escarpment (Braun, 1950). Where streams cut the escarpment, a much more mesic condition prevailed. These ravine slopes were characterized by white pine (Pinus strobus), yellow birch (Betula allegheniensis), beech (Fagus grandifolia), shellbark hickory (Carya ovata), butternut (Juglans cinerea), tuliptree (Liriodendron tulipifera), magnolia (Magnolia macrophylla, Magnolia tripetala), red maple (Acer rubrum), sugar maple (Acer saccharum), holly (Ilex opaca), blackgum (Nyssa sylvatica), sourwood (Oxydendrum arboreum) and white ash (Fraxinus americana). This mixed mesophytic forest was common along the slopes of ravines and a more xeric oak-hickory was dominant on upper slopes. Where valley floors developed, sweetgum (Liquidambar styraciflua) and sycamore (Platanus occidentalis) were common in riverine forests. The Western Coal Field was therefore a mosaic of

different forest communities. The plateau and upper slopes were dominated by oak and hickory. Lower slopes were occupied by a mixed mesophytic forest with a diverse assemblage of tree species including dominants of beech and sugar maple. Valley areas were often swampy and contained sweetgum and sycamore.

The adjoining Mississippian Plateau was characterized by an extensive prairie community when the earliest Euro-American settlers arrived in the region (McInteer, 1942; Sauer, 1927; Weller, 1927). These early settlers thought that the absence of trees indicated poor soil, and that the most productive land was covered by dense forests. The prairie was named "the Barrens" on Filson's map in 1784. The barrens area was depicted on Filson's map as occupying a narrow belt from the Ohio River just west of Louisville southward to the Tennessee state line and westward to the Cumberland River. The arc-like distribution of barrens corresponds with the area immediately south of the boundary formed by the Dripping Springs Escarpment. Although early historic accounts emphasize the treeless conditions, some limited areas were forested, particularly gallery forests within river valleys. Early Euro-American settlements such as Elizabethtown, Bowling Green and Hodgenville, were usually established in these wooded areas (McInteer, 1942). According to Sauer (1927: 127):

> It cannot, therefore be regarded as a relic grassland, but must be considered as an area in which edaphic conditions were unsuited to tree growth, or one that had become deforested, in which the forest islands and tongues were remnants of a vanished forest, not outposts of an invading forest.

Jackson Pond therefore lies within a transitional area between the forested Western Coal Field and the prairie barrens area to the south and east. The location of Jackson Pond within limestone terrain suggests that the flora in the immediate vicinity of the pond would be more similar to that of the Pennyroyal Barrens area.

The presettlement vegetation of southern Larue County included relict prairie outliers known to exist in Grayson County to the west of Jackson Pond (Bryant, 1977). Sauer (1927: 127) noted that Gilbert Imlay, Land Commissioner in the Back Settlements, indicated around A.D. 1792 that south of Elizabethtown there was an "extensive plains, which stretches upwards of one hundred and fifty miles in a southwest course.. .." This plain corresponds to Filson's barrens area which encompasses the study area of southern Larue County around Jackson Pond. Mesic forests grew along the Dripping Springs Escarpment one kilometer southeast of Jackson Pond, providing presettlement vegetational mosaics of prairies and forests.

Sauer (1927) has documented the settlement of the Pennyroyal region as occuring from A.D. 1780 to A.D. 1820 (Figure 3). In A.D. 1780 the region was virtually uninhabited, with 5000 people in the area by 1790 and 150,000 by 1820. Euro-American impact upon the region as recorded in the sediments of Jackson Pond would therefore be initially found within this period.

Barton (1919) has published accounts of the amount of standing timber in Kentucky, tabulated by counties in the early twentieth century. Barton's study indicated the composition of forests in Larue

Figure 3. Euro-American settlement of the Pennyroyal Physiographic Province.

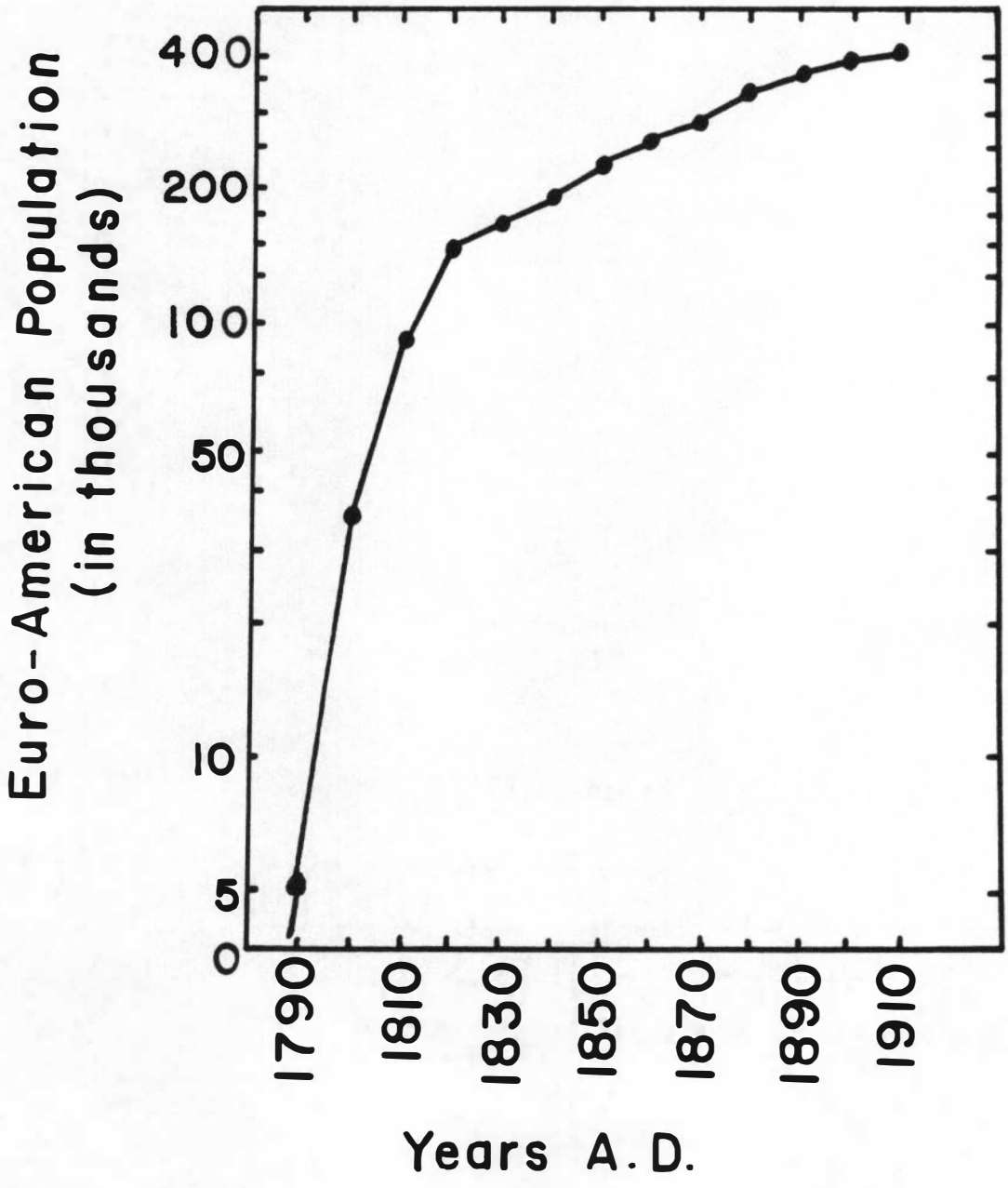

Euro-American Population
(in thousands)
400
200
100
50
10
5
0
1790
1810
1830
1850
1870
1890
1910
Years A.D.

Figure 3

and the adjacent counties of Hart and Green (Table 1). Overall, species of oak were dominant, with other trees such as beech, chestnut (Castanea dentata), hickory, and poplar also present in significant percentages.

Land area surrounding Jackson Pond today is primarily in pasture or cultivated for corn. A narrow belt of trees, primarily oak, hickory, sweetgum, and maple, grows around Jackson Pond at an elevation just above the typical high-water mark for the pond. Beyond this outer perimeter of the pond, trees in the adjoining terrain have been cut and the area is now a pasture except for a low swampy area connecting Jackson Pond to another permanent pond in a sinkhole 350 m to the east (Figure 2). Buttonbush (Cephalanthus occidentalis) grows extensively at the fringe of the pond in the zone characterized by seasonal oscillations in water level. Jackson Pond is covered by a thick mat of water lilies (Nuphar), with several small pools of open water (up to four meters diameter) within the central portion of the pond. According to Mr. Jackson, the current owner, Jackson Pond contains a permanent pool of standing water and has not dried out in the last 50 years. During the most severe droughts (i.e. the 1930's and the 1950's) the majority of the pond basin lacked standing water except for a small pool at the geographic center of the basin. Even then, sediment outside of the permanent pool remained moist. Average yearly fluctuations in water level are small, approximately 50 cm. In addition to Nuphar presently covering much of the pond surface, aquatic plants within open pools of water include knotweed (Polygonum), swamp loosestrife (Decodon verticillatus), bladderwort Utricularia) and sedges (Carex).

PERCENTAGE MEASUREMENTS OF WOOD VOLUME BY COUNTY

Trees	Larue County	Hart County	Green County
White Oak	15.70	9.30	4.60
Black Oak	23.50	46.70	55.10
Post Oak	6.20	21.10	0.00
Chestnut Oak	13.00	0.00	0.00
Beech	0.01	0.00	17.20
Poplar	0.01	3.80	4.90
Hickory	13.70	8.50	9.30
Maple	0.06	0.00	0.86
Sycamore	0.03	0.00	0.37
Chestnut	24.30	6.20	4.60
Gum	0.00	3.20	1.80
Locust	0.00	3.20	0.00
Walnut	0.00	0.00	0.85
Other Trees	3.30	3.70	0.34
Percent of Land in Forest	23.49	40.52	21.51
Percent of Land in Prairie or Cultivation	76.51	59.48	77.49

Table 1. Measurements of standing timber in Larue, Hart, and Green Counties, early 1900's (adapted from Barton, 1919).

The pond is situated within an area mapped within poorly drained soils of Melvin silt loam (Arms et al., 1979). This soil type is common within nearly level (0 to 2% slopes) upland depressions, floodplains and karst valleys. Melvin soils are subject to flooding and ponding for brief periods during rainy seasons. Soils of Melvin silt loams are considered of limited urban use due to high hazard of sporadic flooding, extreme wetness and a seasonally high water table (Arms et al., 1979).

Mean annual precipitation is 130 cm, with approximately 50% of the rainfall occuring between April and September (Arms et al., 1979; Visher, 1929). Average winter temperatures for December through February are 2°C, with freezing temperatures occuring on 70 to 85 days each winter and the average frost-free period ranging from 180 to 185 days a year. Average summer (July) temperatures range from a minimum of 23°C to a maximum of 43°C (Arms et al., 1979; Visher, 1929).

III. METHODS

Fieldwork

A series of 7.5-minute U.S.G.S. topographic quadrangle maps was inspected for northern and western Kentucky, southern Ohio, Indiana, and Illinois in order to locate natural lakes, ponds or swamps for prospective full-glacial palynological sites. Each topographic quadrangle was rated for its site potential in terms of natural ponds or swamps, utilizing four criteria for identification of prospective sites. The pond first had to be permanently wet in order to prevent oxidation of plant fossils. Secondly, the presence of a fringe of swamp forest indicated a high water table and minimal disturbance by man. Thirdly, in order to provide a record of pollen influx that would reflect changes in vegetation independent of sedimentation patterns, closed basins were located that contained neither stream inlets nor outlets. Fourth, formal names on a map indicated possible historic permanence. I identified a series of high-potential sites near Mammoth Cave, Kentucky, along a north-south transect from Elizabethtown to Monroe, and cored the best of the prospective sites, Jackson Pond, in the Fall of 1981.

At Jackson Pond, a 110 cm length sediment core was recovered only 10 m from the edge of the pond. Subsequent analysis revealed excellent pollen and plant macrofossil preservation, with a shift from boreal to deciduous dominance of species at 95 cm sediment depth. A second trip in the Fall of 1983 was to retrieve a complete sediment core from the

deepest pool at the geographic center of Jackson Pond. A wooden raft was constructed and attached to two four-man inflatable rafts. Concrete anchors positioned at all four corners of the wooden platform stabilized the position of the raft for coring activities. Two sediment cores, 83-A and 83-B, located at a distance of one meter apart, were recovered from the center of the pond. Core segments were retrieved in meter-length drives with a modified Livingstone square-rod piston corer (Wright, 1967). A chain hoist used to extrude the deeper drives made penetration and removal of core segments from deep within pond sediments possible. All core segments were described in the field, including depth interval below platform surface, sediment color (Munsell Color, 1975), and grain size. The cores were then wrapped and placed in 1-m long wooden boxes. All cores were subsequently stored in a refrigerated room in Hesler Hall at the University of Tennessee, Knoxville.

Laboratory Analysis

Sediment core 83-B was analyzed for pollen and loss-on-ignition (LOI) with samples obtained with a 1-cm^3 calibrated brass sampler (Birks, 1976). Volumetric sediment samples were taken for estimates of bulk density, mineral and organic components of the sediment, and calculation of sediment influx. The amount of water remaining in the sediment was determined by first weighing each sample, then baking it overnight at 100°C. Following cooling of the sample, it was reweighed and residual water loss (the difference in weight in g/cm^3 sediment) calculated. Organic content, carbonate minerals and non-carbonate minerals were also calculated by the loss-on-ignition procedure of Dean (1974). All samples

were heated at 550°C for one hour, cooled, and reweighed for weight loss due to the combustion of organic material. Then, the samples were heated again at 1000°C for one hour, cooled, and reweighed to determine the amount of carbonate minerals. The weight of the remaining residue corresponds to noncarbonate minerals (Dean, 1974).

For palynological analyses, each 1-cm^3 sediment sample had one or more tablets of Eucalyptus globulus pollen grains (Stockmarr batch number 903772) added to it before chemical processing. Each tablet contains an average of 16,180 Eucalyptus pollen grains, which are used along with tabulation of native-pollen grains and spores to calculate palynomorph concentrations within the sediment sample (Maher, 1977). The number of Eucalyptus tablets needed for each sample was determined by preliminary pollen analysis of selected levels, in which a single Eucalyptus tablet was added to each sample. Fossil palynomorph to exotic pollen ratios in these samples were then used to determine the number of Eucalyptus tablets required for an adequate ratio calculation of pollen influx for differing sections of the sediment core.

All sediment samples were chemically treated using a palynomorph-extraction procedure modified from that of Faegri and Iversen (1975) (See Appendix A for a description of the chemical procedure used). Macroscopic organic matter, clay minerals, and silicate minerals are thereby removed, producing a concentrated residue of pollen grains and spores. All slides were prepared by placing several drops of silicone oil with a vicosity of 2000 centistokes on the center of the slide. A portion of the palynological residue was then mixed with the silicone oil

and spread across the area to be covered by the cover slip, thus minimizing selective distribution of pollen grains beneath the cover slip. All pollen counts were made by starting at the right-hand corner of the coverslip and thoroughly covering either half or the entire coverslip with traverses at uniform-distance intervals. A minimum of 300 arboreal (tree) pollen grains was counted for each sample, along with spores of shrubs, lianas, herbs, ferns, and aquatic plants encountered on the systematic transects. All slides were routinely counted using a Leitz Dialux 20 microscope at a magnification of 500X with 12.5 X eyepieces and a 40.0 X NPL oil-immersion objective (numerical aperature 0.70). When identification required more optical resolution, a drop of anisole was placed on the surface of the coverslip and a magnification of 1250X was achieved with a 100.0 X NPL oil-immersion objective (numerical aperature 1.32).

All conifer grains were tallied as complete grains when the cap and one attached bladder were observed. Isolated conifer bladders were tallied as units of ½ grain. Tetrad palynomorphs were counted either as complete dispersal units when all four of the individual bladders were present or as individual grains when isolated. Fragments of other pollen types were tallied as complete if more than half of the grain was present. Percentages for arboreal pollen grains (AP) were calculated based on the total Tree-Pollen Sum (a minimum count of at least 300 grains). Percentages of non-arboreal pollen grains (NAP) were calculated based on a total Upland Pollen and Spore Sum. Non-arboreal pollen types included shrubs, lianas, upland herbs, ferns, horsetails, club mosses, and unknown types. Obligate aquatics and indeterminable palynomorph grains

were calculated based on a Total Upland Pollen and Spore and Aquatic Sum. Fifty-eight pollen samples were counted, spaced at approximately 400 to 700 year intervals in the Pleistocene sediments and 800 year intervals in the Holocene sediments (30 cm apart and five centimeters apart respectively). Estimation of the depth intervals that corresponded to a given time interval was based upon initially broad spacing of samples throughout the sequence and establishing a preliminary chronology. A finer temporal resolution was used for a late-glacial section (100 year intervals with 2.5 cm spacing) in which rapid biotic changes within a short span of time were identified. Literature and reference slides for palynological identification were available from the Program for Quaternary Studies at the University of Tennessee, Knoxville. Key literature used for identification included: Amman (1977); Bassett et al. (1978); Berglund and Praglowski (1961); Helmich (1963); Kapp (1969); Lieux (1980a, 1980b); Lieux and Godfrey (1982); McAndrews et al. (1973).

Measurements of the internal cap diameter of pine pollen permits the separation of northern and southern Diploxylon Pinus due to size variation (Whitehead, 1964). Six samples were studied, five from full-glacial and late-glacial sediments at 2000 year intervals and a sixth from the historic zone. One hundred grains were counted from each of full-glacial and late-glacial samples, with 50 grains counted from the historic sample due to lower pine percentages of only 8% of the AP (below the pollen threshhold of greater or equal to 12% of the AP needed for local representation, H. Delcourt and P. Delcourt, 1985). Following identification procedures established by Amman (1977) northern diploxylon

pine was identified as either jack pine (Pinus banksiana) or red pine (Pinus resinosa).

Six sediment segments were subsampled from core 83-B; the volume of each segment was chosen to contain five grams of organic carbon as calculated from the loss-on-ignition analysis. These segments were submitted for radiocarbon analysis at the Laboratory of Isotope Geochemistry University of Arizona, Tucson, Arizona. A gas-proportional counter was used for the youngest radiocarbon sample, and a liquid-scintillation counter used for the remaining five, older samples.

Assemblages of plant macrofossils were examined from core 83-B, with a total of 29 macrofossil samples selected for analysis. Macrofossil samples were centered on stratigraphic levels associated with pollen spectra, with macrofossil samples processed for all recognized pollen zones. All samples consisted of a 5-cm vertical section of core (100 cm^3) which was sieved through USA Standard sieves with meshes of 212 μm, 150 μm, and 90 μm. All seeds and fruits, conifer needles, other recognizable plant debris, and insects were picked out and preserved in a macrofossil preservative consisting of 35% water, 50% glycerin and 15% formaldehyde. Taxonomic literature and reference collections were available for comparative purposes at the Program for Quaternary Studies, Knoxville, Tennessee. Particularly useful references included: Berggren (1969); Delcourt et al. (1979); Martin and Barkley (1961); Montgomery (1977); Schopmeyer (1974).

Pollen Zonation

The CONSLINK (constrained single-link cluster analysis) program of Birks (1979) was used to distinguish times of greatest change in the pollen-percentage diagram as an aid to developing local informal pollen assemblage-zones for the Jackson Pond record. CONSLINK uses a dissimilarity coefficient, the Manhattan Metric to compare the composition of stratigraphically adjacent pairs of pollen samples. The Manhattan Metric is calculated as $d(j,k) = \Sigma(Pij - Pik)$. In this equation "d" is the unweighted dissimilarity between two adjacent levels j and k, Pij is the total difference in the pollen spectra of level j, and Pik is the total difference in pollen spectra of level k (Prentice, 1982).

Modern Analogues

One quantitative method of reconstructing past vegetation is the use of dissimilarity coefficients between fossil and modern pollen assemblages to derive modern analogues of the fossil spectra. H. Delcourt and P. Delcourt (1985) have compiled for calibration a total of 1684 modern pollen samples between 25° and 60°N latitude and 50° to 105°W longitude, encompassing tundra, prairie, and boreal through warm-temperate forests of the eastern North America.

Utilization of these data has permitted the identification of contemporary analogues for fossil pollen levels at Jackson Pond. The three best analogue determinations for each of the three coefficients of dissimilarity were calculated at 1000 year intervals, from the surface sample designated 0 yr B.P. (years before present) to 20,000 yr B.P. (based upon ages interpolated using the radiocarbon chronology). The three

analogue procedures used were Euclidean Distance, Chord Distance, and Standardized Euclidean Distance, each weighing pollen taxa differently for dominant, sub-dominant and rare taxa (Prentice, 1982). The dissimilarity coefficient for Euclidean Distance is weighted towards the dominant taxa, Chord Distance de-emphasizes dominant taxa, and Standardized Euclidean Distance weighs all taxa equally, standardizing them based upon the observed variance in the total data set.

In the formulas used in calculating the dissimilarity coefficients, Pij represents the pollen percentages of taxon i in pollen spectrum j, Pik represents the pollen percentages of taxon i in pollen spectrum k, $\sum_i$ represents the summation over all taxa, d(j,k) represents the dissimilarity between pollen spectra j and k, and s_i represents the standard deviation of taxon i in the data set. The formulas are:

Euclidean Distance

$$d\ (j,k) = \sqrt{\sum_i (Pij - Pik)^2}$$

Chord Distance

$$d\ (j,k) = \sqrt{\sum_i (Pij - Pik)^2}$$

Standardized Euclidean Distance

$$d\ (j,k) = \sqrt{\sum_i \left(\frac{Pij - Pik}{s_i}\right)^2}$$

Analogue results are presented in tabular form in Appendix B.

Palynomorph Influx

Studies of the contemporary pollen rain in eastern North America have demonstrated statistically significant relationships between pollen percentages and vegetation composition (Delcourt et al., 1983; Webb and

McAndrews, 1976; Webb et al., 1981). Of particular importance to this study is the determination of the influx or accumulation of pollen and spores, which has been quantitatively correlated with the structure of vegetation surrounding the depositional environment (Davis, 1969; Davis et al., 1973; Ritchie and Lichti-Federovich, 1967). A number of studies utilizing modern pollen rain determined by both pollen traps and surface-sediment samples, as well as influx estimates based upon fossil pollen samples provide a guide for interpretation of palynomorph influx from fossil pollen sites. Values of palynomorph influx in tundra environments range from 5 grains to 1000 $gr \cdot cm^{-2} \cdot yr^{-1}$ (Ritchie and Lichti-Federovich, 1967; Birks, 1973; Davis, 1969; Lamb, 1980). The transition from a tundra to a taiga or open spruce woodland, as documented by Ritchie and Lichti-Federovich (1967), has values of 275 grains up to 2000 $gr \cdot cm^{-2} \cdot yr^{-1}$. Ritchie and Lichti-Federovich (1967) have indicated that palynomorph-influx values in an open conifer forest are 3000 to 12,000 $gr \cdot cm^{-2} \cdot yr^{-1}$. Within this broad influx range others, such as Lamb (1980) and Ritchie (1967), have interpreted boreal forests. It is likely that distinguishing open woodlands from boreal forests may require additional data, such as non-arboreal pollen percentages to characterize the extent of forest openness. In this study tundra will be considered any level in which influx is less than 1000 $gr \cdot cm^{-2} \cdot yr^{-1}$ and NAP values are 25 to 40% of the Upland Pollen and Spore Sum. A taiga to open spruce woodland will consist of an influx of 1000 to 5000 $gr \cdot cm^{-2} \cdot yr^{-1}$ with NAP values of 18 to 40% of the Upland Pollen and Spore Sum. Boreal forests will have greater than 5000 $gr \cdot cm^{-2} \cdot yr^{-1}$ and NAP values of less

than 15% of the Upland Pollen and Spore Sum. Deciduous forests in Michigan were found by Davis et al. (1973) to range from 7700 to as high as 84,000 $gr \cdot cm^{-2} \cdot yr^{-1}$. Lower values indicate an open deciduous woodland. Prairie vegetation would be indicated by low influx (less than 1000 $gr \cdot cm^{-2} \cdot yr^{-1}$), high non-arboreal pollen percentages (more than 25% of the Upland Pollen and Spore Sum), and indicator species (Davis et al., 1973; P. Delcourt and H. Delcourt, 1981). These influx and NAP values for definition of deciduous communities will be used in this study.

Determination of influx values can therefore be of considerable assistance in correctly identifying the biotic communities represented by fossil pollen spectra. Pollen influx data can help interpret pollen percentage diagrams where the decline of one taxon can increase the apparent percentages of other, even though they may not have increased in actual numbers on the landscape. Influx rates are determined by adding a known number of exotic palynomorphs to a given amount of sediment for which the sedimentation accumulation rate is known. In this study, Eucalyptus tablets with a given 16,180 grains per tablet have been used (Maher, 1977). The formula for calculating influx is as follows Davis et. al., 1973):

$I = (n/a) \cdot b \cdot c \cdot d.$

In this equation, I equals palynomorph influx, n equals the total number of pollen grains counted in a given stratigraphic level, a equals the number of Eucalyptus grains counted, b equals the number of Eucalyptus grains in each Eucalyptus tablet, c equals the number of Eucalyptus

tablets added to 1 - cm^3 of sediment and d equals the sediment accumulation rate in cm/yr. The resulting influx rates and concentrations for Jackson Pond are presented in Appendixes C and D.

Taxon Calibration

Delcourt et al. (1984) have developed taxon calibrations for nineteen major forest taxa utilizing Continuous Forest Inventories. Percentages of arboreal pollen from an extensive array of modern pollen samples were compared to the percentage of growing stock volume of each taxon in commercial forest inventories by Canadian and U.S. forest services. Calibrations were developed using geometric-mean linear regression of pollen percent versus growing stock volume percent for paired samples. The resulting calibrations allow quantitative reconstructions of past forest composition by factoring in differences in pollen productivity and pollen dispersability of various taxa which tend to result in either under-representation and over-representation of pollen. Calibrations for 19 major tree taxa were used to recalculate arboreal pollen percentages in fossil-pollen samples into quantitative estimates of past forest composition (Appendix E).

IV. RESULTS

Lithostratigraphy

Two cores, 83-A and 83-B, were taken from an open deep pool in the geographic center of the pond. Total depth for each core (from the surface of the coring platform) was, respectively, 720 and 718.5 cm. An impenetrable sand lens was encountered in both cores between 715 and 718 cm. For core JPK 83-B, the distance from the coring platform to the top of the water surface was 29 cm; water depth was 64 cm. The lithologic description of core JPK 83-B is as follows:

Depth (cm)	Lithology
93	Water/Sediment interface.
93 - 128	Fibrous peat becoming more consolidated towards the base (10YR2/0).
128 - 157	Silty fibrous peat (10YR3/2).
157 - 237	Organic silty clay (10YR3/2).
237 - 293	Organic silty clay (10YR3/1).
293 - 553	Silty clay with sparse organic matter (10YR3/1).
553 - 559	Silty clay (7.5YR2/0).
559 - 576	Silty clay (10YR3/1).
576 - 579	Slightly silty clay (7.5YR2/0).
579 - 587	Silty clay (10YR3/1).
587 - 591	Slightly silty clay (7.5YR2/0).
591 - 607	Clayey silt with sparse particles of vivianite starting at 599 cm (10YR3/1).
607 - 612	Slightly silty clay (7.5YR2/0)
612 - 616	Clayey silt (10YR3/1).
616 - 621	Slightly silty clay (7.5YR2/0).

621 - 625	Clayey silt with abundant vivianite (10YR3/1).
625 - 633	Slightly silty clay (7.5YR2/0 with mottling of 10YR3/1).
633 - 677	Slightly silty clay (7.5YR2/0).
677 - 682	Slightly silty clay (7.5YR2/0 with mottling of 10YR3/1).
682 - 717.5	Slightly silty clay (7.5YR2/0).
717.5 - 718.5	Silty sand (5YR2/0).

Loss-on-Ignition analysis (Figure 4) showed a residual water content in the sediment ranging from 30.7% to 88.8%. The uppermost peat zone from 93 cm (the sediment/water interface) down to 140 cm depth had an average water content of 80%. Organic content of the oven-dry sediment ranged from 5.4 to 72.9%, with the peat zone characterized by the highest percentages of 25 to 72.9%. Below 150 cm depth organic matter was significantly less, ranging from 5.4 to 11.9%. Calculated carbonate minerals ranged from 1.5 to 4% of the oven-dry weight, with an average of about 3.2%. Loss-on-Ignition data showed calculated carbonate content throughout the core as less than four percent of the overall dry weight. Because of the high clay content, the calculated carbonate content probably reflects the release of water-of-hydration from minerals (Dean, 1974) rather than significant input of freshly eroded carbonate into the sediments. Loss-on-Ignition data is available in Appendix F.

Chronology and Sediment Accumulation Rates

Six radiocarbon dates (Table 2) were used to provide an absolute chronology for the sediment core. The dates were internally consistent,

Figure 4. Loss-On-Ignition results.

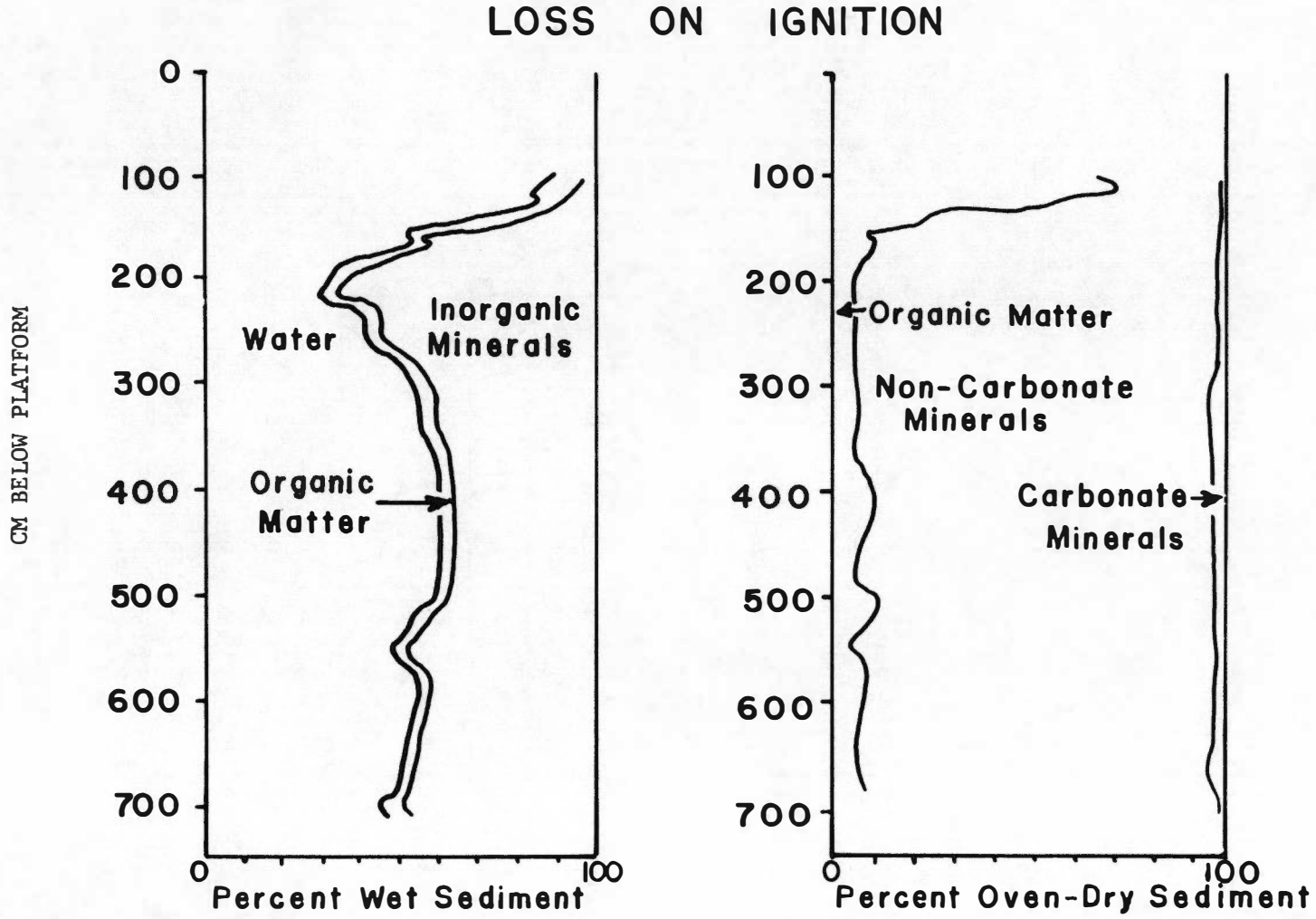

LOSS ON IGNITION
CM BELOW PLATFORM
0
100
200
300
400
500
600
700
Water
Inorganic Minerals
Organic Matter
0
100
Percent Wet Sediment
Organic Matter
Non-Carbonate Minerals
Carbonate Minerals
0
100
Percent Oven-Dry Sediment

Figure 4

Table 2. Sediment accumulation rates and times for Jackson Pond.

Radiocarbon Age (yr B.P. +/-1SD	Sample Depth In cm (Lab Number for Date)	Midpoint Depth (cm)	Time Elapsed Between Midpoint Depths (yr)	Sediment Interval	Average Sediment Accumulation Rate of (cm/yr)	Average Sediment Accumulation Time of (yr/cm)
0 (A.D. 1983)	Sediment Surface 93.0 cm	93.0				
			153	40.0	0.26	3.83
120+/-50	128-138 (A-3870)	133.0				
			820	27.5	0.03	29.82
940+/-80	155-166 (A-3871)	160.5				
			9100	60.0	0.01	151.67
10,040+/-190	215-226 (A-3872)	220.5				
			1820	49.5	0.03	36.77
11,860+/-250	263-277 (A-3873)	270.0				
			5890	240.0	0.04	24.54
17,750+/-270	505-515 (A-3874)	510.0				
			2580	195.0	0.08	13.23
20,330+/-630	700-710 (A-3875)	705.0				
			130	13.5	0.08	13.23
20,460 est.	718.5	718.5				

ranging from 120 yr B.P. near the top of the core to 20,330 yr B.P. at the base. The uppermost radiocarbon determination was taken partly within the historic rise in Ambrosia type pollen. The radiocarbon date of 120+/-50 yr B.P., along with low values for carbonate in the LOI results, verifies that the radiocarbon dates from this site require no correction factor to compensate for old carbon potentially introduced by solution of limestone.

Calculated sedimentation rates derived from the radiocarbon determinations (Table 2) show a high sedimentation rate for full-glacial and late-glacial times (20,460 to 10,040 yr B.P.), a slow Holocene rate (10,000 to 120 yr B.P.), and a very rapid sedimentation during the historic period. Comparative depositional rates for six palynological sites are depicted on Figure 5. A striking correlation of sedimentation rates is found, with sites clustering into main two groups. Jackson Pond, Cupola Pond, and Anderson Pond all show rapid full-glacial and late-glacial, slow Holocene, and rapid historic sedimentation rates. Goshen Springs and Lake Annie provide a record almost the reverse, with slow full-glacial and late-glacial and rapid Holocene and historic sedimentation rates. White Pond lies intermediate between the groups, with a relatively linear sedimentation rate.

Rates of Palynomorph Influx

Influx rates at the base of the sediment core from 20,460 to 20,330 yr B.P. ranged from 8600 to 15,000 $gr \cdot cm^{-2} \cdot yr^{-1}$, with an average of 11,800 $gr \cdot cm^{-2} \cdot yr^{-1}$ (Figure 6). From 20,330 to 16,800 yr B.P. influx

Figure 5. Comparative sedimentation rates of six southeastern lacustrine sites. (modified from P. Delcourt, 1984).

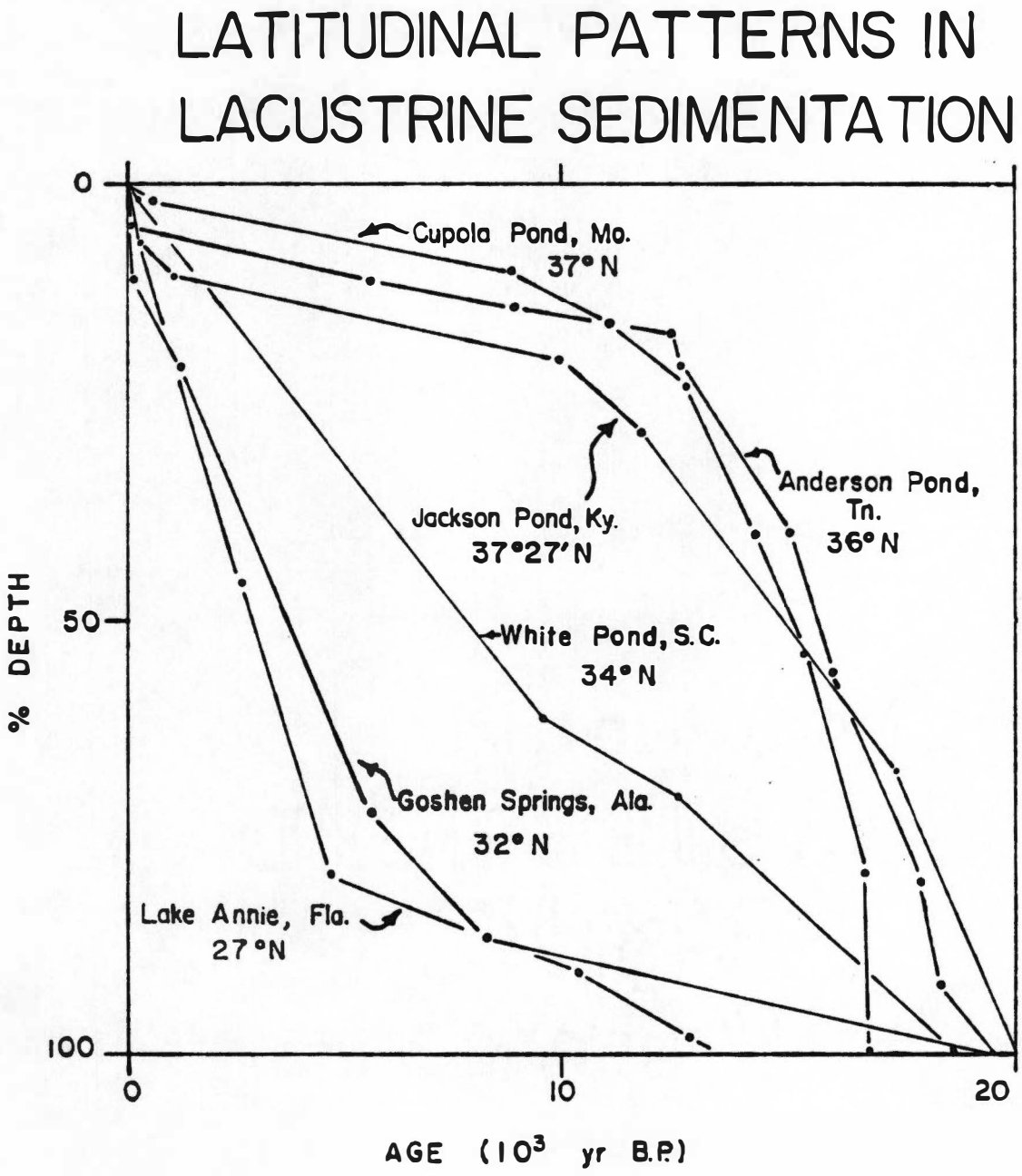

LATITUDINAL PATTERNS IN
LACUSTRINE SEDIMENTATION
0
50
100
% DEPTH
0
10
20
AGE (10³ yr B.P.)
Cupola Pond, Mo.
37° N
Jackson Pond, Ky.
37°27' N
Anderson Pond,
Tn.
36° N
White Pond, S.C.
34° N
Goshen Springs, Ala.
32° N
Lake Annie, Fla.
27° N

Figure 5

Figure 6. Total palynomorph and mineral influx results.

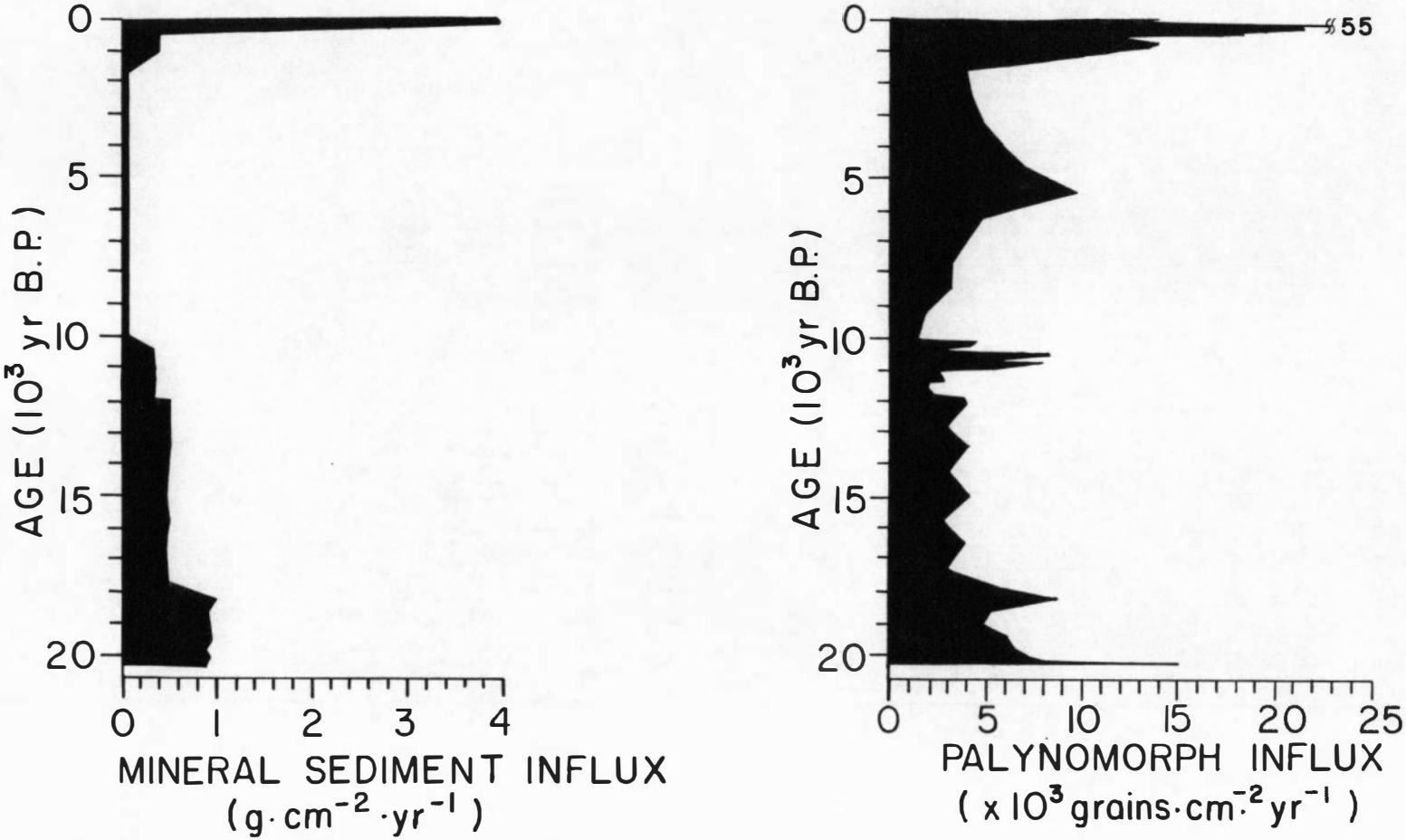

0
5
10
15
20
AGE (10^3 yr B.P.)
0
1
2
3
4
MINERAL SEDIMENT INFLUX
($g \cdot cm^{-2} \cdot yr^{-1}$)
55
0
5
10
15
20
25
PALYNOMORPH INFLUX
($\times 10^3$ grains$\cdot cm^{-2} yr^{-1}$)

Figure 6

values ranged from 3000 to 8800 $gr \cdot cm^{-2} \cdot yr^{-1}$, with an average of 6070 $gr \cdot cm^{-2} yr^{-1}$. From 16,800 to 11,300 yr B.P. influx values ranged from 1800 to 4200 $gr \cdot cm^{-2} \cdot yr^{-1}$, with a 3330 $gr \cdot cm^{-2} \cdot yr^{-1}$ average. Influx rates then rose temporarily to 8200 $gr \cdot cm^{-2} \cdot yr^{-1}$ before falling to an average of 2500 $gr \cdot cm^{-2} \cdot yr^{-1}$. Low influx rates were maintained throughout much of the Holocene interval from 10,000 yr B.P. to 120 yr B.P., with a peak at 5500 yr B.P. of 9900 $gr \cdot cm^{-2} \cdot yr^{-1}$. The increase between 940 yr B.P. and the historic time of Euro-American settlement may merely be a reflection of the radiocarbon date's effect upon apparent influx values than a real increase in palynomorph influx. Historic occupation of the area, however, is correlative with a significant increase in influx up to 55,000 $gr \cdot cm^{-2} \cdot yr^{-1}$, reflecting extensive erosion of upland soils, downslope transport, and accelerated deposition of pollen and minerals in the basin.

When mineral influx rates are compared to the palynomorph influx some parallel trends become apparent (Figure 6). During full-glacial times mineral influx was approximately 0.940 $g \cdot cm^{-2} \cdot yr^{-1}$, but dropped to 0.0490 $g \cdot cm^{-2} \cdot yr^{-1}$ at 17,800 yr B.P., this correlating with a similar decline in pollen influx values. The full-glacial pollen influx decline can therefore be in part attributed to a decrease in mineral sediment influx from the catchment area. From that point until historic occupation mineral influx and pollen influx are unrelated. During the historic interval, however, a dramatic increase occurred in the influx of both mineral sediment and pollen, indicating the pollen increase to be a reflection of the increase in mineral sediment.

Biostratigraphy

Five informal biostratigraphic zones have been recognized based upon changes in the pollen spectra. These were the *Pinus* Zone, occurring from 718 to 705 cm (20,460 yr B.P. to 20,330 yr B.P.), the *Picea*-*Pinus* Zone, occurring from 705 to 255 cm (20,330 yr B.P. to 11,300 yr B.P.), the *Fraxinus* Zone, occurring from 255 to 220 cm (11,300 yr B.P. to 10,040 yr B.P.), the *Ostrya*/*Carpinus* Zone, occurring from 220 to 203 cm (10,040 yr B.P. to 7300 yr B.P.), and the *Quercus* Zone, occurring from 203 to 93 cm (7300 yr B.P. to the present). The *Quercus* Zone was subdivided into the *Salix* Subzone, occurring from 203 to 180 cm (7300 yr B.P. to 3900 yr B.P.), the *Carya* Subzone, occurringe from 180 to 140 cm (3900 yr B.P. to 120 yr B.P.), and the *Ambrosia* Subzone, occurring from 140 to 93 cm (120 yr B.P. to the present). CONSLINK was usegul in distinguishing several of the zones, but performed poorly across the Pleistocene/Holocene transition because of major, rapid changes in pollen assemblages. Rather than to split out numerous pollen zones consisting of one or a few samples each for that time interval (11,300 yr B.P. to 10,040 yr B.P.), as indicated by results of CONSLINK, I have designated the interval a major, transitional *Fraxinus* Zone. The results of palynomorph and macrofossil analysis and individual taxon influxes are illustrated in Figures 7 to 12, with numerical documentation of each in Appendixes G, H and I.

Pinus Zone (718 to 705 cm depth, 20,460 yr B.P. to 20,330 yr B.P.). In this zone the arboreal pollen sum, calculated as percentage of total arboreal pollen (AP), was dominated by *Pinus* and *Picea*. *Pinus* comprised 61 to 70% of the AP, with *Picea* a major secondary taxon

Figure 7. Percentage diagram of selected tree pollen.

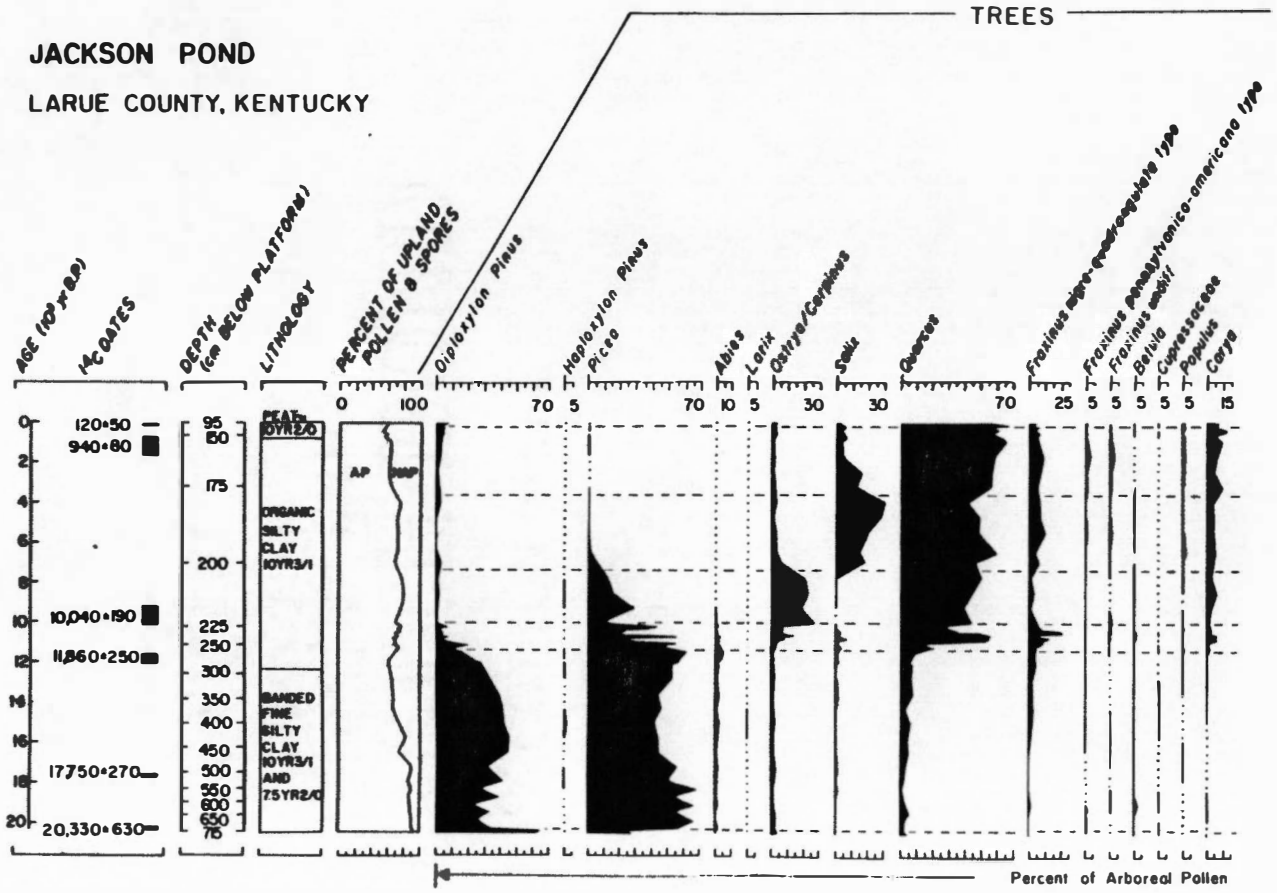

JACKSON POND
LARUE COUNTY, KENTUCKY
TREES
AGE (10³ yr B.P.)
14C DATES
DEPTH (cm BELOW PLATFORM)
LITHOLOGY
PERCENT OF UPLAND POLLEN & SPORES
Diploxylon Pinus
Haploxylon Pinus
Picea
Abies
Larix
Quercus/Carpinus
Salix
Quercus
Fraxinus nigra-pendulate type
Fraxinus pensylvanica-americana type
Fraxinus undiff.
Betula
Cupressaceae
Populus
Carya
120±50
940±80
10,040±190
11,860±250
17750±270
20,330±630
PEAT 10YR2/0
ORGANIC SILTY CLAY 10YR3/1
BANDED FINE SILTY CLAY 10YR3/1 AND 7.5YR2/0
AP
NAP
Percent of Arboreal Pollen

Figure 7

Figure 8. Percentage diagram of selected tree and shrub pollen.

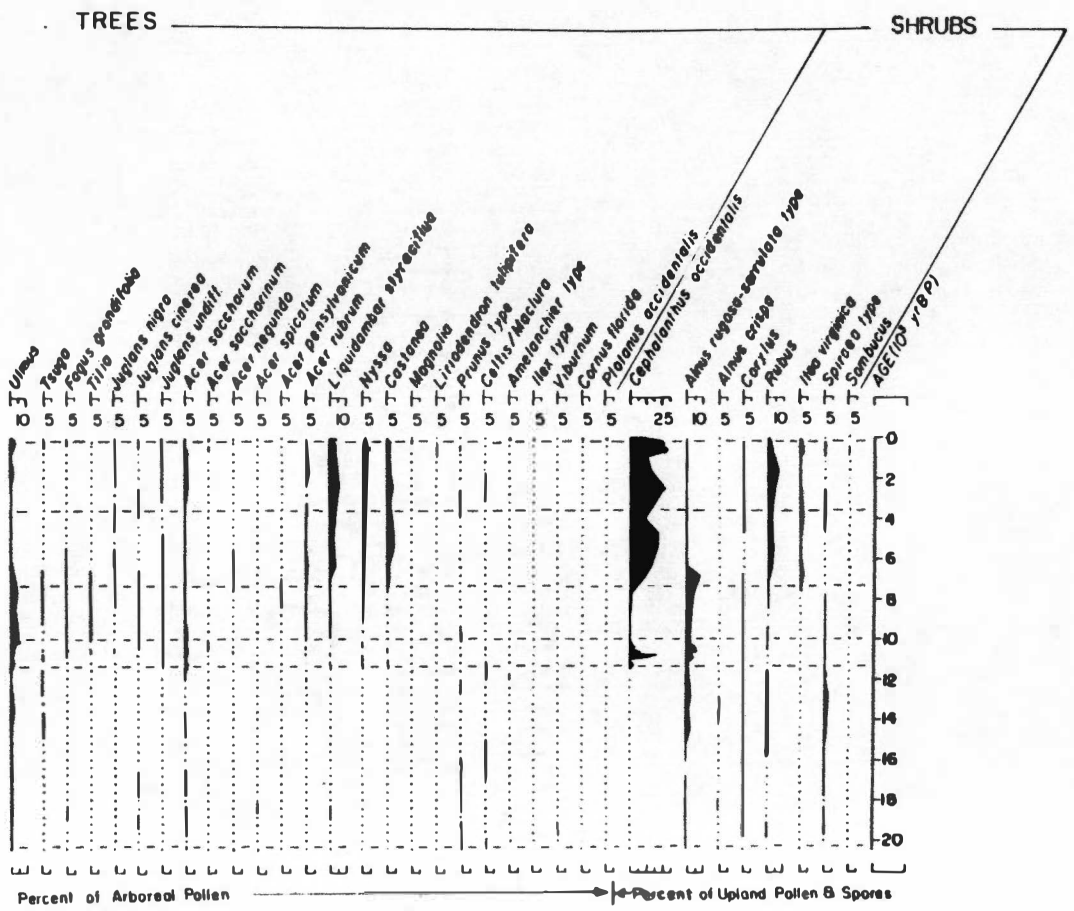

TREES
SHRUBS
Ulmus
Tsuga
Fagus grandifolia
Tilia
Juglans nigra
Juglans cinerea
Juglans undiff.
Acer saccharum
Acer saccharinum
Acer negundo
Acer spicatum
Acer pensylvanicum
Acer rubrum
Liquidambar styraciflua
Nyssa
Castanea
Magnolia
Liriodendron tulipifera
Prunus type
Celtis/Maclura
Amelanchier type
Ilex type
Viburnum
Cornus florida
Platanus occidentalis
Cephalanthus occidentalis
Alnus rugosa-serrulata type
Alnus crispa
Corylus
Rubus
Itea virginica
Spiraea type
Sambucus type
AGE(10³ yr B.P.)
Percent of Arboreal Pollen
Percent of Upland Pollen & Spores

Figure 8

Figure 9. Percentage diagram of selected upland herb pollen.

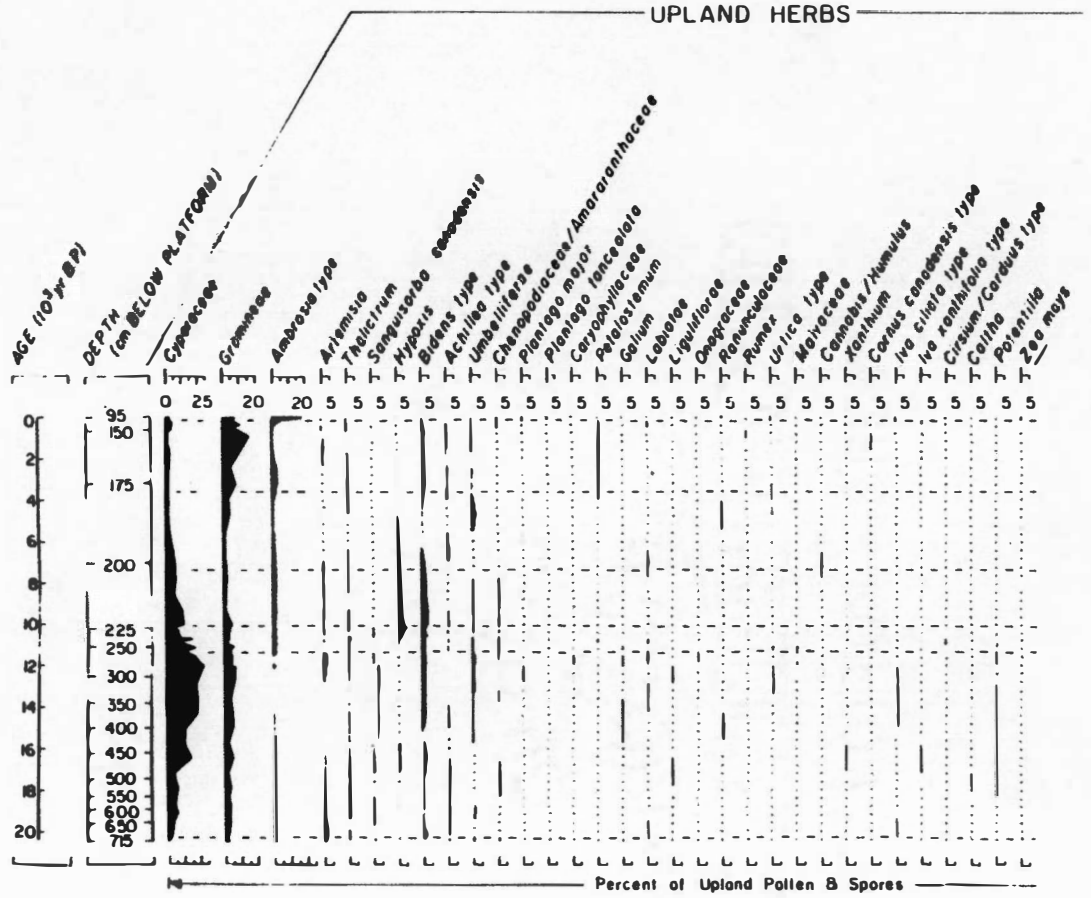

UPLAND HERBS
AGE (10³ yr BP)
DEPTH (cm BELOW PLATFORM)
Cyperaceae
Gramineae
Ambrosia type
Artemisia
Thalictrum
Sanguisorba canadensis
Hypoxis
Bidens type
Achillea type
Umbelliferae
Chenopodiaceae/Amaranthaceae
Plantago major
Plantago lanceolata
Caryophyllaceae
Potalostemum
Galium
Labiatae
Liguliflorae
Onagraceae
Ranunculaceae
Rumex
Urtica type
Moraceae
Cannabis/Humulus
Xanthium
Cornus canadensis type
Iva ciliata type
Iva xanthifolia type
Cirsium/Carduus type
Calitha
Potentilla
Zea mays
0 25 20 20 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
95
150
175
200
225
250
300
350
400
450
500
550
600
650
715
0
2
4
6
8
10
12
14
16
18
20
Percent of Upland Pollen & Spores

Figure 9

Figure 10. Percentage diagram of selected fern, fern allies, and aquatic plants.

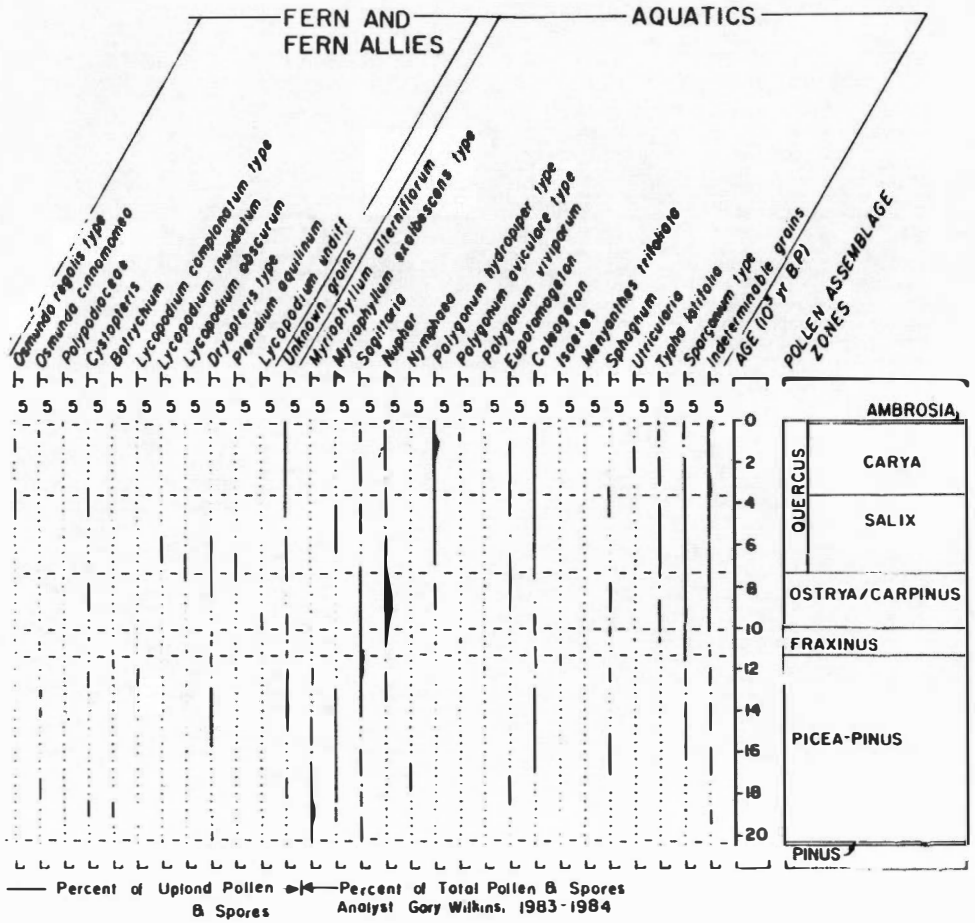

FERN AND FERN ALLIES
AQUATICS
Osmunda regalis type
Osmunda cinnamomea
Polypodiaceae
Cystopteris
Botrychium
Lycopodium complanatum type
Lycopodium inundatum
Lycopodium obscurum
Dryopteris type
Pteridium aquilinum
Lycopodium annotinum
Unknown grains
Myriophyllum alterniflorum
Myriophyllum exalbescens type
Sagittaria
Nuphar
Nymphaea
Polygonum hydropiper type
Polygonum aviculare type
Polygonum viviparum
Eupatorium
Cyperaceae
Isoetes
Menyanthes trifoliata
Sphagnum
Utricularia
Typha latifolia
Sparganium type
Indeterminable grains
AGE (10³ yr BP)
POLLEN ASSEMBLAGE ZONES
AMBROSIA
CARYA
QUERCUS
SALIX
OSTRYA/CARPINUS
FRAXINUS
PICEA-PINUS
PINUS
Percent of Upland Pollen & Spores
Percent of Total Pollen & Spores
Analyst Gary Wilkins, 1983-1984

Figure 10

Figure 11. Plant macrofossil diagram.

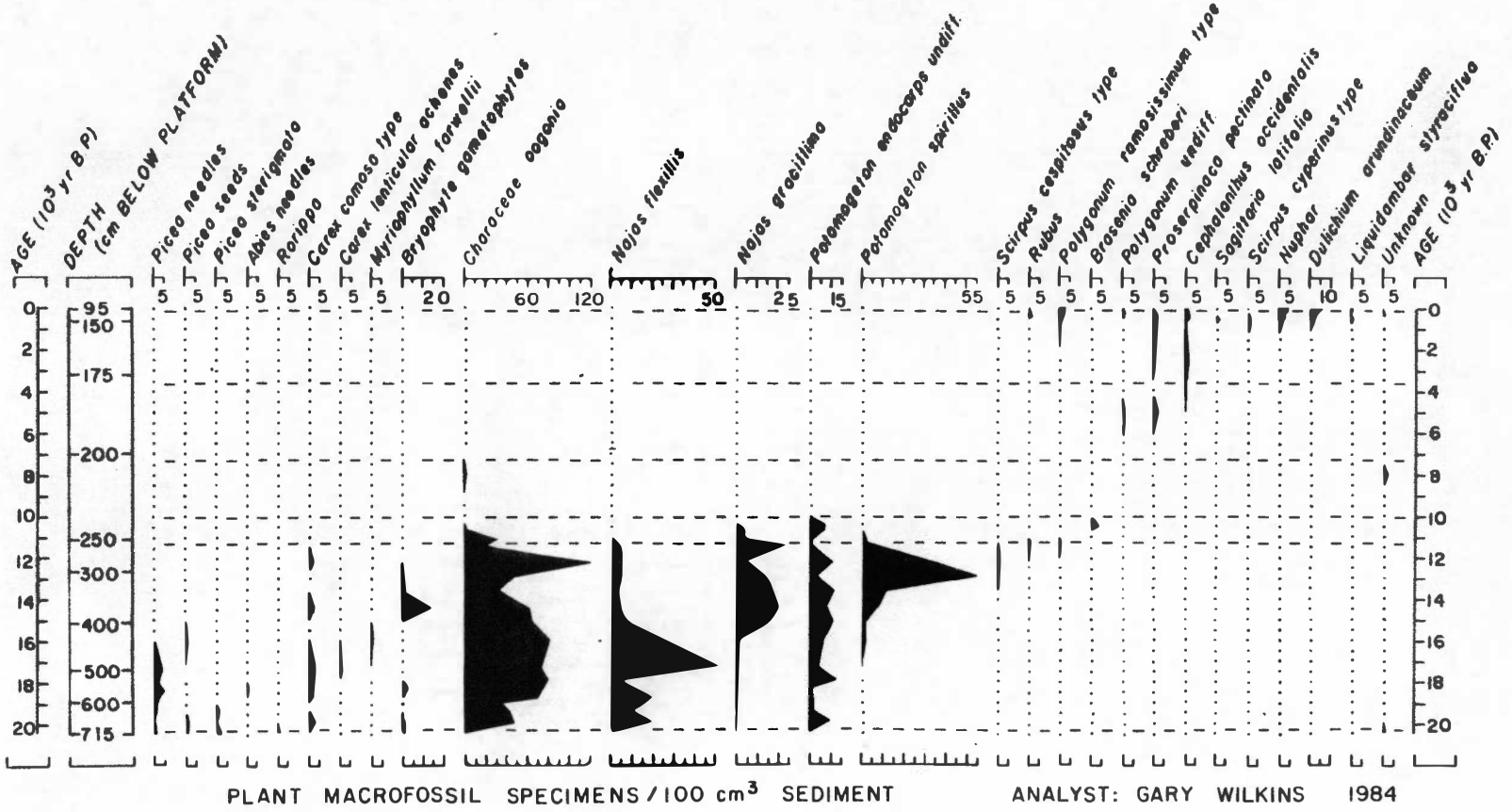

AGE (10³ yr B.P)
DEPTH (cm BELOW PLATFORM)
Picea needles
Picea seeds
Picea sterigmata
Abies needles
Ranunculus
Carex comosa type
Carex lenticular achenes
Myriophyllum farwellii
Bryophyte gametophytes
Characeae oogonia
Najas flexilis
Najas gracillima
Potamogeton endocarps undiff.
Potamogeton spirillus
Scirpus cespitosus type
Rubus
Polygonum ramosissimum type
Brasenia schreberi
Polygonum undiff
Proserpinaca pectinata
Cephalanthus occidentalis
Sagittaria latifolia
Scirpus cyperinus type
Nuphar
Dulichium arundinaceum
Liquidambar styraciflua
Unknown
AGE (10³ yr B.P)
PLANT MACROFOSSIL SPECIMENS / 100 cm³ SEDIMENT
ANALYST: GARY WILKINS 1984

Figure 11

Figure 12. Palynomorph influx diagram for selected taxa.

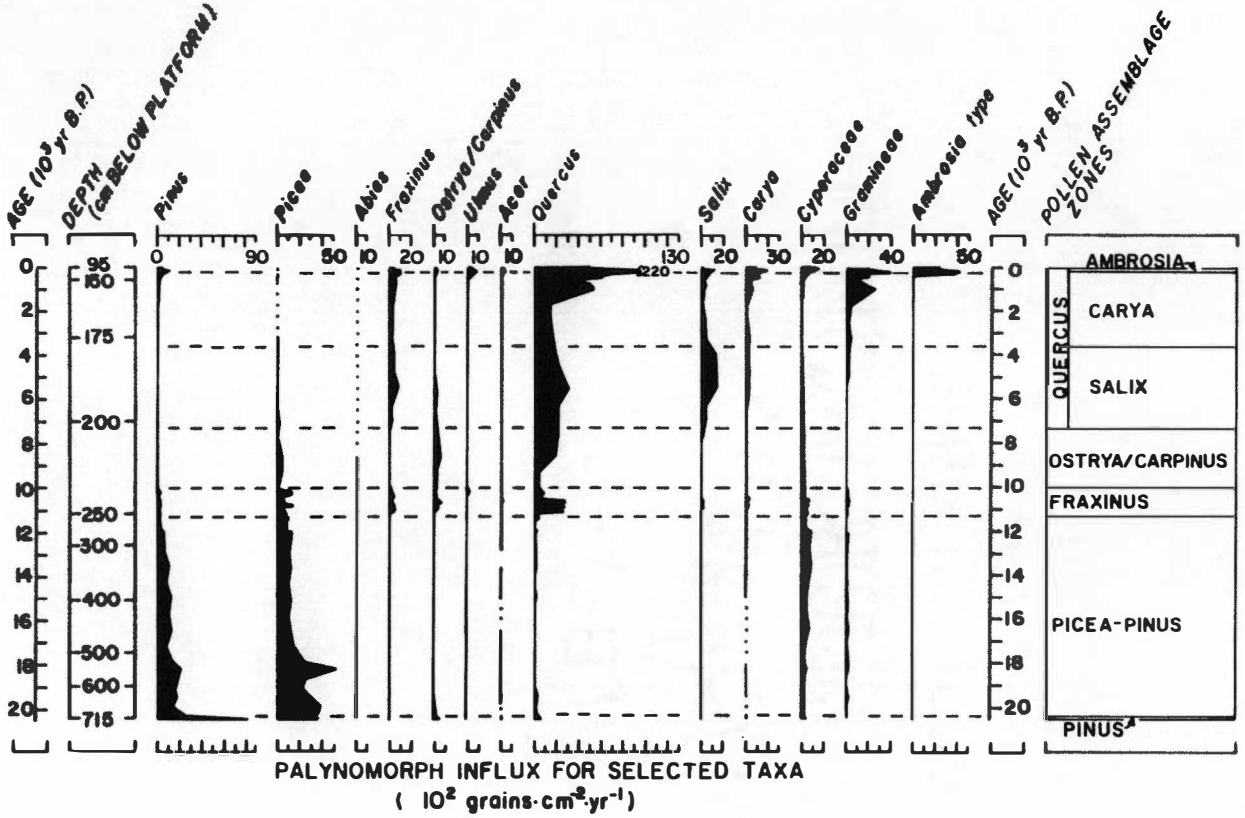

AGE (10³ yr B.P.)
DEPTH (cm BELOW PLATFORM)
Pinus
Picea
Abies
Fraxinus
Ostrya/Carpinus
Ulmus
Acer
Quercus
Salix
Carya
Cyperaceae
Gramineae
Ambrosia type
AGE (10³ yr B.P.)
POLLEN ASSEMBLAGE ZONES
AMBROSIA
QUERCUS
CARYA
SALIX
OSTRYA/CARPINUS
FRAXINUS
PICEA-PINUS
PINUS
PALYNOMORPH INFLUX FOR SELECTED TAXA
(10² grains·cm⁻²·yr⁻¹)

Figure 12

consisting of 20 to 26% of the AP. Minor elements were Quercus at 4 to 5%, Ostrya/Carpinus at 3% and trace amounts of Fraxinus nigra-quadrangulata type, Carya, Ulmus, Acer spicatum, Acer negundo, and Cupressaceae (Figures 7, 8). The total percentage of deciduous taxa within the AP sum equalied 10%. The percentage of non-arboreal pollen (NAP), calculated on the basis of the total Upland Pollen and Spore Sum, was very low (Figure 7). Cyperaceae, Gramineae and Artemisia together attained only 7% of the total pollen, with all NAP only 9.5% of the total pollen sum. The only aquatic pollen recorded was Myriophyllum alterniflorum. Total palynomorph influx values ranged from 15,000 to 8600 $gr \cdot cm^{-2} \cdot yr^{-1}$, averaging 11,800 $gr \cdot cm^{-2} \cdot yr^{-1}$ (Figure 6). Selected taxon pollen influx values are, Pinus (6700 to 8400 $gr \cdot cm^{-2} \cdot yr^{-1}$), Picea (1600 to 3600 $gr \cdot cm^{-2} \cdot yr^{-1}$), Quercus (300 to 700 $gr \cdot cm^{-2} \cdot yr^{-1}$), and Cyperaceae (120 to 500 $gr \cdot cm^{-2} \cdot yr^{-1}$)(Figure 12). Macrofossils recovered include needles, sterigmata, a seed, and a needle fragment of Picea. Also found were Chara oogonia and a seed of Rorippa (Figure 11).

Picea-Pinus Zone (705 to 255 cm depth, 20,330 yr B.P. to 11,300 yr B.P.). This zone, dominated by Picea and Pinus, is discussed in two parts, the first interval ranging from 20,330 yr B.P. to 16,800 yr B.P., and the second from 16,800 yr B.P. to 11,300 yr B.P. Picea percentages increased rapidly at the beginning of the zone to 56.9% at 700 cm, with a range of 41 to 68% within the interval. Pinus decreased from 61 to 35% at 700 cm, and fluctuated briefly, until at 15,780 yr B.P. it began to drop in percentage composition of the AP steadily throughout the

remainder of the zone. Secondary taxa were Abies with a trace to 1.5%, Fraxinus nigra-quadrangulata type and Fraxinus pennsylvanica-americana type 0 to 1.6%, Betula a trace to 1%, Quercus 0.9 to 5.5%, and Ostrya/Carpinus 1 to 2.6%. Present in trace quantities only were Salix, Ulmus, Carya and Acer saccharum (Figures 7, 8). Total deciduous AP varied from 2 to 14%, with the lowest percentage recorded at 18,000 yr B.P. Mean values for Diploxylon Pinus pollen-cap measurements were 33.6 μm at 20,300 yr B.P. and 34.9 μm at 18,300 yr B.P., with the range of variation respectively, 25.70 to 47.00 μm and 26.00 to 48.41 μm (Figure 13). These values place the pine population well within the mean range of northern Diploxylon pines. Also, morphological attributes suggest jack pine rather than red pine. Non-arboreal pollen remained minor, 5 to 7% of the Upland Pollen Sum. Cyperaceae ranged from 2 to 6% and Gramineae 2.5 to 4%. Trace amounts of Artemisia, Thalictrum, Bidens type, Ambrosia type, were found. Aquatics present in trace amounts were Myriophyllum exalbescens type, Myriophyllum alterniflorum, and Sagittaria (Figures 9, 10). Influx values during this interval ranged from 3000 to 8800 gr·cm^{-2}·yr^{-1}, with an average influx of 6070 gr·cm^{-2}·yr^{-1} (Figure 6). Selected taxon pollen influx values (Figure 12) were, Pinus (870 to 2400 gr·cm^{-2}·yr^{-1}), Picea (1500 to 5400 gr·cm^{-2}·yr^{-1}), Quercus (98 to 180 gr·cm^{-2}·yr^{-1}), Ostrya/Carpinus (45 to 160 gr·cm^{-2}·yr^{-1}), and Cyperaceae (142 to 482 gr·cm^{-2}·yr^{-1}).

The remainder of the zone, from 16,800 yr B.P. to 11,300 yr B.P., was dominated by Picea at 41 to 62% and Pinus 9 to 45%. Secondary arboreal elements were Abies, a trace to 5%, Ostrya/Carpinus 1 to 2.7%,

Figure 13. Measurements of Diploxylon Pinus pollen (internal cap diameter) for selected levels.

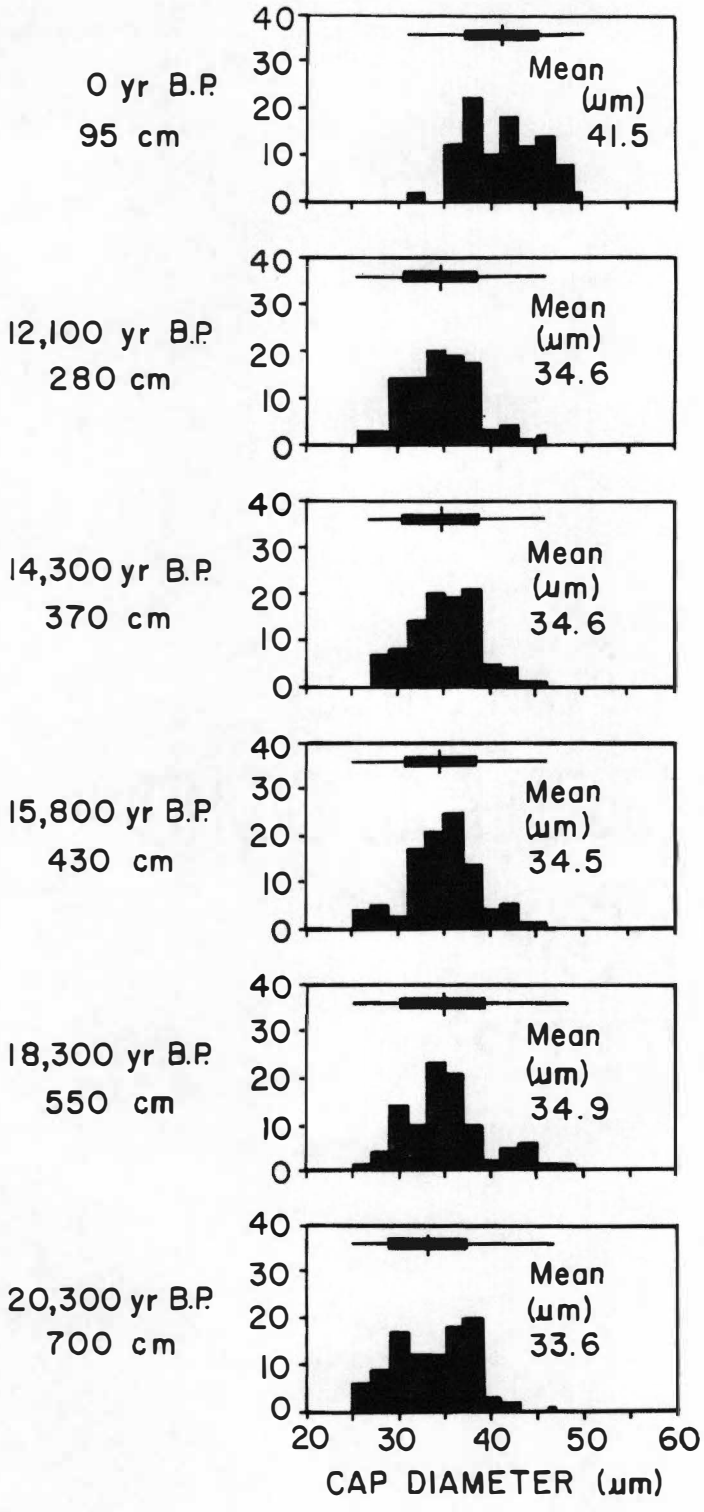

0 yr B.P.
95 cm
Mean (µm) 41.5
12,100 yr B.P.
280 cm
Mean (µm) 34.6
14,300 yr B.P.
370 cm
Mean (µm) 34.6
15,800 yr B.P.
430 cm
Mean (µm) 34.5
18,300 yr B.P.
550 cm
Mean (µm) 34.9
20,300 yr B.P.
700 cm
Mean (µm) 33.6
0
10
20
30
40
20
30
40
50
60
CAP DIAMETER (µm)

Figure 13

Salix a trace to 2%, Quercus 3.5 to 9%, Fraxinus nigra-quadrangulata type and Fraxinus pennsylvanca- americana type 1 to 5%, and Ulmus a trace to 1.6%. Trace taxa were Populus, Carya and Acer saccharum (Figure 7, 8). Total deciduous AP ranged from 7 to 20%, with representation of deciduous tree taxa rising gradually within this interval. Mean values of Diploxylon . Pinus pollen-cap measurements were 34.5 μm at 15,800 yr B.P. and 34.6 μm at both 14,300 and 12,100 yr B.P. (Figure 13). All three samples were within the range of values for northern Diploxylon pine, with morphology indicating jack pine. The NAP ranged from 18 to 38% of the Upland Pollen and Spore Sum, increasing significantly over the values recorded in the previous portion of the zone. Cyperaceae ranged from 7 to 24%, Gramineae 2 to7%, Spiraea 0 to 2%, Corylus and Alnus rugosa-serrulata type a trace to 2%. Other NAP present in trace amounts were Bidens type, Thalictrum, Potentilla, Achillea type, Sanguisorba canadensis, Chenopodiaceae/Amaranthaceae and Umbelliferae. Aquatics present were trace amounts of Coleogeton and up to 2% Sagittaria (Figures 9, 10). Influx values ranged from 1800 to 4200 $gr \cdot cm^{-2} \cdot yr^{-1}$, with an average of 3330 $gr \cdot cm^{-2} \cdot yr^{-1}$, approximately half that found from 20,330 to 16,800 yr B.P. (Figure 6). Selected taxon pollen influx values (Figure 12) are Pinus (210 to 1300 $gr \cdot cm^{-2} \cdot yr^{-1}$), Picea (785 to 1310 $gr \cdot cm^{-2} \cdot yr^{-1}$), Quercus (77 to 232 $gr \cdot cm^{-2} \cdot yr^{-1}$), Ostrya/Carpinus (4 to 35 $gr \cdot cm^{-2} \cdot yr^{-1}$), and Cyperaceae (77 to 232 $gr \cdot cm^{-2} \cdot yr^{-1}$). The decline in spruce and pine influx values is indicated, with a corresponding increase in sedge (Figure 12).

Macrofossils recovered from the entire Picea-Pinus Zone included Picea needles, needle fragments, seeds and sterigmata. Also found was a single Abies needle at 18,300 yr B.P. (550 cm depth). Seeds and fruits of Najas gracillima, Najas flexilis, Chara oogonia, Carex comosa, Potamogeton endocarps, lenticular Carex achenes, Myriophyllum farwellii, and Scirpus cespitosus type were also recovered (Figure 11).

Fraxinus Zone (225 to 220 cm depth, 11,300 yr B.P. to 10,040 yr B.P.). This zone marks a period of rapid biotic change. The rapid fluctuations of pollen percentages are considered representative of a real vegetation response rather than contamination from another level. The reasons for this are several: (1) the zone is within a single unbroken segment of core of a homogenous sediment type (there is no break between two core samples to suggest possible contamination); (2) the fluctuations of pollen percentages are dominated by several peaks of Picea, but each is progressively smaller than the previous one; (3) contamination from other levels would tend to homogenize rather than produce spikes in the data.

Quercus rose rapidly to 53 to 55% of the AP, dominating the arboreal taxa. Secondary taxa were Picea 7 to 19%, Ostrya/Carpinus 4 to 8.5%, Fraxinus nigra-quadrangulata type 9 to 10%, Salix 1.5 to 7%, and Carya 1.5 to 6%. Found as minor elements were Acer saccharum 1%, Ulmus a trace to 1.5%, Abies a trace to 2% and Populus a trace to 1.5%. Present in trace amounts only were Liquidambar styraciflua, Juglans, and Acer rubrum (Figures 7, 8). Cephalanthus occidentalis appeared for the first

time and reached 13 to 18% of the NAP, with other taxa represented by Alnus rugosa-serrulata type 2.5 to 4%, Cyperaceae 6 to 7% and Gramineae, Hypoxis, Bidens type, and Ambrosia type at 1%. Aquatics are represented by trace amounts of Nuphar, Coleogeton and Sagittaria (Figures 9, 10).

This was followed by a rapid but brief resurgence of Picea which dominated the arboreal spectra at 55%, with secondary taxa of Quercus and Fraxinus at 14% each. Minor elements were Abies 2%, Ostrya/Carpinus 3%, Ulmus 1%, Carya 1.5%, and traces of Fagus grandifolia, Acer negundo, and Acer saccharum (Figure 7, 8). Non-arboreal pollen, representing 26% of the pollen sum, consisted of Alnus rugosa-serrulata type 2%, Cyperaceae 16%, Gramineae 3.3%, Thalictrum 1.5%, Bidens type 1%, Ambrosia type 1%, and a trace of Hypoxis (Figure 9, 10). Influx values ranged from 4000 to 7000 $gr \cdot cm^{-2} \cdot yr^{-1}$ (Figure 6), with Picea, Pinus, Quercus and Cyperaceae reaching, respectively, influx values of 1630, 220, 430, and 655 $gr \cdot cm^{-2} \cdot yr^{-1}$ (Figure 12).

This Picea dominated portion of the zone is folowed by a shared arboreal dominance among three taxa, Picea, 21 to 43.5%, Quercus 25 to 35.7%, and Fraxinus 7.5 to 22.5%. Minor taxa were Ostrya/Carpinus 5 to 7.3%, Ulmus 1 to 5.5%, Carya 1 to 5.5%, Salix 0 to 3%, Acer saccharum a trace to 1.5%, and Abies a trace to 1%. Present in trace amounts were Fagus grandifolia, Tilia, Tsuga, Betula, Juglans, Liquidambar styraciflua, Castanea, Acer saccharinum (silver maple), and Celtis/Maclura (Figures 7, 8). Non-arboreal pollen was 22 to 30% of the total Upland Pollen and Spore Sum, consisting primarily of Cyperaceae 5.5 to 9%, Alnus rugosa-serrulata type 5 to 6%, Cephalanthus occidentalis a trace to 8%,

Gramineae 2 to 3.5%, and Hypoxis, Bidens type, and Ambrosia type at 1 to 3%. Present in trace amounts were Artemisia and Umbelliferae. Aquatics present were Typha latifolia, Nuphar, Sagittaria, and Eupotamogeton in trace amounts (Figures 9, 10 pp 47,49). Influx values ranged from 2200 to 8200 gr·cm^{-2}·yr^{-1}, averaging 5000 gr·cm^{-2}·yr^{-1} (Figure 6 p 39). Selected influx values are Quercus (602 to 2922 gr·cm^{-2}·yr^{-2}), Picea (16 to 1557 gr·cm^{-2}.yr^{-1}), and Ostrya/Carpinus (107 to 480 gr·cm^{-2}·yr^{-1}) (Figure 12 p 53).

Ostrya/Carpinus Zone (220 to 203 cm depth, 10,040 yr B.P. to 7300 yr B.P.). Arboreal pollen in this zone was dominated by Quercus 39 to 50%, Ostrya/Carpinus 5 to 26%, and Picea 5 to 28.5%. Minor taxa were Fraxinus 1.5 to 8%, Ulmus 2.5 to 5%, Acer saccharum a trace to 1%, and Carya 1.5 to 6%. Trace taxa were Salix, Fagus grandifolia, Tsuga, Tilia, Juglans, and Acer rubrum (Figures 7, 8 pp 43, 45). Non-arboreal pollen varied from 19 to 30% of the Upland Pollen and Spore Sum. Non-arboreal taxa identified included Cephalanthus occidentalis 0 to 1%, Rubus 1 to 6.5%, Alnus rugosa-serrulata type 2 to 4%, Cyperaceae 6 to 11%, Gramineae 1 to 6%, Ambrosia type 1 to 1.5%, Bidens type 2 to 4%, and Hypoxis a trace to 3%. Aquatics found were Nuphar 1 to 4%, Typha latifolia 1 to 2%, and a trace presence of Sagittaria and Eupotamogeton (Figures 9, 10 pp 47, 49). Influx values varied from 1600 to 3300 gr·cm^{-2}·yr^{-1}, averaging 2500 gr·cm^{-2}·yr^{-1} (Figure 6 p 39). Selected influx values (Figure 12 p 53) are Quercus (502 to 1300 gr·cm^{-2}·yr^{-1}), Picea (25 to 420 gr·cm^{-2}·yr^{-1}), Ostrya/Carpinus (260 to 597 gr·cm^{-2}·yr^{-1}),

Ulmus (55 to 110 $gr \cdot cm^{-2} \cdot yr^{-1}$), and Cyperaceae (180 to 234 $gr \cdot cm^{-2} \cdot yr^{-1}$). Macrofossils were extremely rare in this zone, consisting of only Chara oogonia and insect fragments (Figure 11 p 51).

Quercus Zone: Salix Subzone (203 to 180 cm depth, 7300 yr B.P. to 3900 yr B.P.). This subzone was dominated by Quercus at 42 to 60% and Salix 13 to 30%, with Salix rising very rapidly from 0 to 17% at the base of the zone. Other arboreal taxa present as secondary elements were total Fraxinus 4 to 13.5%, Ostrya/Carpinus a trace to 5%, Ulmus a trace to 2%, Carya 4 to 9%, Castanea 1 to 4%, Nyssa a trace to 2%, and Liquidambar styraciflua 1 to 5.5%, Acer saccharum a trace to 2%, and Acer rubrum a trace to 1.5%. Also present as trace taxa were Populus, Betula, and Celtis/Maclura (Figures p 43). Non-arboreal pollen ranged from 24 to 38% of the total Upland Pollen and Spore Sum. Non-arboreal types found included Cephalanthus occidentalis 10 to 22%, Rubus 1 to 6.5%, Itea virginica a trace to 1.5%, Gramineae 2 to 8%, Cyperaceae 1 to 5%, and Alnus rugosa-serrulata type a trace to 6.5%. Found in trace percentages were Corylus, Bidens type, Thalictrum, and Umbelliferae. Aquatics consisted of trace numbers of Polygonum hydropiper type, Typha latifolia, Sagittaria, Nuphar, Coleogeton, and Eupotamogeton (Figure 10 p 49). Influx values ranged from 3900 to 9900 $gr \cdot cm^{-2} \cdot yr^{-1}$, averaging 6400 $gr \cdot cm^{-2} \cdot yr^{-1}$ (Figure 6 p 39). Selected pollen influx values (Figure 12 p 53) are Quercus (1280 to 3540 $gr \cdot cm^{-2} \cdot yr^{-1}$), Ostrya/Carpinus (50 to 530 $gr \cdot cm^{-2} \cdot yr^{-1}$), Salix (490 to 1470 $gr \cdot cm^{-2} \cdot yr^{-1}$), Carya (70 to 310 $gr \cdot cm^{-2} \cdot yr^{-1}$), and Gramineae (80 to 200 $gr \cdot cm^{-2} \cdot yr^{-1}$). Macrofossils

found in this interval consisted of seeds of Polygonum undifferentiated and Proserpinaca palustris (Figure 12 p 53).

Quercus Zone: Carya Subzone (180 to 140 cm depth, 3900 yr B.P. to 120 yr B.P.). This subzone was dominated by Quercus at 55 to 67% of the AP. Secondary AP were Carya 4 to 11%, Fraxinus 4 to 11%, Salix 3 to 6.4%, Nyssa 1 to 5%, Liquidambar styraciflua 3 to 5.5%, Juglans a trace to 1.6%, Castanea 1.5 to 3%, Populus a trace to 2%, Acer saccharum a trace to 2%, and Acer rubrum a trace to 1%. Present as trace taxa were Liriodendron tulipifera and Magnolia (Figures 7, 8 pp 43, 45). Non-arboreal pollen represented 36 to 45% of the total pollen sum, with Rubus 1.5 to 6.5%, Cephalanthus occidentalis 11 to 23%, Gramineae 7 to 17%, Cyperaceae 1 to 4%, and Itea virginica a trace to 1.5%. Present as trace taxa only were Ambrosia type, Bidens type, Petalostemum, Artemisia and Thalictrum. Aquatics present were Polygonum hydropiper type a trace to 2.5%, and traces of Sagittaria, Typha latifolia, and Polygonum aviculare type (Figure 9, 10 pp 47, 49). Pollen influx ranged from 4000 to 17,000 $gr \cdot cm^{-2} \cdot yr^{-1}$, averaging 9770 $gr \cdot cm^{-2} \cdot yr^{-1}$ (Figure 6 p 39). Selected taxon pollen influx values (Figure 12 p 53) are Quercus (1500 to 5920 $gr \cdot cm^{-2} \cdot yr^{-1}$), Salix (110 to 510 $gr \cdot cm^{-2} \cdot yr^{-1}$), Carya (110 to 1170 $gr \cdot cm^{-2} \cdot yr^{-1}$), and Gramineae (198 to 2210 $gr \cdot cm^{-2} \cdot yr^{-1}$). Macrofossils recovered within this interval include fruits and seeds of Polygonum ramosissimum type, Rubus, Polygonum undifferentiated, Nuphar, Proserpinaca palustris, Cephalanthus occidentalis, Dulichium

arundinaceum, Scirpus cyperinus type, Sagittaria latifolia, and Liquidambar styraciflua (Figure 11).

Quercus Zone: Ambrosia Subzone (140 to 93 cm depth, 120 yr B.P. to present). The AP in this subzone was dominated by Quercus 55 to 66%. Secondary taxa were Salix 3 to 5%, Fraxinus 4 to 9%, Carya 4 to 7%, Castanea 0 to 3.3%, Nyssa 1 to 3%, Liquidambar styraciflua 3 to 6%, Juglans 1 to 3%, Ulmus 1 to 5%, and Populus, Acer rubrum, and Acer saccharum at a trace to 2%. Present as trace taxa were Tilia, Tsuga, Fagus grandifolia, and Acer saccharinum (Figures 7, 8 pp 43, 45). Diploxylon Pinus pollen-cap measurements of 50 pine grains at 95 cm depth had a mean value of 41.5 μm and a range of 31 to 50 μm. These values identify the pine population as southern Diploxylon pine (Figure 13 p 57). Non-arboreal pollen reached 36 to 44% of the total pollen sum. Non-arboreal pollen identified were Cephalanthus occidentalis 7 to 21%, Ambrosia type 2 to 18.5%, Gramineae 6 to 9%, Itea virginica 1%, Cyperaceae 1.5 to 5%, Chenopodiaceae/Amaranthaceae 1%, Bidens type 1%, and Rubus 2%. Present as trace taxa were Plantago lanceolata, Plantago major, and Thalictrum. Aquatics found were Nuphar 0 to 4.5%, and a trace taxa of Polygonum hydropiper type, Sagittaria, Coleogeton, and Typha latifolia (Figures 9, 10 pp 47, 49). Influx values were high, ranging from 10,700 to 56,000 $gr \cdot cm^{-2} \cdot yr^{-1}$, averaging 22,880 (Figure 6 p 39). Selected pollen taxon influx values (Figure 12 p 53) are Quercus (4100 to 22,110 $gr \cdot cm^{-2} \cdot yr^{-1}$), Carya (350 to 2170 $gr \cdot cm^{-2} \cdot yr^{-1}$), Gramineae (860 to 3760 $gr \cdot cm^{-2} \cdot yr^{-1}$), and Ambrosia

type (62 to 4210 $gr \cdot cm^{-2} \cdot yr^{-1}$). Macrofossils found were Dulichium arundinaceum, Liquidambar styraciflua, Nuphar, and Polygonum ramosissimum type (Figure 11 p 50).

Modern Analogue Analysis

Modern analogues were determined for Jackson Pond at 1000 year intervals using three dissimilarity coefficients; Chord, Standardized Euclidean and Euclidean (Figures 14 to 16). This has permitted a quantitative approach in determining modern vegetation analogues for the Jackson Pond palynomorph record from the present day to 20,000 yr B.P.

Plotted analogue sites for Chord Distance (Figure 14) show a north to south progression through time the last 20,000 years. From 20,000 to 12,000 years ago analogues are located in central Canada just south of Hudson Bay in regions characterized by spruce and jack pine. From 11,000 to 7000 yr B.P. they are found farther to the south, clustered within a Beech-Maple forest association around the Great Lakes. The remainder of the record, from 6000 to 1000 yr B.P., places analogues within Oak-Hickory or Western Mesophytic regions.

Standardized Euclidean Distance (Figure 15) analogue locations for 10,000 to 20,000 years ago are within northern hardwood or boreal forest associations in Canada, but are scattered and display no consistent trends as found in Chord Distance. The cluster of Beech-Maple analogues found in Chord Distance is also present, although only at 8000 and 9000 years ago. Analogues for the remainder of the record, (7000 to 1000 years ago), are within the Southern Evergreen forest.

Figure 14. Location of modern analogues as determined by Chord Distance. Numbers are in thousands of years. Position of numbers refers to following geographic locations; 1,2,3,6=Franklin County, Tennessee, 4,5=East-Central Illinois, 7=Washtenaw County, Michigan, 8,9,10,11=Northeastern Illinois, 12=Timiskaming District, Ontario, 13,14,15,16,17,18=Sioux Lookout District, Ontario, 19,20=Eastern Area, Ontario. The position of the solid triangle indicates the location of Jackson Pond.

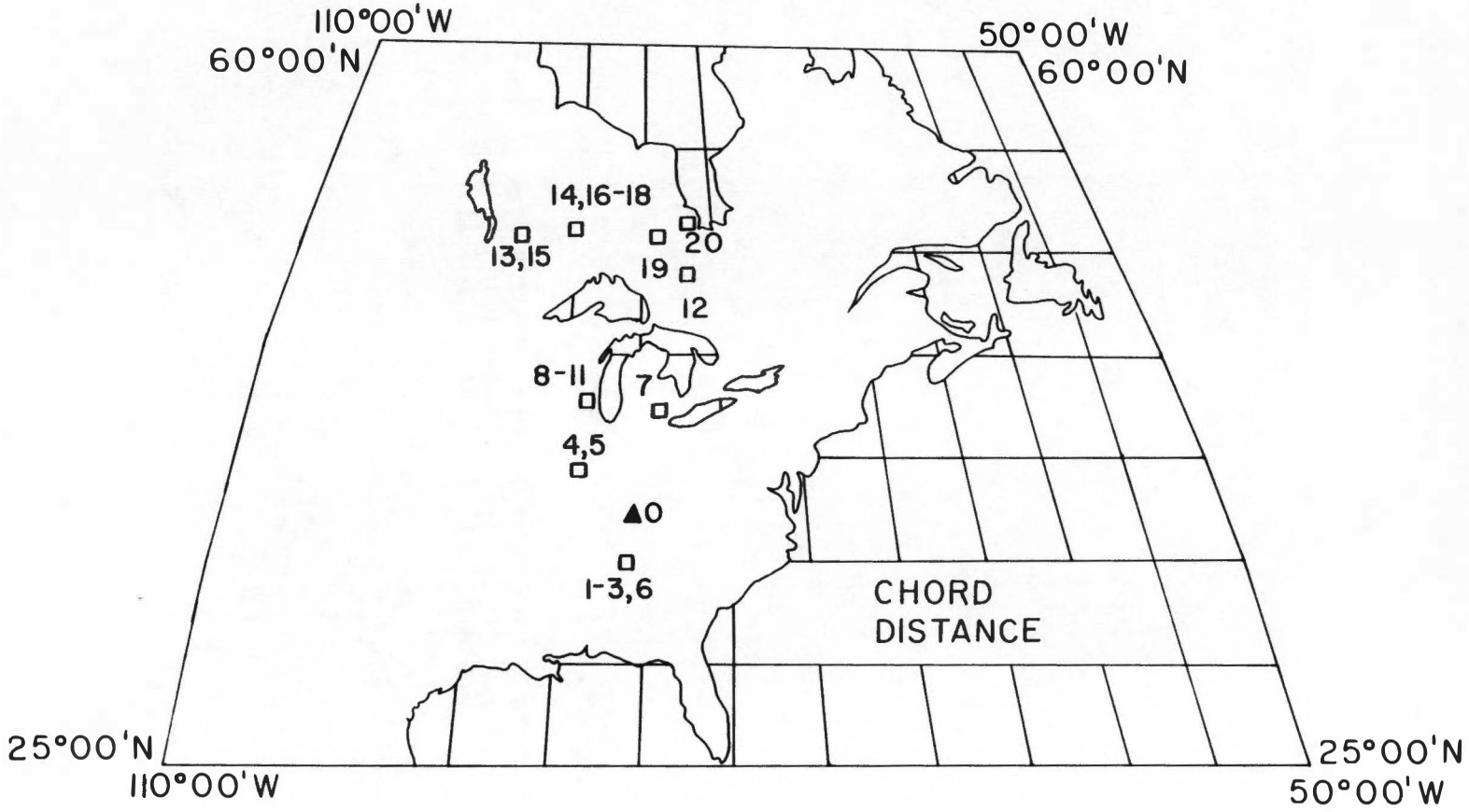

110°00'W
60°00'N
50°00'W
60°00'N
14,16-18
13,15
20
19
12
8-11
7
4,5
0
1-3,6
CHORD
DISTANCE
25°00'N
110°00'W
25°00'N
50°00'W

Figure 14

Figure 15. Location of modern analogues as determined by Standard Euclidean Distance. Numbers are in thousands of years. Position of numbers refers to following geographic locations; 1,2, 3,6=White County, Arkansas, 4,5=Adams County, Mississippi, 7=Garland County, Arkansas, 8,9=Dane County, Wisconsin, 10=North Bay District, Ontario, 11=Bas St.-Laurent, Quebec, 12,19=Haute Gatineau, Quebec, 15=Temiscamingue, Quebec, 16=Sioux Lookout District, Ontario, 17,18= Eastern Manitoba, 20=Eastern Area, Ontario. The position of the solid triangle indicates the location of Jackson Pond.

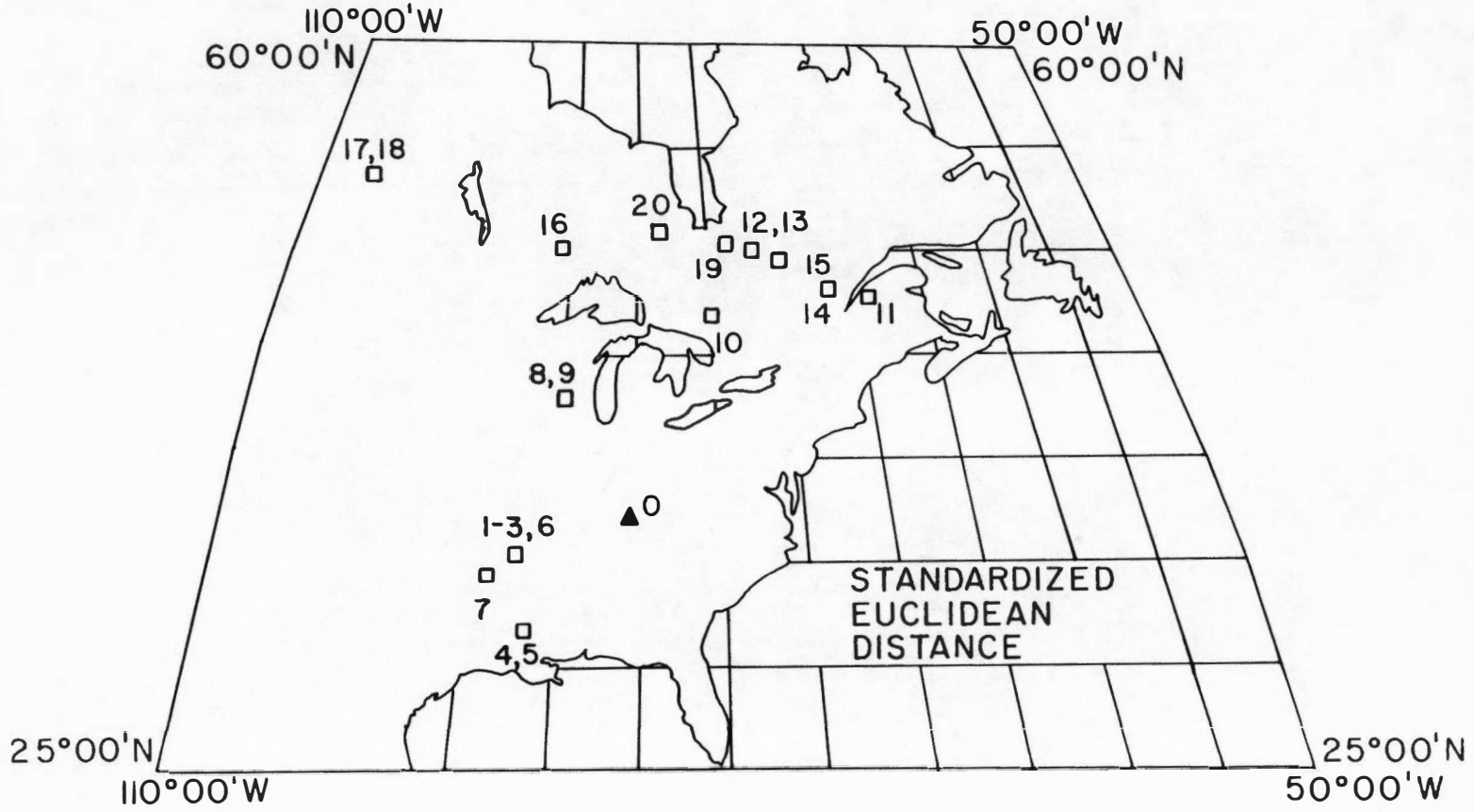

110°00'W
60°00'N
50°00'W
60°00'N
17,18
16
20
12,13
19
15
14
11
10
8,9
0
1-3,6
7
4,5
STANDARDIZED
EUCLIDEAN
DISTANCE
25°00'N
110°00'W
25°00'N
50°00'W

Figure 15

Figure 16. Location of modern analogues as determined by Euclidean Distance. Numbers are in thousands of years. Positions of numbers refers to following geographic locations; 1,2=White County, Arkansas, 3,6,7=East-Central Illinois, 9=Northeastern Illinois, 8,10=Dane County, Wisconsin, 11=Litchfield County, Conneticut, 12=Kapuskasing District, Ontario, 13=Timiskaming District, Ontario, 14=Quevillon, Quebec, 15,16=Charlevoix, Quebec, 17,18=Sioux Lookout District, Ontario, 19=Central Quebec, 20= Haute Gatineau, Quebec. The position of the solid triangle indicates the location of Jackson Pond.

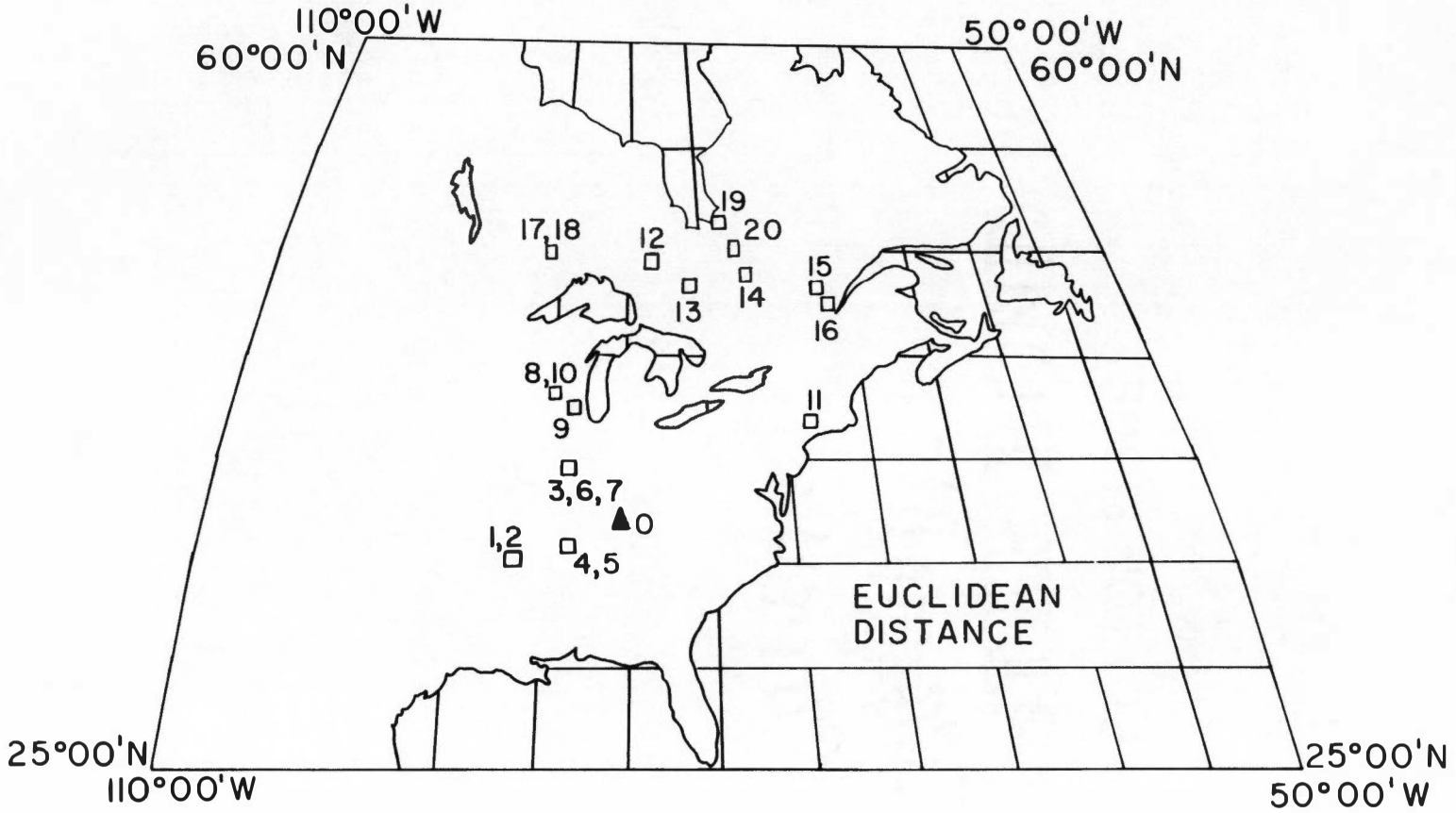

110°00'W
60°00'N
50°00'W
60°00'N
19
17,18
12
20
15
14
13
16
8,10
11
9
3,6,7
0
1,2
4,5
EUCLIDEAN
DISTANCE
25°00'N
110°00'W
25°00'N
50°00'W

Figure 16

Euclidean Distance (Figure 16) follows a pattern which appears to position itself as intermediate between the Chord and Standardized Euclidean analogue patterns. Before 10,000 years ago analogues are scattered through Canada in mixed hardwood-conifer and boreal associations, with the exception of 11,000 yr B.P. which was within an oak-chestnut region in northeastern United States. From 10,000 to 8000 years ago analogues are within the Great Lakes Beech-Maple associations. The remainder of the analogues, from 7000 yr B.P. to 1000 yr B.P., are within Oak-Hickory, Western Mesophytic and Southeastern Evergreen associations.

Coefficients of dissimilarity for all three methods used here are plotted on Figure 17. Chord Distance coefficients have a maximum value of 14, whereas both Euclidean and Standardized Euclidean Distances have no maximum values. These are no standard cutoff values available which indicate either acceptable analogues or those which should be rejected. Therefore, the relative range of values and the geographic scatter of analogue sites are used to determine acceptable analogue sites.

Given the relative patterns on Figure 17 all three methods appear to show close analogues for full-glacial and late-glacial times from 20,000 yr B.P. to 12,000 yr B.P. At 11,000 yr B.P. all three then show a time in which analogues do not correspond closely with the pollen record. The maximum effects of this poor analogue time are found from 11,000 yr B.P. to 10,000 yr B.P., after which there is a gradual progression to closer analogues throughout the Holocene. Only Chord Distance, however, provides an orderly north to south progression of analogue sites from

Figure 17. Comparison of modern analogues using coefficients of dissimilarity.

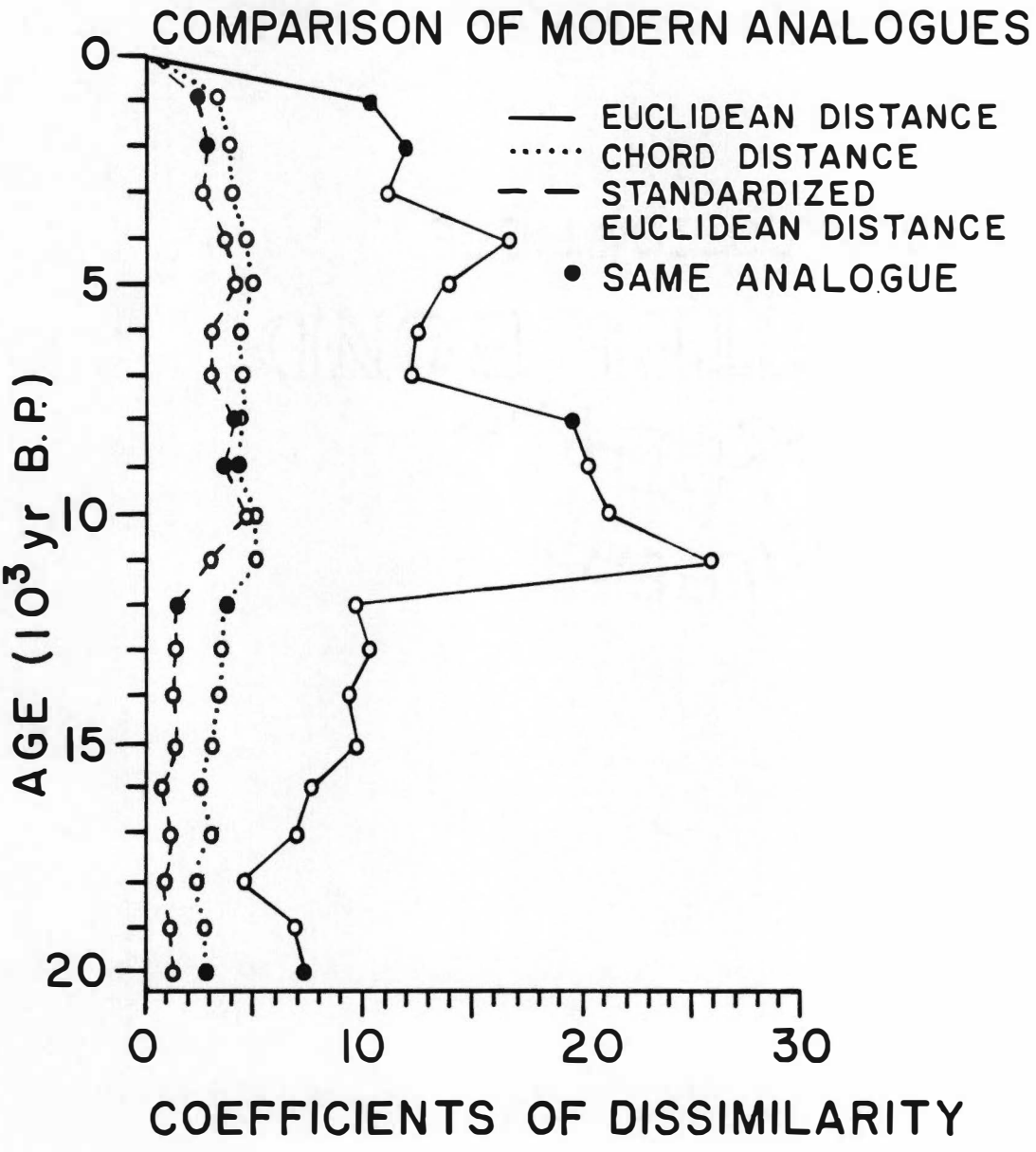

COMPARISON OF MODERN ANALOGUES
EUCLIDEAN DISTANCE
CHORD DISTANCE
STANDARDIZED EUCLIDEAN DISTANCE
SAME ANALOGUE
AGE (10^3 yr B.P.)
0
5
10
15
20
0
10
20
30
COEFFICIENTS OF DISSIMILARITY

Figure 17

the full-glacial through Holocene times, following a natural thermal gradient. This continuation of close dissimilarity coefficient values and a progressive latitudinal shift in analogue sites through time, with associated clustering of analogues during similar pollen asemblage zones, indicates Chord Distance as the best analogue method. Smith (1984) also found Chord Distance provided the best analogues for Cupola Pond when using all three of the dissimilarity methods. This superior analogue definition provided by Chord Distance is due to its de-emphasizing dominant taxa but not weighing all taxa equally. Thus, the taxa present as minor, relatively unimportant components are considered, but not given equal weight with the important dominant taxa. This minimizes local "noise" provided by the minor taxa. Also, the major dominants are not given a disproportionate emphasis which can remove necessary sub-dominant information useful in determination of close analogue sites.

Quantitative Vegetation Reconstruction

Taxon calibrations, depicted in Figure 18, were used to correct for differences in pollen productivity and dispersal as it biases the palynological record. The lowermost Pinus Zone was not represented in the analysis because the taxon calibration program analyzed data in 1000 year intervals ending at 20,000 yr B.P., just before the Pinus Zone began at 20,330 yr B.P. A note of caution, however, is necessary. Taxon calibrations are, just as percentile data, unable to differentiate vegetation density. Also, taxon calibrations do not reflect localized conditions such as basin size and topographic features which can affect the

Figure 18. Reconstructed forest composition based upon taxon calibration for major tree species.

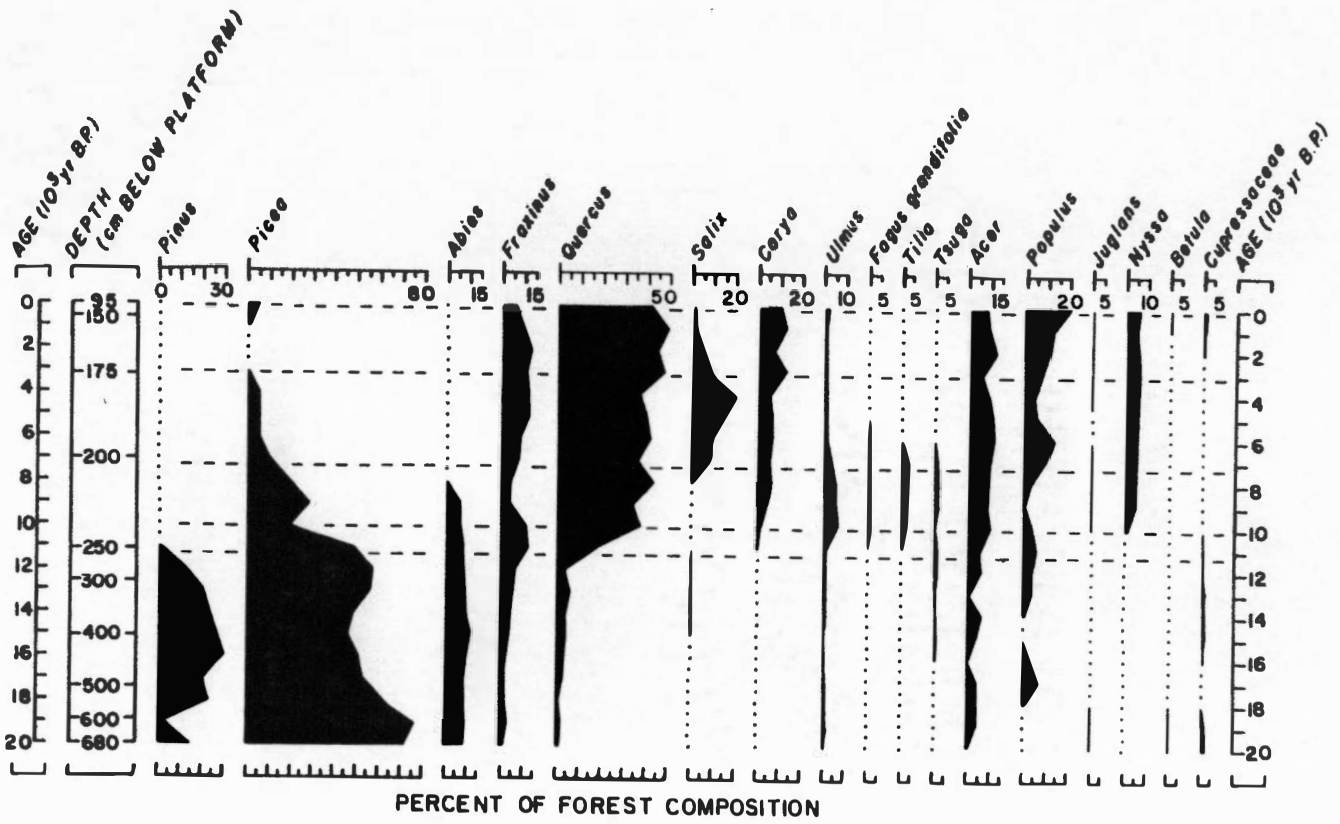

AGE (10³ yr B.P.)
DEPTH (cm BELOW PLATFORM)
Pinus
Picea
Abies
Fraxinus
Quercus
Salix
Carya
Ulmus
Fagus grandifolia
Tilia
Tsuga
Acer
Populus
Juglans
Nyssa
Betula
Cupressaceae
AGE (10³ yr B.P.)
PERCENT OF FOREST COMPOSITION

Figure 18

pollen record. It does permit, however, some correction of pollen data, which then results in more reliable interpretation of changes in vegetation composition. Therefore, paleoecological interpretations in the following section will consider vegetation reconstruction data in determination of vegetation composition.

V. PALEOECOLOGICAL INTERPRETATIONS

Interpretations of Palynomorph Influx

The question of long-distance transport and its effect upon pollen sequences and pollen influx is crucial to interpreting the pollen data from Jackson Pond. This is of particular importance when discussing tundra or taiga environments, where it is now documented that the presence of arboreal pollen is often the result of long distance transport, whereas non-arboreal pollen represents the local vegetation Birks, 1973; Nichols and Kelly, 1978). The low pollen productivity of tundra and spruce-dominated taiga make these areas particularly susceptible to over-representation of non-local pollen. Similar difficulties are encountered in interpretation of transitional communities between deciduous forest and prairie.

Long-distance transport of pollen is now a well-understood phenomenon (Barry et al., 1981; Elliot-Fisk et al., 1982; Nichols, 1970; Tyldesley, 1973). Pollen studies have shown that arboreal pollen can be transported hundreds of kilometers and significantly alter pollen-percentage spectra of low palynomorph influx (Nichols, 1970; Nichols and Kelly, 1978). The question is no longer whether long-distance pollen transport is a factor but rather to what degree it has affected the palynological record. Raynor et al. (1974) have found that pollen tends to be transported in discrete clouds, reflecting the tendency for pollen to be distributed over a wide area when meteorological conditions are favorable. Deposition of this pollen can then be affected dramatically

by rainfall, which acts as an effective means of washing out and depositing the pollen (McDonald, 1962).

Studies of long-distance transport of pollen in tundra regions have shown conclusively that areas of low pollen productivity will be disproportionally affected by the presence of pollen transported over long distances. Areas of high productivity will minimize these effects by producing much higher quantities of pollen locally and "drowning out" long-distance pollen. Recent studies have approached this problem of low influx and long-distance pollen transport south of the Laurentide Ice Sheet. From late-Wisconsinan sediments in Minnesota (Birks, 1981). analyzed fossil pollen types that were unlikely for ecological or phytogeographical reasons to have grown in Minnesota in the past. Certain pollen types showed statistically significant trends through time whereas others were trend-free in their distributions. Birks (1981) interpreted distributions of this latter group to reflect the migration and prevalence of plant taxa to the south of Minnesota. Trace appearances of these taxa may indicate their increase in abundance or migration into regions to the south which were serving as a reservoir area for the exotic pollen found in Minnesota. Another recent study, by Webb et al. (1983), examined the percentages of certain arboreal pollen taxa in southern Quebec following ice retreat. They found that Quercus pollen was most widespread at 9000 yr B.P., and then decreased in amount until 6000 yr B.P. This pattern was interpreted to reflect the long-distance transport of some Quercus pollen into an area of treeless vegetation. As forests developed to the north, the pollen productivity

increased and minimized the representation of the long-distance transport of Quercus pollen.

These studies indicate that long-distance transport of pollen along the southern flank of the Laurentide could have affected pollen percentages in areas of low influx such as deglaciated sites in the Midwest. Influx rates and non-arboreal percentages therefore are crucial in any interpretation of tundra, open boreal parklands or prairie-deciduous woodland transition areas.

Paleoecological Record at Jackson Pond

Jackson Pond provides a continuous vegetational history from full-glacial climatic extremes from about 20,460 yr B.P. through the Holocene. This is the first record studied with pollen influx in the area within 300 km of the Laurentide Ice Sheet that spans most of the Woodfordian Substage (23,000 yr B.P. to 12,500 yr B.P.) of the Wisconsinan Glaciation (Delcourt et al., 1980; Willman and Frye, 1970). The full-glacial period peaked by 18,000 yr B.P., with climatic amelioration noted by 16,500 yr B.P. in oxygen-isotopic studies of planktonic foraminifera in the western Gulf of Mexico (Kennett and Shackleton, 1975), pollen studies in the southeastern United States (H. Delcourt, 1979; Delcourt et al., 1980; P. Delcourt and H. Delcourt, 1984), and first retreat of the Laurentide Ice Sheet (Dreimanis, 1977; Prest, 1970). Full-glacial conditions lasted until approximately 16,500 yr B.P., after which there was a late-glacial period of transition until Holocene climatic patterns were established about 12,500 yr B.P. (P. Delcourt and H. Delcourt, 1984).

Pinus Zone (20,460 yr B.P. to 20,330 yr B.P.). Relatively high pollen influx, ranging between 8600 to 15,000 $gr \cdot cm^{-2} \cdot yr^{-1}$, and low NAP values (9 to 10% of the Upland Pollen and Spore Sum) document the presence of a closed boreal forest during this zone. Based upon the high pine percentages, pine-pollen influx, and pine pollen-cap measurements, the vegetation surrounding Jackson Pond was dominated by jack pine. Subdominants of spruce and fir grew with limited populations of deciduous trees, including oak, elm, black ash, and hornbeam. Spruce macrofossils from this zone indicate that it was growing immediately around the pond.

Today, jack pine grows best in the boreal forest region of Canada in climates characterized by warm to cool summers and cold winters. It can maintain itself on very dry to well-drained nutrient-poor soils (Fernald, 1970). Spruce is today found in boreal forests within both well-drained nutrient-rich forest soils in uplands and in wet poorly-drained bottomlands (Fowells, 1965; Gleason and Cronquist, 1963). The ability of black spruce (Picea mariana) and red spruce (Picea rubens) to maintain their populations today within wet poorly-drained bottomland soils, and the recovery of spruce macrofossils at Jackson Pond are interpreted as evidence that, during this zone, spruce was concentrated around the pond, with jack pine dominating the uplands. During this interval, cool summers and cold winters limited evaporation, resulting in a permanent high water level. The absence of shrubs and presence of Myriophyllum alterniflorum indicate the existence of a deep, open-water pond.

Picea-Pinus Zone (20,330 yr B.P. to 11,300 yr B.P.). From 20,330 yr B.P. to 16,800 yr B.P. (full-glacial times), northern pines declined rapidly and then fluctuated around 25 to 45% of the AP, with spruce becoming the forest dominant. Total pollen influx (5300 to 8800 gr·$cm^{-2}·yr^{-1}$) and NAP percentages (10 to 12% of the Upland Pollen and Spore Sum) continue to indicate a closed boreal forest, with spruce and pine sharing co-dominance of the uplands. Plant macrofossils of Picea and Abies document the presence of spruce and fir. Deciduous taxa ranged from 2 to 10% of the AP, with the lowest percentage at approximately 18,000 yr B.P., peak full-glacial times. Oak is the only deciduous taxon to be represented in the pollen spectra at all stratigraphic levels during this period, and it fell to below 1% of the AP at the stratigraphic level of 520-cm depth. Other deciduous taxa such as hornbeam and black ash were present as minor taxa, with elm and sugar maple present only as scattered occurrences in the arboreal-pollen record (Figure 7 p 43). The pollen spectra therefore reflect increasingly harsh environmental conditions as the glacial environment reached its peak at around 18,000 yr B.P., with populations of deciduous taxa such as oak, elm, hornbeam, sugar maple, and black ash becoming severely limited.

Some alder (Alnus rugosa-serrulata type and Alnus crispa) grew immediately around the pond. A deep, open-water pond is indicated by pollen of the perennial aquatics Myriophyllum alterniflorum, Myriophyllum exalbescens type, and Sagittaria. Myriophyllum alterniflorum is today common in lakes and rivers, mostly within calcareous terrains of the northeast United States, across the Great

Lakes and north to Newfoundland and Alaska (Fernald, 1970; Muenscher and Conrad, 1944). It is found consistently, up to 2% of the Upland Pollen and Spore and Aquatic Sum through this zone. Present as a palynomorph with sporadic occurrence through this zone, the Myriophyllum exalbescens type is today found over the same area as Myriophyllum alterniflorum but extends farther to the south into Indiana and Illinois (Fernald, 1970).

Aquatic macrofossils were dominated by Chara oogonia, Najas flexilis seeds, and Potamogeton endocarps, with lesser numbers of seeds of Najas gracillima and achenes of Carex comosa type. While those identifiable types have differing geographic distributions, the prevalent range is a northeastern United States-Great Lakes distribution (Fernald, 1970; Muenscher and Conrad, 1944). The lack of strictly temperate species in the plant-macrofossil assemblage is compatible with boreal conditions indicated by fossil pollen evidence.

Quantitative reconstructions of forest composition, based upon taxon calibrations, indicate spruce as the dominant taxon, reaching 65 to 80% of the past forest composition. Pine was the primary subdominant, with fir populations consistently representing about 8% of the forest dominance. Consistent members of the forest community included deciduous taxa such as ash, oak, elm and maple. The closest modern analogues indicated by Chord Distance clustered in the boreal forest of Canada within regions classified by Rowe (1972) as the Hudson Bay Lowlands and Northern Coniferous vegetational associations (Figure 14 p 67), which are today dominated by forests of white spruce and black spruce. These

extant forests include modest populations of jack pine, balsam fir (Abies balsamea) and outposts of white elm (Ulmus americana), and eastern white cedar (Thuja occidentalis). Vegetation density can vary from dense, closed boreal forests to open woodlands depending upon local site conditions. All analogue sites from the full-glacial pollen spectra are located south of the lower southern fringe of the Canadian permafrost region (Rowe, 1972).

A boreal forest therefore surrounded Jackson Pond through peak glacial times. A forest of intermixed spruce and pine dominated the uplands, with spruce and fir dominant in moist valley soils. Some deciduous taxa, including oak, elm, sugar maple, black ash and hornbeam (Ostrya or Carpinus), were present through much, and perhaps all of the zone as very minor populations scattered through the forest. A high water level is indicated for Jackson Pond, reflecting conditions of either low evaporation rates or high precipitation.

From 16,800 yr B.P. to 11,300 yr B.P. (late-glacial times), spruce remained the forest dominant, while steadily declining values for pine indicate its gradual reduction in its population size. Minor amounts of fossil pollen of both hemlock and white pine, the sole representative of Haploxylon pine in eastern North America, were found throughout this interval. Deciduous taxa were primarily represented by oak, hornbeam, ash, sugar maple and elm, all of which formed minor forest components. Calculation of individual taxon influx (Figure 12 p 53) indicates the reduction in populations of both pine and spruce. Although pollen influx from both taxa declined, there is a greater degree of influx reduction

for pine. Significantly, there is no corresponding increase in influx values for other arboreal taxa, most particularly the deciduous elements. The forest canopy throughout this interval was thinning out, with a gradual reduction of pine and spruce but without significant replacement of the boreal elements by deciduous taxa. Total-pollen influx (1800 to 4200 $gr \cdot cm^{-2} \cdot yr^{-1}$) and increasing percentages of NAP (21 to 38%) indicate that the forest became more open, leaving a spruce-dominated open woodland with a subdominant of jack pine and minor elements of fir, black ash, oak, elm, hornbeam, and sugar maple. Reconstruction based upon taxon calibrations reflect a similar pattern, although underrepresented pollen types such as maple and hemlock show some apparent increase in percentage composition of the reconstructed forest community. Modern analogues determined by Chord Distance continued to be located within Rowe's (1972) Hudson Bay Lowlands and Northern Coniferous regions.

Myriophyllum alterniflorum declined, with some sporadic presence of Myriophyllum exalbescens type. A northern perennial, Sanguisorba canadensis, characteristic of boggy ground, wet meadows, and stream banks (Fernald, 1970; Gleason and Cronquist, 1963) appeared consistently throughout the interval. Sanguisorba canadensis is presently found from Newfoundland to Manitoba, south to Indiana and Ohio, and infrequently in the Appalachian Mountains south to Georgia (Gleason and Cronquist, 1963). Cyperaceae dominated the NAP, with Gramineae also significant. The paucity of shoreline shrubs such as willow and alder are interpreted as evidence that the pond remained open with aquatics and wetland herbs

growing within and along the fringes of the pond.

Macrofossils of species of wetland-aquatic plants were recovered throughout this zone, although there was a noticeable shift in the overall composition of the types found. At approximately 16,500 yr B.P., seeds of Najas gracillima became common while the numbers of seeds for Najas flexilis declined. Endocarps of undifferentiated Potamogeton continued to be recovered but were supplemented by the appearance of Potamogeton spirillus. Also recovered were plant macrofossils of of Myriophyllum farwelli, Carex comosa type, and Scirpus cespitosus. The shift in plant-macrofossil types is correlative with the change in pollen influx and species abundance and reflects a change in aquatic environments associated with the developing late-glacial climatic regime.

Fraxinus Zone (11,300 yr B.P. to 10,040 yr B.P.). At 11,300 yr B.P., changing climatic conditions were reflected in the first dramatic shift away from a spruce-dominated forest. Spruce declined to as little as 7% and oak reached 55% of the AP. Other deciduous taxa, hornbeam, hickory, sugar maple and elm also increased in percentage composition of the arboreal-pollen spectra. A screen of buttonbush and alder developed within the littoral zone around the pond, with the aquatic Sagittaria increasing to 2% of the total pollen sum. Although Cyperaceae declined, the remainder of the upland herb and aquatic community changed very little.

At 10,800 yr B.P., there was a brief biotic reversal of the trend

toward establishment of a temperate biota. Spruce again attained dominance, reaching 55% of the AP while oak dropped to 14%. Significantly, there was no similar dramatic fluctuation in other deciduous arboreal taxa, although many taxa such as hickory and hornbeam declined in pollen percentages. Black ash rose to 14% of the AP while elm, sugar maple, fir and black walnut continued to be present. The primary evidence for a biotic reversal was the replacement of oak by spruce in the pollen percentage diagram (Figure 7 p 43). Buttonbush declined markedly, with alder and willow remaining as littoral-zone shrubs. Pollen of upland herbs and aquatics showed no significant change, except for a resurgence of Cyperaceae.

From 10,600 yr B.P. to 10,040 yr B.P., a northern hardwood-conifer biotic association was established in central Kentucky. Oak, spruce, and black ash shared dominance with, respectively, 25 to 36%, 21 to 44%, and 8 to 23% of the AP. It is likely that the black ash, typically found in bogs, along streams or in poorly drained woods with a high water table and frequent standing water (Fowells 1965) was associated with spruce within the lowland valley surrounding Jackson Pond. Mesic deciduous taxa such as beech, basswood, and hemlock appear as a suite of taxa for the first time and were probably located on moist soils of slopes and valley bottoms. Buttonbush briefly expanded as a shrub along the pond perimeter but declined to near absence by the end of the interval, with alder, willow and hazel remaining a consistent part of the littoral thicket. Populations of Nuphar, Utricularia, Brasenia schreberi, and Typha expanded or became locally established within this

interval.

Plant-macrofossil evidence documents a changing environmental and biotic community within this zone. Plant macrofossils characteristic of the preceding Picea-Pinus zone were either scarce or absent. Among these are, for example, Potamogeton spirillus, two Najas species, and Chara. Seeds of the aquatic Brasenia schreberi were recovered for the first time.

Values of total-pollen influx (2200 to 8300 $gr \cdot cm^{-2} \cdot yr^{-1}$) indicate an expansion of oak forest during times of high influx, with open spruce woodland dominant during periods of low influx within this interval. Initial influx spikes of oak may indicate the expansion of populations of cold-hardy oak species such as bur oak (Quercus macrocarpa), northern red oak (Quercus rubra), and swamp white oak (Quercus bicolor). These oak species, which today tend to have a northern distribution within temperate latitudes, may have provided the initial seed source for northward expansion into late-glacial boreal forests with subsequent climatic amelioration as boreal taxa were reduced or eliminated.

The rapidly fluctuating nature of this zone makes it difficult for taxon calibration or analogues to be as precise in recognition of the varying assemblages as pollen percentage data. Chord Distance indicates that the best modern analogue for 11,000 yr B.P. is located within beech-maple forests of the Great Lakes Region. This analogue reflects the temperate forest community that established itself following the drop in Picea and Pinus at 11,300 yr B.P. Quantitative forest reconstructions based on taxon calibrations emphasized the dramatic shift in dominance

of tree taxa during this interval, with oak attaining dominance, pine being eliminated, spruce populations declining markedly, the initial appearance of hickory, basswood and beech, and the population expansion of elm, sugar maple and ash.

Ostrya/Carpinus Zone (10,040 yr B.P. to 7300 yr B.P.). Spruce declined within this early-Holocene interval, while hornbeam rose to as much as 26% of the AP and oak dominated the arboreal taxa. Ostrya and Carpinus are found today in a variety of environmental situations, with both taxa often being found associated with moist woodlands, ravine bottoms and slopes near streams (Curtis, 1959; Gleason and Cronquist, 1963; Radford et al., 1964; Steyermark, 1963). It is therefore probable that an expansion of both Ostrya and Carpinus occurred around Jackson Pond. Mesic forests also included elm, hemlock, beech, and basswood, which all increase or maintain a consistent portion of the pollen spectra within this interval.

Non-arboreal taxa also indicated an increase in soil moisture and pond water level. Nuphar and Typha expanded to 4% and 2% respectively of the total pollen sum. Other aquatics appearing sporadically included Sagittaria and Eupotamogeton. Cyperaceae, Bidens type and Hypoxis all increase, each being representative or submersed or shoreline herbs. The decline of buttonbush, which thrives in swampy conditions, also indicates higher water levels which have pushed back and/or eliminated buttonbush locally. Alder remained as a local shrub surrounding the pond. Total pollen influx (1600 to 3300 $gr \cdot cm^{-2} \cdot yr^{-1}$) and high NAP

values of 19 to 30% of the total pollen sum indicate an open woodland.

Chord Distance analogues for this time remain within Braun's (1950) beech-maple forest region. Curtis (1959) has characterized the Wisconsin portion of this region as mesic hardwood forest in which the most important trees are sugar maple, basswood, beech, slippery elm, red oak, and hornbeam. The forest composition surrounding Jackson Pond was dominated by oak, with spruce in decline. Mesic taxa such as hemlock, basswood, beech and elm were found along moist mesic slopes and valley bottoms. Immediately around the pond, which had reached a high water level covered with lilies, were populations of hornbeam, black ash, sugar maple and alder. Scattered through the woodland were other deciduous taxa such as hickory, black walnut, and butternut.

Quercus Zone: Salix Subzone (7300 yr B.P. to 3900 yr B.P.). A significant warming trend occurred within this mid-Holocene interval. Mesic taxa such as beech, basswood, and hemlock were eliminated, and elm declined to less than 1% of the AP. Hornbeam also declined drastically and was replaced by willow, which reached up to 30% of the AP. Warm-temperate taxa including sweetgum, blackgum, and red maple were also established. Aquatic species which established populations, as represented by plant macrofossils, were Proserpinaca palustris and Polygonum.

A warming trend is also indicated by the expansion of buttonbush to 22% and virginia willow to 2% of the total pollen sum. Alder was replaced by Rubus. Wetland herbs such as sedges and composites all

declined. Grasses increased and Petalostemum, a prairie indicator (Steyermark, 1963), appeared. Among aquatics, Sagittaria and Typha remained but Nuphar was eliminated. Polygonum hydropiper type, often found in moist ground near streams and ponds (Steyermark, 1963) also appeared consistently within the paleoecologic record.

Total pollen influx (3300 to 9900 $gr \cdot cm^{-2} \cdot yr^{-1}$) and NAP (24 to 38%) indicate an upland vegetational mosaic with open woodland dominated by oak and prairie openings. Upland forests also included hickory, black walnut, chestnut, and cottonwood. Immediately around the pond, within the valley, were sweetgum, red maple, sugar maple, black ash and green/white ash. Based upon taxon calibrations maple, cottonwood and blackgum were more prevalent than indicated on the pollen percentage diagrams. An extensive shrub-thicket of buttonbush, willow, blackberry, raspberry, and virginia willow grew immediately around the pond. The expansion of shrubs and decline in aquatics indicate swampy conditions due to either a lowering of the water table or greater seasonal fluctuations of the water table.

Quercus Zone: Carya Subzone (3900 yr B.P. to 120 yr B.P.). During this interval open grasslands expanded and the population of willow declined markedly. Oak continued to dominate the woodland, with hickory as a subdominant. Lowlands around Jackson Pond continued to be occupied by sweetgum, blackgum, red maple and ash. Other deciduous taxa present were black walnut, butternut, sugar maple, magnolia, cottonwood, silver maple, tuliptree, chestnut, and hornbeam. Buttonbush continued to

dominant the shrub-thicket around the pond. Blackberry and grass increased and prairie plants, such as Petalostemum, were present locally.

Polygonum hydropiper expanded in the low, seasonally fluctuating water levels of the pond. The local marsh was dominated by Dulichium arundinaceum, Sagittaria latifolia, Nuphar, and Proserpinaca palustris, with a littoral shrub community dominated by buttonbush and blackerry.

Chord Distance analogues were all located within the Western Mesophytic Forest region. Reconstructed forest composition based on taxon calibrations, indicate that cottonwood and maple were locally important. Pollen influx values (up to 17,000 $gr \cdot cm^{-2} \cdot yr^{-1}$) and high NAP values (36 to 45%) document the persistence of the vegetational mosaic of upland forests and prairie openings.

Quercus Zone: Ambrosia type Subzone (120 yr B.P. to present). Changes in vegetation during this time interval, corresponding to the historic occupation of the region, reflects land clearance and cultivation by Euro-American settlers. Ragweed increases and grass remains as a major component of the non-arboreal community. Water level rose in the pond and Nuphar populations were re-established. Mesic taxa including elm, beech, basswood, and hemlock reappeared. Local re-establishment of mesic taxa may reflect lowered fire frequency during the historic period. This factor is particularly important because the rolling karst terrain and sinking stream drainage in the area surrounding Jackson Pond would not prevent the fire from spreading or protect vegetation. Disturbance-favored taxa such as Plantago major, Plantago

lanceolata and Chenopodiaceae/Amaranthaceae all appear in the pollen record. Temperate, moisture-tolerant taxa such as sweetgum, blackgum, and red maple continued to grow around the pond, with buttonbush and blackberry growing as a screen of shrubs within the littoral zone. Tree taxa were dominated by oak, with hickory, cottonwood, black walnut, butternut, sugar maple, and ash present as minor elements. Pollen influx increased by an order of magnitude due to high mineral influx associated with Euro-American cultivation and soil erosion on the surrounding farmland of the Jacksons.

VI. CLIMATIC PATTERNS AND VEGETATIONAL GRADIENTS

Crucial to any reconstruction of biota along the southern flank of the Laurentide would be the climatic regime associated with the glacial advance and retreat. Modern climatic systems in the eastern United States are determined primarily by the patterns established by the Arctic, Pacific, and Tropical Maritime Air Masses (Bryson, 1966). Interaction of these air masses has been shown to correspond closely to the major biotic provinces (Bryson, 1966; Bryson and Wendland, 1967; Wright, 1968). The climatic changes initiated by the advance of the Laurentide Ice Sheet would have correlative shifts in the major air systems and their dependent biotic provinces. According to Bryson and Wendland (1967) glacial times would have had a different climatic pattern, with the Laurentide ice sheet serving as both a barrier against the full force of the Arctic Air Mass and as the first major east-west oriented topographic feature encountered by the northward-moving Maritime Tropical Air Mass. The Pacific Air Mass, redirected by Cordilleran ice, would have been funneled between the Arctic and the Maritime Tropical fronts, producing a climatic tension zone from 37° to 40°N latitude, with biotic provinces adapting to this differing pattern of air systems (Bryson and Wendland, 1967; MacIntyre et al., 1976).

More recently, P. Delcourt and H. Delcourt (1983; 1984) have used vegetational ecotones through time to identify past positions of major climatic boundaries for the Maritime Tropical, Pacific, and Arctic Air Masses. They have found synchronous changes of vegetation along broad

latitudinal belts south of the Laurentide, postulating that the shifting climatic zones operate as forcing functions for dependent biotic zones. At 18,000 yr B.P. a narrow ecotonal area is believed to have separated the Pacific Airmass to the north from the Maritime Airmass to the south, with the boundary marking the mean winter position of the Polar Front (Figure 19). Further, the Arctic Airmass was confined well to the north by the ice sheet. Therefore, at 18,000 yr B.P. the Polar Front was fixed at 33°N latitude, with the Pacific Airmass extending throughout the year between 33°N and the ice boundary while the Maritime Tropical Airmass dominated south of the 33°N latitude. At approximately 16,500 yr B.P. a strengthening of the Bermuda High is postulated to have caused a northward extension of the Maritime Tropical Airmass during the summer season, with attendant increased mean summer temperatures and rainfall from the southeastern mid-latitudes to the southern flank of the Laurentide Ice Sheet (P. Delcourt and H. Delcourt, 1984).

I suggest that the climatic patterns projected by Bryson (1966) and redefined by P. Delcourt and H. Delcourt (1983; 1984) provide a crucial perspective for interpreting biotic response to paleoenvironments during full-glacial times. While the Polar Front is seen as occupying a mean 33°N latitude position, there would have been seasonal and annual fluctuations in strengths and latitudinal movements of air systems. It is probable that the Maritime Tropical Airmass would have on occasion penetrated to the ice front itself. Also, the extremely cold Arctic Air Mass was prevented by the ice sheet from directly affecting the

Figure 19. Location map showing positions of major air mass boundaries 18,000 years ago. (from P. Delcourt and H. Delcourt, 1974).

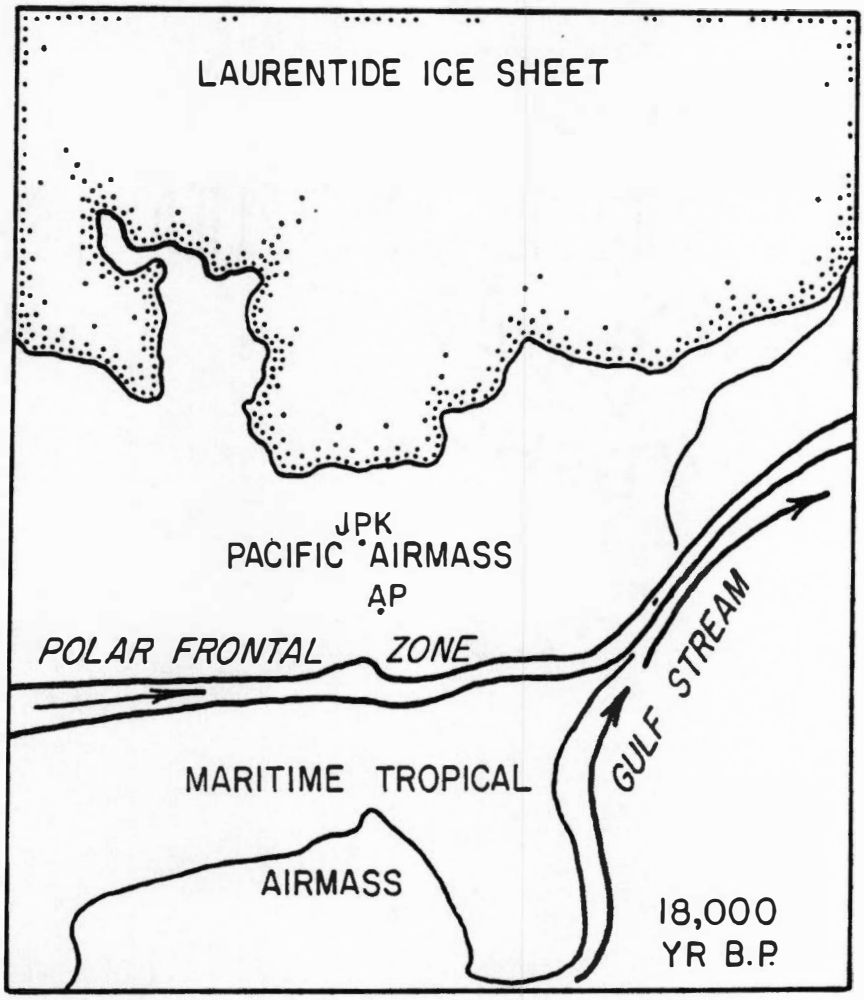

LAURENTIDE ICE SHEET
JPK
PACIFIC AIRMASS
AP
POLAR FRONTAL ZONE
GULF STREAM
MARITIME TROPICAL
AIRMASS
18,000
YR B.P.

Figure 19

paleoenvironment. These factors would have combined to provide a climatic system quite different from that found in areas of tundra or boreal forest environments today. As Terasmae (1977: 81) has pointed out, "The differences in atmospheric circulation and distribution of vegetation at these times must be properly considered in order to avoid erroneous conclusions based on indiscriminate use of modern analogues." The postulated climatic systems would have provided an environmental pattern in which the periodic infusion of the temperate Maritime Tropical Airmass could have produced an ameliorative effect upon the paleoenvironment.

These ameliorative conditions are reflected in the record of periglacial features south of the ice front. In a recent review of periglacial environments of North America Pewe (1983) has addressed this problem. Although he indicates a continuous permafrost from eastern Washington to New Jersey, Pewe does note the lack of physical evidence for permafrost adjacent to the ice sheet from Illinois to the Appalachians. Also, I would suggest that recent studies such as Frest and Fays' (1980) work on Peoria Loess mollusca indicate a possible band of tundra to taiga south of the ice front in this area.

Areas to both the east and west of the Illinois to Appalachian region provide strong evidence of permafrost conditions. To the west within the Minnesota-Iowa Driftless Region Black (1965a, 1965b) and Flemal et al. (1973) have found both ice wedge casts and pingo scars, indicating continuous permafrost. Along the higher elevation

Appalachian Mountains widespread occurrences of patterned ground, rock streams and solifluction deposits have also been recorded (Clark, 1968; Goldthwait, 1976; Michalek, 1968; Pewe, 1973; Potter and Moss, 1968; Smith, 1953). Finally, east of the Appalachians, Walters (1978) has recorded more than 250 ice-wedge casts within 80 kilometers of the former ice front boundary. According to Pewe (1973) ice-wedge casts are found today in areas where the minimum winter temperatures are -15° to -20°C or lower, with mean annual temperatures of -6° to -8°C. The presence of ice-wedge casts in New Jersey and the Minnesota-Iowa area is therefore reflective of a marked climatic change in which continuous permafrost is likely.

I conclude that the glacial climatic patterns resulted in an environmental system for which we lack a contemporary analogue. It may be that, as Wayne (1967) has previously suggested, the area south of the ice front contained only scattered patches of perennially frozen ground where local factors were particularly harsh. I suggest that somewhat milder conditions prevailed along the ice front boundary from Illinois to the Appalachians than is presently encountered in contemporary boreal environments, this permitting the survival of cold-hardy deciduous taxa near the ice front.

Full-glacial vegetation near Jackson Pond was characterized by a spruce-pine boreal forest with minor elements of fir, oak, black ash, elm, sugar maple and hornbeam. There is no evidence of a tundra, with Jackson Pond's location 190 km south of the maximal ice front placing it beyond any tundra fringe area. The very low percentages of deciduous

pollen indicate, however, that the climatic extremes were probably too harsh for temperate taxa much closer to the ice front. Whether such deciduous taxa survived at 50 or 150 km from the ice front is an interesting question, but in some respects of limited importance. The record from Jackson Pond has provided a full-glacial sequence in which the presence of a limited number of deciduous taxa can be logically postulated only 190 km from the ice front based upon pollen percentage data and taxon calibration reconstructions. More importantly, many other temperate deciduous taxa were not found. These included hickory, beech, basswood, red maple, sweetgum, blackgum, chestnut, tuliptree, magnolia, black walnut, butternut, and perhaps hemlock. The refugial areas for these taxa were not within central Kentucky.

Jackson Pond's location at 37°27'N, 85°30'W places it within the biotic zone dominated by the Pacific Air Mass during full-glacial times. Significantly, it is not within the periphery of this zone as was Anderson Pond situated to the south. It therefore should reflect a different response to climatic amelioration than that found at Anderson Pond. As expected, the biotic response at Jackson Pond differs considerably in its temporal sequence of taxa response from Anderson Pond. At approximately 17,000 yr B.P. to 16,500 yr B.P. a number of critical changes occur at Jackson Pond. Influx values decline, non-arboreal pollen percentages increase, macrofossils change types represented and mineral influx declines. These changes reflect the development of a late-glacial climatic system in which the Maritime Tropical Air Mass gained strength and became a more active component of the environmental pattern

in Kentucky. There is, however, a fundamental difference in the responses noted at around 16,500 yr B.P. at Anderson and Jackson Ponds. At Anderson Pond the nearby deciduous taxa to the south and the sites location at the periphery of the boreal forest resulted in an immediate influx of deciduous taxa. At Jackson Pond this deciduous immigration was delayed until 12,000 yr B.P. to 11,300 yr B.P. due to its more northerly latitude, where the Pacific Air Masses dominance was maintained for a much longer span of time.

The interplay of major air mass systems is also reflected in sedimentation rates within lacustrine ponds north of the full-glacial Polar Front (Figure 5 p 37). P. Delcourt (1984) suggested that cool and moist conditions led to low rates of evapotranspiration, high groundwater tables, and increased overland flow which, combined with increased freeze-thaw activity, led to high sediment influx into lacustrine basins. Jackson Pond's sediment influx rate supports this contention as it follows the same sediment influx pattern found at Anderson Pond (H. Delcourt, 1979; P. Delcourt, 1984) and Cupola Pond (Smith, 1984). Sites well south of the full-glacial and late-glacial Polar Front showed a markedly different trend of sedimentation due to a combination of factors including minimal summer precipitation, low sea levels, low groundwater tables or forested landscapes. White Pond, in South Carolina, shows an almost linear sedimentation rate from full-glacial through Holocene times (Figure 5), reflecting its position just south of the maximal Polar Front boundary where it received increased moisture from the south but not the severe cold found to the north.

Climatic amelioration at around 11,300 yr B.P. caused the first major biotic shift at Jackson Pond, with an expansion of deciduous taxa already in the area and the introduction of other deciduous taxa such as beech, hickory, black walnut and butternut. P. Delcourt and H. Delcourt (1983) have traced the shift in climatic zones and associated forest communities in the eastern United States for the last 20,000 years. Their reconstruction places the Polar Frontal Zone across Jackson Pond during this time interval, from 12,000 yr B.P. to 11,000 yr B.P. The Polar Frontal Zone marks the boundary at that time between dominance of the Pacific Air Mass and a co-dominance of the Maritime Tropical and Pacific Air Masses. Accordingly, during this interval Jackson Pond would have been positioned squarely within a major climatic tension zone. This position is reflected in first the major shift away from a spruce dominated woodland and, more importantly, by dramatic shifts in vegetation composition during this interval. Minor fluctuations in regional climatic regimes resulted in significant biotic changes along this tnesion zone, as recorded at Jackson Pond.

By 10,040 yr B.P. Jackson Pond had become established within the co-dominating Maritime Tropical and Pacific Air Masses. At this time a taxon sequence occurred at Jackson Pond that can also be observed in the pollen records of Anderson Pond and Cupola Pond. The sites have a fir peak immediately preceding a hornbeam peak, both following the first dramatic rise in oak. Each site records a mesic forest, but the latitudinal gradient provides for a different temporal span and vegetation sequence. At Anderson Pond this mesic period, represented by an

Ostrya/Carpinus rise, occurred at 12,500 yr B.P., and ended at 9500 yr B.P., placing a 2000 to 2500 year time lag between it and Jackson Pond where it occurred from 10,040 yr B.P. to 7300 yr B.P. Further, the middle-Holocene Hypsithermal, dating approximately 7500 yr B.P. to 3500 yr B.P., shows an immediate effect at Jackson Pond following the mesic Ostrya/Carpinus zone whereas at Anderson Pond there was a brief period between the hornbeam rise and the onset of the Hypsithermal. The same biotic response was found at each site, but at Jackson Pond the time lag resulted in the hornbeam rise being followed immediately by dry xeric conditions. The underlying cause of these biotic responses in varying geographic localities may again be related to major air mass systems. In each site the shift to mesic Ostrya/Carpinus taxa occurred primarily just after the Polar Frontal Zone moves north of the site. I would suggest that the mesic period which follows represents an interval in which a combination of increased Maritime Tropical Air Mass precipitation, decline of boreal taxa and continuation of mild temperatures provides an environmental situation conducive to the expansion of mesic northern taxa. The over-riding controls enforced by the climatic air masses are therefore observed as crucial to accurately interpreting changes in the paleovegetation.

A dry period representing the local establishment of Holocene climatic patterns followed this mesic community at 7300 yr B.P. The migration into the area of various temperate taxa as a community, represented by sweetgum, blackgum, red maple, and chestnut occurs at this time, with swamp shrubbery represented by buttonbush and virginia willow

also becoming prevalent. Low pollen influx and high NAP values indicate an oak-savanna woodland.

A significant increase in willow and slight increase in oak pollen influxes from 7300 yr B.P. to 3850 yr B.P. may reflect the dominance of warm Hypsithermal climatic conditions. Increased temperatures during this time would have increased evapotranspiration and encouraged dry xeric upland oak as well as swamp related species around the pond. Willow, such as black willow (Salix nigra) or prairie willow (Salix humilus), may have developed as either a shrub screen around the pond or as an understory type within an oak savanna during this period.

Mesic deciduous taxa which established themselves by 10,040 yr B.P. were eliminated during the Hypsithermal. Benninghoff (1964) and Kapp (1977) have suggested that the Prairie Peninsula served as a filter barrier which kept the migration of mesic taxa such as hemlock and beech from moving northward through the Midwest. The elimination of mesic taxa at Jackson Pond during the early Holocene supports this contention of a Holocene filter barrier. Warm and dry climatic conditions during this interval eliminated or inhibited the spread of mesic taxa around Jackson Pond.

There has been considerable debate over the nature of the prehistoric vegetation of the this portion of Kentucky due to its relatively treeless condition when first observed by Euro-American settlers (Dicken, 1935; Garmen, 1925; McInteer, 1942; Shaler, 1885; Transeau, 1935). This grassland dominance of the area led to its being called the "Barrens" by these early settlers.

A number of factors were postulated as causing the grasslands, including fires, soil, human interaction, and the climate. Some (Shaler, 1885) have suggested that the Barrens were a recent phenomena caused by indians burning areas to increase carrying capacity of the region for hunting. Cited as support for this interpretation are the numerous accounts of the development of forested areas within the region following historic occupation. Jackson Pond's record, however, indicates a long-established savanna , not a recent aboriginally induced phenomena. I would suggest that the prominent grass rise recorded in the Jackson Pond pollen spectra over the last 2000 years of the Holocene may reflect aboriginal impact. Burning by indians during' this interval would have resulted in the expansion of grasslands within an already dominant oak-savanna. Euro-American occupation of the' region stopped both aboriginal burning and discouraged the natural spread of fires. The re-establishment of forests following Euro-American settlement may therefore not reflect a return to a "natural" biotic community, but rather control of fire frequency by settlers which permitted the establishment of denser forest communities. Supportive evidence of this is observed at Jackson Pond, where mesic taxa are found in the historic Ambrosia zone for the first time following their decline around 7300 B.P. It therefore seems likely that McInteer (1942) was correct in suggesting a number of factors, including soil, fire frequency, and climatic controls were the primary cause of the Barrens. A sparsely forested community dominated by oak was established in the early Holocene, with a rolling terrain, sinking

drainage, and thin soils encouraging fire frequency and maintaining the oak savanna until historic occupation of the region.

VII. CONCLUSIONS

Major conclusions of this study can be summarized as:

1. During the full-glacial climatic extremes Jackson Pond was surrounded by a boreal forest dominated by spruce and jack pine.

2. Deciduous taxa were reduced to only 2% of the arboreal pollen sum at full-glacial extremes (18,000 yr B.P.). These taxa consisted of oak, hornbeam, elm, black ash, and sugar maple. There is no evidence to indicate survival of other temperate deciduous taxa.

3. Late-glacial climatic amelioration at approximately 17,000 yr B.P. is represented by a decline in the boreal components and replacement of the boreal forest with an open spruce-pine woodland. Despite the decline in boreal taxa, there is no corresponding increase in deciduous taxa.

4. The late-glacial/Holocene transition period is marked by rapid biotic fluctuations in which oak, black ash and spruce co-dominated.

5. An open oak-savanna characterizes the Holocene, indicating the "Barrens" observed by Euro-American settlers in early historic times was primarily a natural phenomenon. Some aboriginal impact during the last 2000 years of the Holocene may have contributed to fire frequency and increased grasslands.

6. The biotic associations found at Jackson Pond were a direct result of the interaction of major air mass systems. Changing positions of the Pacific, Maritime Tropical and Arctic Air Masses were responsible for establishing environmental parameters which controlled vegetation composition of the region around Jackson Pond.

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APPENDIXES

APPENDIX A

EXTRACTION TECHNIQUE

CHEMICAL TREATMENT OF SAMPLES

1. Transfer sediment and exotic pollen to a 15-ml polypropylene centrifuge tube with 10 ml hydrochloric acid (HCL), stir, heat several minutes in a boiling water bath until reaction with calcareous sediments and matrix of Eucalyptus tablets stops; add 1 ml tertiary butyl alcohol (TBA) to wet particles that otherwise might float on the meniscus; centrifuge 2 minutes, decant supernant into a bucket containing sodium bicarbonate to neutralize excess acid.

2. Add 10 ml 10% potassium hydroxide (KOH); stir; heat for 2 minutes on a boiling water bath. This step disperses organics and breaks down humic substances.

3. If sandy or containing bits or organic matter, sieve through a 250 μm mesh screen. Concentrate by centrifugation, adding 1 ml TBA each time; decant.

4. Wash with 10 ml distilled water until supernatant is clear, stir, add 1 ml TBA, centrifuge, and decant after each water wash. These washes remove humic substances and clay-sized particles that, if not removed, would later interfere with dispersion.

5. Add 10 ml 10% HCL, stir, add 1 ml TBA, centrifuge, decant.

6. Add 5 ml concentrated hydrofluoric acid (HF), stir, heat in boiling water bath 20 minutes, stiring after 10 minutes; add 95% ethyl alcohol (ETOH) to reduce density, add 1 ml TBA, centrifuge, decant; if still silty, repeat this step up to 4 times. This step removes silicate minerals.

7. Add 5 ml concentrated HCL, stir, heat in boiling water bath 20 minutes, stirring after 10 minutes, add ETOH, centrifuge, decant; repeat if necessary. If this material threatens to boil over, squirt with ETOH in centrifuge tube. This step removes the silicofluoride gel that may form from HF reaction with silicate-rich sediments.

8. Rinse with 10 ml glacial acetic acid to further dehydrate, stir, add 1 ml TBA, centrifuge, decant.

9. Acetolyze with 4.5 ml acetic anhydride + 0.5 ml concentrated sulfuric acid, added directly to each centrifuge tube and well-stirred; heat 1 minute in boiling bath, stirring well after 30 seconds; add 5 ml glacial acetic acid, stir, centrifuge, decant.

10. Rinse with 10 ml glacial acetic acid to remove the acid - soluble products of acetylation, stir, add 1 ml TBA, centrifuge, decant.

11. Rinse with 7 ml water + 3 ml 10% KOH to neutralize and disperse material, stir, add 1 ml TBA, centrifuge, decant.

12. Sieve through a 7 μm mesh screen, centrifuge, decant, repeating until supernant is clear.

13. Add 10 ml water + 1 drop 0.5% Safranin 0 stain, stir, add 1 ml TBA, centrifuge, decant.

14. Wash with 10 ml TBA to dehydrate, stir, centrifuge, decant.

15. Transfer to labeled 1 dram vials with TBA, centrifuge, decant.

16. Add a few drops of silicone oil (2000 centistokes vicosity), stir, allow TBA to evaporate overnight in a dust-free place.

APPENDIX B

MODERN ANALOGUE DATA

Table B-1 Modern Analogues

Yr B.P.	Site No.	FIPS Code	Latitude	Longitude	Relative Coefficient of Dissimilarity
		BEST 3 EUCLIDEAN DISTANCES			
0	1029	55049	43.07	-89.85	8.15
0	50243	05087	36.10	-93.73	8.49
0	50240	05145	35.17	-91.75	8.55
1000	50240	05145	35.17	-91.75	10.49
1000	491	26901	41.80	-84.90	10.86
1000	912	17902	38.57	-89.00	11.60
2000	50240	05145	35.17	-91.75	11.99
2000	911	17901	39.42	-88.43	12.92
2000	487	26901	42.18	-85.12	14.57
3000	911	17901	39.42	-88.43	11.14
3000	50240	05145	35.17	-91.74	13.97
3000	50020	47017	35.80	-88.63	14.38
4000	50020	47017	35.80	-88.63	16.56
4000	911	17901	39.42	-88.43	20.19
4000	909	17901	40.17	-87.65	21.95
5000	50020	47017	35.80	-88.63	13.78
5000	911	17901	39.42	-88.43	14.97
5000	913	17903	37.75	-89.12	20.98
6000	911	17901	39.42	-88.43	12.41
6000	50020	47017	35.80	-88.63	13.76
6000	772	18085	41.07	-85.97	14.42
7000	911	17901	39.42	-88.43	12.31
7000	50020	47017	35.80	-88.63	12.69
7000	913	17903	37.75	-89.12	15.20
8000	399	55025	43.13	-89.50	19.61
8000	902	55131	43.33	-88.20	22.36
8000	502	17901	42.33	-88.05	22.92
9000	502	17901	42.33	-88.05	22.92
9000	399	55025	43.13	-89.50	28.80
9000	667	09005	41.72	-73.29	29.56
10,000	399	55025	43.13	-89.50	21.30
10,000	477	26901	42.45	-84.78	24.90
10,000	902	55131	43.33	-88.20	25.88
11,000	667	09005	41.72	-73.28	25.97
11,000	1079	70014	48.00	-69.40	27.33
11,000	1063	70002	47.63	-71.23	27.78
12,000	893	68KD1	49.55	-83.02	9.59
12,000	688	68TD1	48.33	-80.50	10.72
12,000	892	68KD1	49.72	-86.15	10.84

Table B-1 (continued)

Yr B.P.	Site No.	FIPS Code	Latitude	Longitude	Relative Coefficient of Dissimilarity
13,000	688	68TD1	48.33	-80.50	10.39
13,000	72		54.02	-105.80	10.79
13,000	879	68SLD	50.12	-90.78	10.81
14,000	699	70011	49.00	-76.97	9.32
14,000	277	63U74	56.33	-97.00	9.52
14,000	280	63U99	55.00	-96.00	10.12
15,000	1075	70002	48.27	-71.67	9.72
15,000	292	63U72	56.75	-100.25	10.53
15,000	1077	70002	47.60	-70.98	10.68
16,000	1077	70002	47.60	-70.98	7.51
16,000	883	68SLD	51.35	-90.17	7.70
16,000	292	63U72	56.75	-100.25	7.70
17,000	879	68SLD	50.12	-90.78	7.08
17,000	72		54.02	-105.80	7.45
17,000	283	63U96	54.67	-94.33	7.78
18,000	879	68SJD	50.12	-90.78	4.37
18,000	72		54.02	-105.80	6.25
18,000	279	63U84	55.00	-97.80	6.27
19,000	584	70000	51.45	-78.53	6.94
19,000	74		54.05	-105.72	7.63
19,000	304	68PEA	51.12	-84.05	7.68
20,000	988	70006	50.03	-77.13	7.38
20,000	307	68PEA	51.32	-83.08	8.60
20,000	893	68KD1	49.55	-83.02	8.73
		BEST 3 CHORD DISTANCES			
0	645	42133	40.07	-76.90	3.29
0	50243	05087	36.10	-93.73	3.37
0	1029	55049	43.07	-89.85	3.46
1000	50005	47051	35.15	-86.20	3.34
1000	917	17901	40.55	-90.17	3.78
1000	50043	28081	34.15	-88.72	3.90
2000	50005	47051	35.15	-86.20	3.85
2000	50240	05145	35.16	-91.75	4.52
2000	917	17901	40.55	-90.17	4.52
3000	50005	47051	35.15	-86.20	3.95
3000	50240	05145	35.17	-91.75	4.20
3000	50020	47017	35.80	-88.63	4.39
4000	911	17901	39.42	-88.43	4.60
4000	50020	47017	35.80	-88.63	4.62
4000	50207	22099	30.34	-91.72	4.84

Table B-1 (continued)

Yr B.P.	Site No.	FIPS Code	Latitude	Longitude	Relative Coefficient of Dissimilarity
5000	911	17901	39.42	-88.43	4.84
5000	50020	47017	35.80	-88.63	4.87
5000	50207	22099	30.34	-91.72	5.26
6000	50005	47051	35.15	-86.20	4.36
6000	50020	47017	35.80	-88.63	4.41
6000	917	17901	40.55	-90.17	4.46
7000	482	26161	42.33	-83.63	4.49
7000	483	26161	42.33	-83.63	4.52
7000	490	26901	41.95	-85.70	4.63
8000	502	17901	42.33	-88.05	4.60
8000	904	55133	43.15	-88.43	5.04
8000	1011	55123	43.68	-90.73	5.09
9000	502	17901	42.33	-88.95	4.22
9000	1011	55123	43.68	-90.73	5.65
9000	904	55133	43.15	-88.43	5.81
10,000	502	17901	42.33	-88.05	4.81
10,000	902	55131	43.33	-88.20	5.17
10,000	493	18149	41.23	-86.63	5.24
11,000	502	17901	42.33	-88.05	5.09
11,000	1079	70014	48.00	-69.40	5.57
11,000	989	70006	50.60	-77.57	5.61
12,000	893	68KD1	49.55	-83.02	3.66
12,000	688	68TD1	48.33	-80.50	3.71
12,000	894	68CD1	49.25	-81.72	3.74
13,000	980	68SLD	51.00	-93.85	3.57
13,000	883	68SLD	51.35	-90.17	3.58
13,000	893	68KD1	49.55	-83.02	3.64
14,000	883	68SLD	51.35	-90.17	3.41
14,000	980	68SLD	51.00	-93.85	3.43
14,000	1075	70002	48.27	-71.67	3.45
15,000	980	68SLD	51.00	-93.85	3.07
15,000	883	68SLD	51.35	-90.17	3.27
15,000	983	68SLD	51.08	-94.18	3.47
16,000	883	68SLD	51.35	-90.17	2.64
16,000	980	68SLD	51.00	-93.85	2.74
16,000	983	68SLD	51.08	-94.18	2.88
17,000	883	68SLD	51.35	-90.17	3.04
17,000	893	68KD1	49.55	-83.02	3.16
17,000	980	68SLD	51.00	-93.85	3.25

Table B-1 (continued)

Yr B.P.	Site No.	FIPS Code	Latitude	Longitude	Relative Coefficient of Dissimilarity
18,000	883	68SLD	51.35	-90.17	2.39
18,000	879	68SLD	50.12	-90.78	2.66
18,000	893	68KD1	49.55	-83.02	2.82
19,000	302	68PEA	51.03	-84.38	2.75
19,000	1041	70002	47.63	-70.93	3.08
19,000	304	68PEA	51.12	-84.05	3.08
20,000	307	68PEA	51.32	-83.08	2.82
20,000	893	68KD1	49.55	-83.02	2.85
20,000	892	68KD1	48.72	-85.15	2.97
		BEST 3 STANDARDIZED EUCLIDEAN DISTANCES			
0	50249	01119	32.43	-88.03	2.56
0	50240	05145	35.17	-91.75	2.64
0	50190	22073	32.53	-92.33	2.97
1000	50240	05145	35.17	-91.75	2.58
1000	50043	28081	34.15	-88.72	3.28
1000	50243	05087	36.10	-93.73	3.40
2000	50240	05145	35.17	-91.75	2.80
2000	50037	28001	31.55	-91.20	4.16
2000	50020	47017	35.80	-88.63	4.19
3000	50240	05145	35.17	-91.75	2.64
3000	50043	28081	34.15	-88.72	3.50
3000	50243	05087	36.10	-93.73	3.54
4000	50037	28001	31.55	-91.20	3.67
4000	50020	47017	35.80	-88.63	4.05
4000	50039	28149	32.30	-90.87	4.28
5000	50037	28001	31.55	-91.20	4.17
5000	50039	28149	32.30	-90.87	4.40
5000	911	17901	39.42	-88.43	4.47
6000	50240	05145	35.17	-91.75	3.04
6000	50020	47017	35.80	-88.63	3.05
6000	50043	28081	34.15	-88.72	3.25
7000	50184	05051	34.51	-93.27	2.96
7000	395	55049	43.00	-90.10	3.21
7000	768	51143	37.08	-79.40	3.32
8000	399	55025	43.13	-89.50	4.10
8000	532	68NBD	47.03	-79.80	4.21
8000	528	68NBD	46.18	-79.42	4.62

Table B-1 (continued)

Yr B.P.	Site No.	FIPS Code	Latitude	Longitude	Relative Coefficient of Dissimilarity
9000	399	55025	43.13	-89.50	3.70
9000	528	68NBD	46.13	-79.42	4.11
9000	532	68NBD	47.03	-79.80	4.13
10,000	532	68NBD	47.03	-79.80	4.79
10,000	399	55025	43.13	-89.50	5.35
10,000	528	68NBD	46.18	-79.42	5.44
11,000	1079	70014	48.00	-69.40	3.01
11,000	1063	70002	47.63	-71.23	3.14
11,000	1043	36071	41.55	-74.07	3.41
12,000	988	70006	50.03	-77.13	1.55
12,000	1063	70002	47.63	-71.23	1.65
12,000	1043	70002	47.63	-70.90	1.65
13,000	988	70006	50.03	-77.13	1.45
13,000	72		54.02	-105.80	1.48
13,000	879	68SLD	50.12	-90.78	1.50
14,000	1075	70002	48.27	-71.67	1.32
14,000	1053	70004	49.80	-74.55	1.43
14,000	881	68SLD	50.42	-90.48	1.43
15,000	1053	70004	49.80	-74.55	1.47
15,000	980	68SLD	51.00	-93.85	1.48
15,000	883	68SLD	51.35	-90.17	1.51
16,000	881	68SLD	50.42	-90.48	0.83
16,000	293	63U72	57.00	-100.83	0.87
16,000	883	68SLD	51.35	-90.17	0.91
17,000	72		54.02	-105.80	1.25
17,000	879	68SLD	50.12	-90.78	1.27
17,000	186	63000	58.67	-94.00	1.29
18,000	72		54.02	-105.80	0.99
18,000	879	68SLD	50.12	-90.78	1.00
18,000	988	70006	50.03	-77.13	1.02
19,000	715	70006	50.65	-78.03	1.19
19,000	74		54.05	-105.72	1.19
19,000	717	70006	50.90	-77.90	1.20
20,000	307	68PEA	51.32	-83.08	1.31
20,000	988	70006	50.03	-77.13	1.34
20,000	586	70000	51.98	-78.07	1.42

APPENDIX C

INFLUX CALCULATIONS

Table C-1 Influx Calculations

Depth (cm)	Native Grains x Exotic Grs. Added/ Exotic Grs. Counted	x Sedimentation Rate	Influx
95	527.5 48,540/617	.3333	13,831
100	514 48,540/777	"	10,702
105	473 48,540/681	"	11,227
110	477.5 48,540/669	"	11,547
115	508 16,180/184	"	14,889
120	542 16,180/172	"	16,993
125	506.5 64,620/333	"	32,810
130	506 48,540/210	"	38,982
135	523 64,620/201	"	56,127
140	542 48,540/37	.0305	21,686
145	554 48,540/48	"	17,087
150	527.5 64,620/100	"	10,413
155	565 64,620/78	"	14,298
160	496 32,360/37	"	13,231
165	494 48,540/39	.0066	4,058
170	486 64,620/48	"	4,325
175	483.5 48,540/31	"	4,997
180	401 32,360/14	"	6,117
185	424.5 64,620/25	"	7,253
190	416 64,620/18	"	9,872
195	416 64,620/36	"	4,935
200	444 32,360/24	"	3,951
205	390 64,620/50	"	3,332
210	381 48,540/37	"	3,299
215	394 64,620/92	"	1,829
220	471.5 16,180/31	"	1,624
225	392 64,620/152	.0275	4,590
227.5	399.5 64,620/166	"	4,283
230	420.5 64,620/248	"	3,017
232.5	401 64,620/316	"	2,258
235	457 48,540/74	"	8,243
237.5	442 64,620/111	"	7,087
240	411 64,620/182	"	4,019
242.5	457 64,620/98	"	8,299
245	441 64,620/144	"	5,451
247.5	435 64,620/316	"	2,450
250	442 48,540/215	"	2,744
255	411 64,620/260	"	2,813
260	449 16,180/107	"	1,867
270	485 48,540/278	"	2,329
275	504 48,540/250	.0407	3,983
280	504 32,360/167	"	4,123
310	467 32,360/206	"	2,986

Table C-1 (continued)

Depth (cm)	Native Grains x Exotic Grs. Added/ Counted	Sedimentation Rate	Influx
340	459 x 32,360/142	.0407	4,257
370	458 x 48,540/281	"	3,220
400	403 x 32,360/126	"	4,212
430	362.5 x 64,620/336	"	2,842
460	424 x 16,180/69	"	4,046
490	343.5 x 64,620/296	"	3,057
520	354 x 32,360/148	.0756	5,581
550	350 x 64,620/193	"	8,873
580	352.5 x 16,180/81	"	5,323
610	349 x 32,360/173	"	4,935
640	346.5 x 48,540/206	"	6,172
670	337 x 48,540/183	"	6,758
700	347 x 48,540/168	"	7,579
710	339.5 x 16,180/48	"	8,652
715	339 x 80,800/137	"	15,133

APPENDIX D

PALYNOMORPH CONCENTRATIONS

Table D-1 Palynomorph Concentrations

Depth (cm)	Native Grains/ Exotic Grains	Exotic Grains/ Tablet	No. of Tablets	Concentration
95	527.5/617= .86	16,180	3	41,744
100	514 /777= .66	"	3	32,036
105	473 /681= .69	"	3	33,493
110	477.5/669= .72	"	3	34,948
115	508 /184= 2.76	"	1	44,656
120	542 /172= 3.15	"	1	50,967
125	506.5/333= 1.52	"	4	98,374
130	506 /210= 2.41	"	3	116,981
135	523 /201= 2.60	"	4	168,272
140	542 /37 = 14.65	"	3	711,111
145	554 /48 = 11.54	"	3	560,151
150	527.5/100= 5.28	"	4	341,721
155	565 /78 = 7.24	"	4	468,572
160	496 /37 = 13.40	"	2	433,624
165	494 /39 = 12.67	"	3	615,001
170	486 /48 = 10.12	"	4	654,966
175	483.5/31 = 16.60	"	3	757,224
180	401 /14 = 28.64	"	2	926,790
185	424.5/25 = 16.98	"	4	1,098,945
190	416 /18 = 23.11	"	4	1,495,679
195	416 /35 = 11.55	"	4	747,516
200	444 /24 = 18.50	"	2	598,660
205	390 /50 = 7.80	"	4	504,816
210	381 /37 = 10.30	"	3	666,616
215	394 /92 = 4.23	"	4	277,001
220	471.5/31 = 15.21	"	1	246,097
225	392 /152= 2.58	"	4	166,977
227	399.5/166= 2.41	"	4	155,975
230	420.5/248= 1.69	"	4	109,376
232	401 /316= 1.27	"	4	82,194
235	457 /74 = 6.17	"	3	299,491
237	442 /111= 3.98	"	4	257,585
240	411 /182= 2.26	"	4	146,267
242	457 /98 = 4.66	"	4	301,595
245	441 /144= 3.06	"	4	198,043
247	435 /316= 1.38	"	4	89,313
250	442 /215= 2.06	"	3	99,992
255	411 /260= 1.58	"	4	102,257
260	449 /107= 4.20	"	1	67,956
270	485 /278= 1.75	"	3	84,945
275	504 /250= 2.02	"	3	98,050

Table D-1 (continued)

Depth (cm)	Native Grains/ Exotic Grains	Exotic Grains/ Tablet	No. of Tablets	Concentration
280	504 /161= 3.13	16,180	2	101,286
310	467 /206= 2.27	"	2	73,457
340	459 /142= 3.23	"	2	104,522
370	458 /281= 1.63	"	3	79,120
400	403 /126= 3.20	"	2	103,552
430	362.5/536= 1.08	"	4	69,897
460	424 /69 = 6.15	"	1	99,507
490	343.5/296= 1.16	"	4	75,075
520	354 /148= 2.39	"	2	77,340
550	350 /193= 1.81	"	4	117,143
580	352.5/81 = 4.35	"	1	70,383
610	349 /173= 2.02	"	2	65,367
640	346.5/206= 1.68	"	3	81,547
670	337 /183= 1.83	"	3	89,313
700	347 /168= 2.07	"	3	100,477
710	339.5/48 = 7.07	"	1	114,392
715	339 /137= 2.47	"	5	199,823

APPENDIX E

VEGETATION RECONSTRUCTION DATA

Table E-1 Vegetation Reconstruction Data

Yr B.P.	Selected Arboreal Taxa Used In Reconstructions %															
	ABIES	ACER	CARYA	CUPRESSACEAE	FAGUS	FRAXINUS	JUGLANS	POPULUS	QUERCUS	SALIX	TSUGA	ULMUS	NYSSA	PICEA	TILIA	PINUS
0	0	8.04	9.89	1.39	0	5.66	.81	19.32	40.87	1.45	0	1.63	6.21	4.51	0	0
500	0	9.19	15.59	1.01	0	5.57	.35	6.47	45.11	1.35	1.38	2.16	7.37	4.44	0	0
1000	0	9.06	12.34	0	0	9.28	.52	13.11	49.54	1.34	0	.45	4.34	0	0	0
2000	0	12.37	6.53	0	0	12.70	0	11.98	44.52	5.41	0	1.19	5.28	0	0	0
3000	0	5.89	12.78	0	0	10.28	.03	8.05	47.29	8.09	0	1.03	6.53	0	0	0
3500	0	7.07	9.60	0	0	10.74	0	5.58	41.22	13.11	0	1.10	6.34	5.20	0	0
4000	0	9.61	4.85	0	0	11.76	0	4.36	36.97	19.59	0	1.14	5.98	5.70	0	0
4500	0	9.15	6.02	0	0	10.02	0	6.57	39.20	17.70	0	1.09	4.89	5.33	0	0
5000	0	10.31	6.18	0	0	11.85	0	5.16	39.88	14.99	0	1.08	4.77	5.31	0	0
5500	0	11.68	5.93	0	1.25	13.33	0	5.15	39.78	11.60	0	1.10	4.83	5.33	0	0
6000	0	11.37	6.28	0	1.24	7.29	0	13.12	41.69	8.42	0	1.21	4.14	5.18	0	0
7000	0	9.50	4.80	0	1.20	7.41	.43	9.52	35.79	9.10	1.28	3.27	3.99	10.01	3.67	0
8000	0	9.13	5.96	0	1.51	3.69	.76	2.38	43.00	0	1.40	4.93	5.33	19.44	2.44	0
9000	6.09	8.38	4.85	0	1.44	3.16	.15	0	34.02	0	1.29	5.19	4.44	28.48	2.48	0
10,000	6.35	10.14	1.29	0	1.73	11.07	0	3.76	37.04	0	0	6.65	0	19.24	2.72	0
11,000	7.86	5.47	0	1.26	0	11.20	0	5.81	17.67	0	1.33	1.37	0	47.98	0	0
12,000	7.72	6.06	0	0	0	5.74	0	3.11	3.90	.46	1.41	1.36	0	57.39	0	12.83
13,000	8.24	0	0	1.25	0	4.78	0	3.16	5.46	0	0	1.13	0	56.17	0	19.79
14,000	8.59	6.35	0	1.23	0	4.43	0	0	3.79	.03	1.39	1.65	0	48.57	0	23.94
15,000	11.12	4.19	0	1.65	0	3.87	0	0	4.66	0	1.30	.79	0	45.67	0	26.72
16,000	9.06	0	0	0	0	2.48	0	2.39	3.62	0	0	.81	0	51.03	0	30.62
17,000	7.96	4.62	0	0	1.41	1.44	0	7.45	2.52	0	0	1.22	0	53.19	0	20.16
18,000	8.16	4.46	0	0	0	1.33	0	0	.86	0	0	.96	0	61.07	0	23.15
19,000	8.93	4.18	0	1.52	0	2.79	.21	0	2.09	0	0	1.40	0	76.48	0	1.96
20,000	8.12	0	0	1.42	0	1.49	0	0	1.44	0	0	.67	0	71.59	0	15.24

APPENDIX F

LOSS-ON-IGNITION DATA

Table F-1 Loss-On-Ignition Data

	weight in grams				
Depth (cm)	Sediment Weight	Water Weight	Organic Weight	Carbonate Mineral Weight	Non-Carbonate Mineral Weight
105	.8555	.7595	.0653	.0023	.0284
115	.8845	.7737	.0808	.0019	.0281
120	.8802	.7515	.0870	.0027	.0390
128	.9981	.8638	.0489	.0024	.0774
145	.9725	.6843	.0721	.0095	.2066
155	1.0366	.5640	.0392	.0116	.4218
160	1.1517	.6150	.0554	.0117	.4696
165	1.1486	.6300	.0582	.0114	.4490
175	1.1476	.5437	.0622	.0214	.5203
180	1.3465	.5439	.0644	.0257	.7125
190	1.4245	.5182	.0639	.0262	.8162
200	1.2462	.4412	.0582	.0268	.7200
210	1.2986	.4289	.0555	.0273	.7869
215	1.1848	.3638	.0460	.0159	.7591
220	1.3769	.4429	.0502	.0176	.8662
230	1.1996	.5155	.0466	.0258	.8167
240	1.2608	.5522	.0473	.0277	.6417
250	.9887	.4272	.0374	.0221	.5120
265	1.1756	.5266	.0384	.0129	.5977
270	1.1963	.5312	.0452	.0145	.6179
275	1.1149	.5749	.0338	.0134	.4928
310	1.0338	.5865	.0315	.0194	.3964
340	1.0224	.5776	.0282	.0189	.3977
370	1.0835	.6558	.0275	.0191	.3811
400	1.0087	.6738	.0344	.0169	.2836
430	.8832	.5623	.0347	.0140	.2722
460	.9203	.5662	.0246	.0149	.3936
490	1.0056	.6278	.0252	.0179	.3347
505	1.0533	.5936	.0503	.0194	.3900
510	1.0642	.5926	.0551	.0142	.4023
550	1.1587	.5810	.0271	.0187	.5319
580	1.0904	.6097	.0441	.0191	.4175
610	1.1476	.6452	.0385	.0211	.4428
639	1.1567	.6094	.0349	.0203	.4921
673	1.1397	.5956	.0342	.0327	.4772
690	1.1922	.5587	.0546	.0296	.5493
700	1.0514	.4840	.0505	.0152	.5017
710	1.0375	.5028	.0584	.0137	.4626

APPENDIX G

PALYNOMORPH TABULATION

EXPLANATION OF ABBREVIATIONS

ABIES	ABIES
ACNEGUND	ACER NEGUNDO
ACRUBRUM	ACER RUBRUM
ACSACNUM	ACER SACCHARINUM
ACSACRUT	ACER SACCHARUM
ACSPICAT	ACER SPICATUM
BETULA	BETULA
OSTRYCAR	OSTRYA/CARPINUS
CARYA	CARYA
CASTANEA	CASTANEA
CELTMACL	CELTIS/MACLURA
CORNFLOR	CORNUS FLORIDA
CUPRESSX	CUPRESSACEAE
FAGUS	FAGUS GRANDIFOLIA
FRAXINUX	FRAXINUS UNDIFF
FRAXNIGT	FRAXINUS NIGRA TYPE
FRAXPNAM	FRAXINUS PENNSYLVANICA/AMERICANA
JUGCINER	JUGLANS CINEREA
JUGNIGRA	JUGLANS NIGRA
LARIX	LARIX
LIQUIDAM	LIQUIDAMBAR
LIRIODEN	LIRIODENDRON
MAGNOLIA	MAGNOLIA
NYSSA	NYSSA
PICEAX	PICEA UNDIFF
PINDIPLX	PINUS DIPLOXYLON UNDIFF
PINHAPLO	PINUS STROBUS
PLATANUS	PLATANUS
POPULUS	POPULUS
PRUNUS	PRUNUS
QUERCUS	QUERCUS
SALIX	SALIX
TILIA	TILIA
TSUGA	TSUGA
ULMUS	ULMUS
ACPENNSY	ACER PENSYLVANICUM
AMELSORB	AMELANCHIER/SORBUS
ILEX	ILEX
VIBTRILO	VIBURNUM TRILOBUM TYPE
ALNCRISP	ALNUS CRISPA
ALNRUGOS	ALNUS RUGOSA
CEPHALAN	CEPHALANTHUS
CORYLUS	CORYLUS

ITEAVIRG	ITEA VIRGINICA
RUBUS	RUBUS
SAMBUCUS	SAMBUCUS
SPIREAT	SPIRAEA
CARYOPHY	CARYOPHYLLACEAE
CHENOMX	CHENOPODIACEAE/AMARANTHACEAE UNDIFF
AMBROSIT	AMBROSIA TYPE
BIDENSTY	BIDENS TYPE
ACHILLEA	ACHILLEA TYPE
IVACILIA	IVA CILIATA TYPE
IVAXANTT	IVA XANTHIFOLIA
XANTHIUM	XANTHIUM
LIGULIFL	LIGULIFLORAE
CYPERACE	CYPERACEAE
OTHGRAMN	GRAMINEAE OTHER
PLANTLAN	PLANTAGO LANCEOLATA
PLANTMAJ	PLANTAGO MAJOR
THALICTR	THALICTRUM
PETALOST	PETALOSTEMUM
LABIATAE	LABIATAE
UMBELLIF	UMBELLIFERAE
RUMEX	RUMEX
CORNCANT	CORNUS CANADENSIS TYPE
URTICA	URTICA
RANCULAX	RANUNCULACEAE UNDIFF
HYPOXISH	HYPOXIS
CANNAHUM	CANNABIS/HUMULUS
ARTEMISI	ARTEMISIA
SANGUICA	SANGUISORBA CANADENSIS
POTENTIT	POTENTILLA TYPE
GALIUM	GALIUM
MALVACEA	MALVACEA
ONAGRACE	ONAGRACEAE
ZEA MAYS	ZEA MAYS
CIRSCART	CIRSIUM/CARDUUS
CATTHAT	CALTHA TYPE
MENTANTH	MENYANTHES
POLYGHYD	POLYGONUM HYDROPIPER TYPE
EUPOTAMO	EUPOTAMOGETON
SAGITTAR	SAGITTARIA
TYPHANSP	TYPHA LATIFOLIA
COLEOGET	COLEOGETON
TYPHANSP	SPARGANIUM
NUPHAR	NUPHAR
POLYGAVI	POLYGONUM AVICULARE TYPE
TYPHALAS	TYPHA LATIFOLIA SINGLE GRAINS

SPHAGNUM	SPHAGNUM
UTRICULR	UTRICULARIA
MYRIOEXA	MYRIOPHYLLUM EXALBESCENS TYPE
ISOETES	ISOETES
POLYGVIV	POLYGONUM VIVIPARUM
MYRIOATT	MYRIOPHYLLUM ALTERNIFLORUM
NYMPHAEA	NYMPHAEA
OSMUNCIN	OSMUNDA CINNAMOMEA TYPE
OSMUNREG	OSMUNDA REGALIS TYPE
BOTRYCH	BOTRYCHIUM
DRYOPTET	DRYOPTERIS
CYSTOPTE	CYSTOPTERIS
POLYPDAC	POLYPODIACEAE
EQUISTEU	EQUISETUM
LYCOINUN	LYCOPOCIUM INUNDATUM
LYCOPOD	LYCOPODIUM UNDIFF
LYCOOBSC	LYCOPODIUM OBSCURUM
PTERIDIU	PTERIDIUM
LYCOCOMP	LYCOPODIUM COMPLANATUM
INDETERM	INDETERMINABLE
UNKNOWN	UNKNOWN
EUCANOS	EUCALYPTUS GRAINS COUNTED

Appendix G includes total palynomorph counts by taxa per level. The numbers in the columns are correspond to depth intervals listed below.

JACKPOND21 123 37 26 25N 85 43 20W289. LAKE GARY R. WILKINS

58. DEPTHS		113. VARIABLES			
SURFACE	95.0	95.0	95.0	0.0	0.0
A3870	128.0	138.0	133.0	120.0	50.0
A3871	155.0	166.0	160.5	940.0	80.0
A3872	215.0	226.0	220.5	10040.0	190.0
A3873	263.0	277.0	270.0	11860.0	250.0
A3874	505.0	515.0	510.0	17750.0	270.0
A3875	700.0	710.0	705.0	20330.0	630.0

DEPTH					
095.0	100.0	105.0	110.0	115.0	120.0
125.0	130.0	135.0	140.0	145.0	150.0
155.0	160.0	165.0	170.0	175.0	180.0
185.0	190.0	195.0	200.0	205.0	210.0
215.0	220.0	225.0	227.0	230.0	232.0
235.0	237.0	240.0	242.0	245.0	247.0
250.0	255.0	260.0	270.0	275.0	280.0
310.0	340.0	370.0	400.0	430.0	460.0
490.0	520.0	550.0	580.0	610.0	640.0
670.0	700.0	710.0	715.0		

Appendix G (continued)

ABIES

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	4.0	1.0	0.5	3.0
3.0	0.0	8.5	1.0	5.5	3.0
7.0	9.0	15.0	11.0	2.5	6.0
2.0	6.0	2.0	7.0	4.5	1.0
4.5	3.0	2.0	2.0	3.0	0.0
1.0	5.0	2.5	0.0		

ACNEGUND

0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0		

ACRUBRUM

1.0	3.0	1.0	4.0	3.0	3.0
2.0	2.0	3.0	3.0	2.0	1.0
3.0	1.0	5.0	0.0	0.0	2.0
2.0	2.0	4.0	4.0	0.0	2.0
0.0	1.0	0.0	0.0	2.0	0.0
6.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		

ACSACNUM

1.0	0.0	0.0	2.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	1.0	0.0	1.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0

Appendix G (continued)

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
ACSACRUT					
1.0	1.0	2.0	3.0	2.0	1.0
3.0	2.0	1.0	2.0	2.0	3.0
4.0	3.0	5.0	4.0	1.0	2.0
2.0	4.0	2.0	1.0	2.0	2.0
3.0	4.0	0.0	2.0	2.0	1.0
5.0	4.0	2.0	4.0	3.0	1.0
2.0	4.0	1.0	0.0	1.0	0.0
0.0	0.0	3.0	0.0	0.0	0.0
1.0	0.0	0.0	1.0	0.0	1.0
0.0	0.0	0.0	0.0		
ACSPICAT					
1.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
BETULA					
5.0	2.0	1.0	0.0	0.0	0.0
3.0	4.0	0.0	2.0	0.0	2.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	1.0	0.0	0.0	1.0	2.0
1.0	1.0	0.0	4.0	3.0	5.0
2.0	4.0	1.0	0.0	2.0	0.0
2.0	1.0	1.0	1.0	1.0	1.0
1.0	0.0	2.0	1.0	1.0	2.0
1.0	1.0	0.0	2.0	5.0	1.0
2.0	1.0	0.0	0.0		
OSTRYCAR					
10.0	6.0	6.0	4.0	3.0	3.0
3.0	5.0	4.0	7.0	6.0	6.0
3.0	1.0	4.0	1.0	4.0	7.0
3.0	6.0	8.0	17.0	62.0	69.0
56.0	88.0	14.0	22.0	17.0	19.0
27.0	43.0	6.0	25.0	12.0	8.0
8.0	7.0	1.0	3.0	2.0	3.0
5.0	3.0	5.0	6.0	3.0	3.0
8.0	6.0	3.0	3.0	3.0	6.0
8.0	6.0	10.0	10.0		
CARYA					
23.0	17.0	17.0	15.0	16.0	18.0
22.0	21.0	17.0	21.0	38.0	18.0
17.0	29.0	18.0	12.0	29.0	10.0
14.0	13.0	16.0	12.0	8.0	18.0
8.0	4.0	6.0	8.0	10.0	2.0
17.0	18.0	3.0	19.0	5.0	1.0
3.0	4.0	2.0	1.0	0.0	1.0
0.0	1.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	1.0
0.0	0.0	0.0	1.0		
CASTANEA					
0.0	1.0	1.0	1.0	2.0	4.0
10.0	9.0	7.0	5.0	4.0	5.0

Appendix G (continued)

4.0	6.0	5.0	10.0	5.0	6.0
11.0	12.0	2.0	4.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
3.0	1.0	0.0	0.0	0.0	0.0
1.0	1.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
CELTMACL					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
2.0	0.0	0.0	0.0	0.0	0.0
2.0	1.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	2.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	2.0	0.0		
CORNFLOR					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
CUPRESSX					
2.0	1.0	0.0	1.0	1.0	2.0
1.0	1.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	2.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	2.0	0.0	0.0
0.0	0.0	0.0	1.0	1.0	0.0
0.0	2.0	1.0	2.0		
FAGUS					
0.0	0.0	0.0	1.0	0.0	0.0
0.0	1.0	1.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	1.0	0.0
1.0	2.0	1.0	0.0	2.0	0.0
4.0	1.0	1.0	2.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
FRAXINUX					
0.0	1.0	2.0	0.0	1.0	1.0
0.0	0.0	0.0	2.0	0.0	3.0
0.0	4.0	9.0	3.0	4.0	2.0
2.0	4.0	0.0	1.0	0.0	0.0
0.0	7.0	2.0	3.0	5.0	4.0
0.0	0.0	2.0	1.0	3.0	1.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	2.0	0.0	2.0	0.0	0.0

Appendix G (continued)

0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0		
FRAXNIGT					
13.0	14.0	11.0	10.0	12.0	16.0
12.0	10.0	8.0	20.0	10.0	22.0
16.0	18.0	29.0	23.0	17.0	22.0
22.0	31.0	13.0	19.0	5.0	10.0
5.0	19.0	19.0	30.0	59.0	64.0
13.0	18.0	40.0	26.0	29.0	26.0
13.0	15.0	12.0	12.0	14.0	13.0
8.0	7.0	8.0	6.0	4.0	2.0
2.0	2.0	0.0	2.0	4.0	2.0
1.0	1.0	1.0	1.0		
FRAXPNAM					
3.0	9.0	4.0	4.0	5.0	7.0
3.0	3.0	2.0	3.0	2.0	11.0
11.0	3.0	5.0	3.0	5.0	6.0
1.0	4.0	3.0	2.0	0.0	1.0
0.0	3.0	2.0	2.0	3.0	1.0
0.0	0.0	2.0	0.0	1.0	2.0
2.0	1.0	2.0	1.0	0.0	2.0
2.0	2.0	1.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	3.0
1.0	0.0	1.0	0.0		
JUGCINER					
0.0	1.0	0.0	2.0	1.0	1.0
0.0	0.0	1.0	2.0	0.0	2.0
1.0	0.0	0.0	0.0	2.0	0.0
0.0	0.0	0.0	1.0	2.0	0.0
1.0	1.0	1.0	0.0	1.0	1.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	2.0	0.0
0.0	0.0	0.0	0.0		
JUGLANSX					
1.0	1.0	1.0	2.0	2.0	1.0
2.0	2.0	3.0	1.0	2.0	1.0
1.0	3.0	1.1	1.1	0.0	0.0
0.0	0.0	0.0	2.0	4.0	0.0
2.0	0.0	1.0	1.0	0.0	1.0
3.0	2.0	0.0	2.0	0.0	1.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
JUGNIGRA					
4.0	3.0	1.0	5.0	3.0	1.0
2.0	2.0	2.0	2.0	1.0	1.0
1.0	1.0	1.0	0.0	0.0	1.0
0.0	0.0	1.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	2.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
LARIX					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0

Appendix G (continued)

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
LIQUIDAM					
14.0	13.0	18.0	14.0	13.0	12.0
10.0	10.0	7.0	9.0	11.0	10.0
9.0	12.0	14.0	17.0	11.0	9.0
5.0	8.0	11.0	3.0	2.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	2.0	1.0	0.0
0.0	2.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0		
LIRIODEN					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	1.0	0.0	1.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
MAGNOLIA					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	2.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
NYSSA					
7.0	4.0	7.0	4.0	3.0	2.0
2.0	6.0	9.0	9.0	9.0	15.0
5.0	1.0	4.0	3.0	6.0	4.0
1.0	2.0	1.0	0.0	2.0	1.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
PICEAX					
1.0	0.0	0.0	2.0	0.0	0.0
2.0	0.0	0.0	2.5	0.0	2.0
1.0	0.0	0.0	0.0	0.0	2.0
1.5	2.0	4.0	18.0	39.0	49.0
86.0	29.0	133.0	118.0	72.0	66.0
36.0	24.0	167.0	18.0	57.0	168.0
148.0	144.0	189.0	175.0	179.0	162.0
160.0	135.0	141.0	124.0	132.0	137.0
170.0	150.0	214.0	164.5	161.0	167.5

Appendix G (continued)

201.0	176.0	65.0	82.0		
PINDIPLX					
24.5	18.0	15.0	12.5	20.0	21.0
10.5	11.0	11.0	13.5	12.0	12.5
9.0	9.0	6.5	0.0	6.5	8.0
1.0	1.0	2.0	11.0	3.0	6.0
4.0	4.5	23.0	11.5	6.0	14.0
14.0	6.0	22.5	5.0	14.5	40.0
62.0	26.0	50.0	71.0	87.0	89.5
102.0	118.0	128.0	127.0	138.0	138.0
98.0	128.0	85.0	122.0	119.0	102.0
77.0	110.0	224.0	189.0		
PINHAPLX					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	1.0	0.0	0.0	1.0
0.0	0.0	0.0	3.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
PLATANUS					
0.0	0.0	1.0	0.0	1.0	2.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
POPULUS					
6.0	2.0	5.0	3.0	3.0	3.0
2.0	3.0	3.0	6.0	2.0	2.0
4.0	4.0	4.0	3.0	2.0	1.0
2.0	1.0	5.0	3.0	1.0	0.0
0.0	1.0	1.0	4.0	1.0	1.0
0.0	1.0	1.0	3.0	0.0	2.0
1.0	5.0	1.0	1.0	1.0	0.0
1.0	0.0	0.0	0.0	0.0	2.0
2.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
PRUNUS					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	2.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	2.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	1.0	1.0	0.0	0.0	2.0
0.0	2.0	0.0	2.0		
QUERCUS					
173.0	198.0	185.0	198.0	192.0	180.0
186.0	190.0	206.0	172.0	192.0	175.0
195.0	208.0	183.0	171.0	176.0	129.0
151.0	149.0	185.0	144.0	153.0	137.0

Appendix G (continued)

119.0	146.0	79.0	94.0	106.0	107.0
162.0	177.0	44.0	169.0	164.0	46.0
45.0	67.0	29.0	22.0	17.0	25.0
21.0	25.0	11.0	20.0	15.0	16.0
11.0	8.0	3.0	7.0	8.0	17.0
9.0	7.0	12.0	16.0		
SALIX					
11.0	15.0	13.0	8.0	10.0	11.0
16.0	17.0	14.0	18.0	10.0	13.0
20.0	10.0	13.0	48.0	40.0	93.0
86.0	62.0	45.0	55.0	2.0	2.0
0.0	0.0	1.0	2.0	5.0	9.0
9.0	2.0	1.0	21.0	6.0	1.0
3.0	10.0	2.0	3.0	6.0	2.0
1.0	5.0	2.0	1.0	1.0	1.0
3.0	0.0	3.0	0.0	1.0	2.0
2.0	0.0	1.0	2.0		
TILIA					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	2.0	1.0	0.0
1.0	1.0	0.0	0.0	0.0	0.0
3.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
TSUGA					
0.0	0.0	1.0	0.0	1.0	1.0
0.0	0.0	0.0	0.0	2.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	1.0	0.0	1.0
0.0	0.0	0.0	1.0	1.0	1.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
ULMUS					
4.0	3.0	6.0	8.0	10.0	11.0
15.0	10.0	6.0	8.0	6.0	3.0
2.0	0.0	4.0	1.0	2.0	2.0
2.0	2.0	3.0	8.0	13.0	8.0
14.0	16.0	17.0	1.0	7.0	5.0
5.0	6.0	1.0	4.0	2.0	3.0
3.0	4.0	1.0	3.0	3.0	1.0
1.0	5.0	2.0	1.0	1.0	1.0
3.0	2.0	0.0	1.0	2.0	0.0
1.0	0.0	1.0	0.0		
ACPENNSY					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		

Appendix G (continued)

AMELSORB

0.0	0.0	0.0	0.0	2.0	4.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0		

ILEX

0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		

VIBTRILO

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0		

ALNCRISP

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	2.0	0.0		

ALNRUGOS

3.0	1.0	1.0	0.0	2.0	2.0
0.0	2.0	4.0	3.0	3.0	1.0
2.0	2.0	1.0	0.0	1.0	0.0
2.0	2.0	1.0	33.0	14.0	12.0
10.0	8.0	10.0	12.0	23.0	20.0
25.0	26.0	8.0	11.0	20.0	12.0
2.0	4.0	3.0	6.0	6.0	9.0
10.0	1.0	9.0	2.0	3.0	3.0
3.0	0.0	1.0	1.0	2.0	2.0
1.0	2.0	1.0			

CEPHALAN

45.0	53.0	43.0	33.0	56.0	76.0
65.0	80.0	99.0	115.0	112.0	123.0
125.0	53.0	68.0	108.0	75.0	39.0
75.0	73.0	55.0	40.0	5.0	4.0
1.0	0.0	5.0	11.0	18.0	3.0

Appendix G (continued)

20.0	33.0	0.0	83.0	60.0	0.0
2.0	13.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
CORYLUS					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	1.0	0.0	2.0
1.0	0.0	1.0	0.0	1.0	1.0
0.0	0.0	0.0	1.0	2.0	2.0
1.0	4.0	2.0	0.0	2.0	4.0
4.0	1.0	0.0	1.0	1.0	2.0
0.0	1.0	3.0	3.0	0.0	5.0
3.0	2.0	1.0	5.0	0.0	2.0
2.0	3.0	0.0	1.0	0.0	1.0
0.0	0.0	1.0	0.0		
ITEAVIRG					
2.0	2.0	1.0	0.0	1.0	3.0
2.0	3.0	5.0	4.0	7.0	6.0
9.0	3.0	2.0	3.0	5.0	6.0
3.0	4.0	3.0	5.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
RUBUS					
2.0	8.0	8.0	4.0	4.0	9.0
14.0	8.0	7.0	11.0	10.0	16.0
16.0	22.0	32.0	22.0	16.0	8.0
9.0	12.0	9.0	1.0	3.0	0.0
0.0	1.0	0.0	1.0	1.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	2.0	1.0	1.0	0.0	0.0
1.0	2.0	2.0	3.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0		
SAMBUCUS					
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	2.0
2.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
SPIREAT					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	1.0	6.0	0.0
2.0	0.0	0.0	0.0	1.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	2.0	0.0	2.0	0.0
0.0	2.0	0.0	1.0	0.0	1.0
4.0	3.0	2.0	5.0	5.0	2.0
8.0	6.0	5.0	1.0	1.0	0.0
2.0	0.0	0.0	2.0	1.0	3.0
0.0	0.0	0.0	0.0		
CARYOPHY					

Appendix G (continued)

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
CHENOAMX					
2.0	1.0	3.0	4.0	3.0	1.0
2.0	2.0	2.0	0.0	2.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	1.0	1.0	0.0	0.0	1.0
0.0	0.0	1.0	1.0	0.0	1.0
2.0	1.0	0.0	1.0	1.0	2.0
2.0	4.0	1.0	1.0	0.0	2.0
1.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0		
AMBROSIT					
97.0	73.0	65.0	73.0	75.0	80.0
65.0	48.0	34.0	7.0	2.0	2.0
5.0	5.0	5.0	11.0	13.0	4.0
1.0	3.0	5.0	7.0	6.0	7.0
6.0	5.0	4.0	6.0	1.0	5.0
5.0	9.0	4.0	3.0	9.0	5.0
4.0	5.0	2.0	4.0	8.0	3.0
2.0	1.0	2.0	1.0	1.0	1.0
3.0	2.0	1.0	3.0	0.0	2.0
3.0	0.0	1.0	2.0		
BIDENSTY					
5.0	1.0	1.0	2.0	3.0	3.0
4.0	3.0	2.0	3.0	7.0	2.0
10.0	2.0	6.0	7.0	8.0	3.0
4.0	2.0	3.0	6.0	10.0	9.0
14.0	15.0	5.0	3.0	7.0	5.0
16.0	6.0	4.0	5.0	1.0	6.0
5.0	6.0	7.0	8.0	6.0	5.0
6.0	7.0	6.0	3.0	0.0	6.0
2.0	1.0	0.0	2.0	1.0	2.0
1.0	5.0	0.0	3.0		
ACHILLEA					
1.0	2.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	3.0	1.0
4.0	2.0	2.0	1.0	1.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	7.0	0.0	0.0	2.0	0.0
0.0	2.0	0.0	1.0	0.0	2.0
1.0	1.0	1.0	2.0	2.0	2.0
3.0	4.0	1.0	0.0	0.0	0.0
1.0	1.0	1.0	1.0	0.0	1.0
0.0	0.0	0.0	1.0		
IVACILIA					
0.0	0.0	1.0	0.0	1.0	1.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0

Appendix G (continued)

0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	0.0	0.0		
IVAXANTT					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	3.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0		
XANTHIUM					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	2.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
LIGULIFL					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0		
0.0	0.0	0.0	0.0		
CYPERACE					
14.0	8.0	10.0	8.0	9.0	11.0
17.0	16.0	16.0	27.0	21.0	20.0
7.0	5.0	13.0	10.0	6.0	5.0
4.0	8.0	20.0	24.0	25.0	21.0
42.0	53.0	20.0	26.0	35.0	29.0
41.0	26.0	67.0	27.0	34.0	62.0
82.0	42.0	79.0	101.0	124.0	114.0
83.0	88.0	86.0	46.0	40.0	66.0
15.0	22.0	19.0	16.0	19.0	15.0
11.0	9.0	5.0	11.0		
OTHGRAMN					
41.0	47.0	36.0	43.0	46.0	46.0
30.0	33.0	35.0	51.0	66.0	36.0
70.0	83.0	51.0	20.0	39.0	13.0
18.0	6.0	7.0	9.0	10.0	5.0
5.0	27.0	15.0	15.0	14.0	10.0
17.0	12.0	14.0	10.0	7.0	25.0
26.0	14.0	23.0	23.0	17.0	36.0
26.0	16.0	23.0	21.0	10.0	24.0
7.0	14.0	10.0	12.0	9.0	12.0
11.0	9.0	5.0	11.0		
PLANTLAN					
4.0	3.0	0.0	2.0	1.0	0.0

Appendix G (continued)

0.0	1.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
PLANTMAJ					
1.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
THALICTR					
1.0	1.0	0.0	2.0	1.0	1.0
0.0	0.0	0.0	2.0	0.0	1.0
0.0	0.0	0.0	1.0	0.0	2.0
0.0	0.0	0.0	1.0	1.0	0.0
0.0	4.0	1.0	1.0	0.0	0.0
0.0	0.0	5.0	3.0	0.0	2.0
2.0	1.0	1.0	4.0	1.0	0.0
3.0	1.0	4.0	4.0	0.0	3.0
0.0	3.0	1.0	2.0	2.0	0.0
0.0	1.0	1.0	0.0		
PLTALOST					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	1.0
3.0	0.0	1.0	1.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
LABIATAE					
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	2.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	1.0	1.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
1.0	1.0	0.0	0.0		
UMBELLIF					
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	1.0	0.0	1.0
0.0	1.0	0.0	0.0	3.0	8.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	1.0	1.0	0.0	2.0	0.0
0.0	0.0	1.0	0.0	1.0	3.0
4.0	0.0	6.0	7.0	3.0	5.0

Appendix G (continued)

5.0	3.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	0.0
0.0	0.0	1.0	0.0		
RUMEX					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
CORNCANT					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
URTICA					
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	0.0	0.0	1.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	1.0	0.0
0.0	0.0	0.0	0.0		
RANCULAX					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
HYPOXISH					
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	1.0	2.0	8.0	8.0
12.0	12.0	20.0	10.0	9.0	13.0
6.0	7.0	1.0	4.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
CANNAHUM					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0

Appendix G (continued)

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
ARTEMISI					
1.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	1.0
0.0	1.0	1.0	2.0	3.0	2.0
0.0	1.0	0.0	0.0	1.0	3.0
1.0	4.0	8.0	6.0	8.0	6.0
2.0	4.0	2.0	4.0	2.0	3.0
1.0	2.0	2.0	1.0	2.0	0.0
5.0	6.0	2.0	1.0		
SANGUICA					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	2.0	0.0	1.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	2.0	0.0	0.0	1.0
2.0	1.0	1.0	2.0	0.0	1.0
0.0	0.0	0.0	1.0	0.0	1.0
0.0	0.0	0.0	0.0		
POTENTIT					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	1.0	1.0
0.0	0.0	1.0	0.0	3.0	0.0
0.0	1.0	1.0	0.0	1.0	1.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
GALIUM					
0.0	0.0	2.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	2.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
MALVACEA					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0

Appendix G (continued)

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
ONAGRACE					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
ZEAMAYS					
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
CIRSCART					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
CALTHAT					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
MENYANTH					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
POLYGHYD					
1.0	0.0	1.0	0.0	0.0	0.0
1.0	1.0	3.0	3.0	5.0	3.0
1.0	11.0	5.0	3.0	2.0	1.0

Appendix G (continued)

1.0	0.0	2.0	0.0	0.0	3.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	2.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
EUPOTAMO					
0.0	1.0	1.0	0.0	0.0	1.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	5.0	0.0	1.0	4.0
0.0	0.0	0.0	1.0	0.0	3.0
0.0	0.0	0.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
SAGITTAR					
2.0	0.0	1.0	3.0	2.0	1.0
0.0	1.0	1.0	0.0	0.0	2.0
1.0	0.0	0.0	1.0	0.0	0.0
2.0	0.0	0.0	0.0	3.0	0.0
2.0	2.0	0.0	2.0	2.0	1.0
0.0	0.0	1.0	1.0	1.0	0.0
11.0	5.0	8.0	6.0	7.0	8.0
2.0	4.0	0.0	0.0	0.0	1.0
0.0	0.0	1.0	0.0	0.0	1.0
1.0	0.0	0.0	0.0		
TYPHALAT					
0.0	0.0	2.0	1.0	2.0	3.0
0.0	0.0	1.0	0.0	4.0	0.0
1.0	0.0	0.0	2.0	0.0	0.0
3.0	0.0	5.0	2.0	0.0	0.0
1.0	0.0	1.0	0.0	0.0	1.0
0.0	2.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
COLEOGET					
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	1.0	4.0	0.0
1.0	1.0	1.0	1.0	0.0	2.0
2.0	0.0	1.0	3.0	0.0	0.0
0.0	1.0	0.0	1.0	0.0	1.0
5.0	0.0	0.0	0.0	2.0	0.0
2.0	0.0	1.0	1.0	2.0	0.0
0.0	2.0	6.0	4.0	3.0	3.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
TYPHANSP					
1.0	0.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	0.0	2.0	0.0
0.0	0.0	0.0	3.0	1.0	0.0
2.0	2.0	3.0	0.0	3.0	1.0
5.0	2.0	4.0	1.0	2.0	0.0
1.0	0.0	0.0	1.0	1.0	0.0
0.0	1.0	0.0	0.0	0.0	1.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0

Appendix G (continued)

0.0	0.0	0.0	0.0		
NUPHAR					
14.0	25.0	8.0	12.0	12.0	12.0
2.0	0.0	0.0	0.0	0.0	1.0
0.0	2.0	2.0	0.0	0.0	1.0
0.0	0.0	1.0	0.0	6.0	16.0
16.0	4.0	1.0	0.0	2.0	1.0
6.0	2.0	0.0	2.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
POLYGAVI					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
TYPHALAS					
0.0	0.0	1.0	2.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	1.0	1.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
SPHAGNUM					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	2.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	1.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	2.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
UTRICULR					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
MYRIOEXA					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	0.0	0.0	0.0	0.0

Appendix G (continued)

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	1.0	2.0	3.0
0.0	1.0	0.0	0.0	2.0	0.0
0.0	0.0	0.0	0.0		
ISOETES					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
POLYGVIV					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	2.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
MYRIOATT					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	1.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	1.0	1.0	2.0	4.0	4.0
0.0	1.0	2.0	2.0		
NYMPHAEA					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
OSMUNCIN					
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	2.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		

Appendix G (continued)

OSMUNREG

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	3.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		

BOTRYCH

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0		

DRYOPTET

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	1.0	1.0	0.0
0.0	0.0	0.0	2.0	0.0	0.0
2.0	1.0	0.0	0.0	1.0	0.0
0.0	1.0	1.0	0.0	0.0	0.0
0.0	1.0	2.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0		

CYSTOPTE

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	1.0
1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0		

POLYPDAC

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		

EQUISETU

0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	1.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0

Appendix G (continued)

0.0 0.0 2.0 0.0 0.0 3.0
0.0 3.0 0.0 3.0 1.0 0.0
1.0 1.0 0.0 3.0 2.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 1.0
LYCOINUN
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 1.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 1.0
LYCOPOD
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 1.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0
LYCOOBSC
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 1.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
1.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0
PTERIDIU
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 1.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 1.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0
LYCOCOMP
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 1.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
0.0 0.0 0.0 0.0 0.0 0.0
INDETERM

Appendix G (continued)

8.0	9.0	12.0	18.0	13.0	11.0
5.0	8.0	6.0	8.0	5.0	3.0
4.0	4.0	3.0	3.0	6.0	2.0
1.0	0.0	2.0	1.0	0.0	2.0
0.0	1.0	0.0	0.0	0.0	1.0
0.0	0.0	1.0	2.0	0.0	0.0
1.0	3.0	0.0	0.0	2.0	1.0
0.0	0.0	1.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	2.0	0.0
0.0	0.0	0.0	1.0		
UNKNOWN					
0.0	1.0	0.0	0.0	0.0	1.0
1.0	1.0	1.0	2.0	2.0	1.0
1.0	1.0	0.0	1.0	0.0	1.0
0.0	0.0	2.0	1.0	0.0	0.0
0.0	2.0	0.0	1.0	0.0	0.0
0.0	2.0	0.0	0.0	0.0	0.0
0.0	2.0	0.0	0.0	1.0	0.0
2.0	2.0	3.0	2.0	0.0	0.0
0.0	0.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0		
EUCANOS					
617.0	777.0	681.0	669.0	172.0	184.0
333.0	210.0	201.0	37.0	48.0	100.0
78.0	37.0	39.0	48.0	31.0	14.0
25.0	18.0	36.0	24.0	49.0	37.0
92.0	31.0	152.0	166.0	248.0	316.0
74.0	111.0	182.0	98.0	144.0	316.0
215.0	260.0	107.0	278.0	250.0	161.0
206.0	142.0	281.0	126.0	336.0	69.0
296.0	148.0	193.0	81.0	173.0	206.0
183.0	168.0	48.0	137.0		

APPENDIX H

MACROFOSSIL TABULATION

Table H-1 Macrofossil Tabulation

Age yr B.P.	Picea needle base	Picea needle tip	Picea needle stertgmata	Picea seed	Picea needle complete	Abies needle complete	Chara oogonia	Ruppia	Potamogeton endocarps	Potamogeton spirillus	Carex comosa	Najas flexilis	Najas gracillima	Bryophyte gem tophytes	Carex lenticular	Myriophyllum farwellii	Scirpus type cespitosus	Rubus	Polygonum type ramosissimum	Braenia schreberi	Polygonum undiff.	Proserpinaca pectinata	Cephalanthus occidentalis	Dulichium arundinaceum	Scirpus type cyperinus	Nuphar	Sagittaria latifolia	Liquidambar styraciflua	Insect frag.	Unidentified
20,400	1		2	1			2	1						1																
19,900				1			48		10		3	26	1	1																9
19,400	1		1				44		2			15	1																	
19,000					1		34		2			17	1																	2
18,700					1		72		1		2	20	1																	1
18,300	1	4				1	76					4	1	3																
17,900		1			1		82		14		1	47	3																	1
17,400	1						75		4		3	27	1		1															
15,900				1			77		7	2		7	16			1														1
15,200							64		11	2		3	20																	1
14,400							63		8	8	3	5	14	16																3
13,700																														
12,800							47		3	56		3	4	1			1													
12,200							120		11	37	2	5	24				1													
11,400							20			3			1					1	1											1
11,100							33		1	2			5																	2
10,800							2		7																					
10,600							2		8											4										
10,300									2											2										
10,100																														
8,800																														
8,000							3																						5	2
7,200																														
5,000																					1	3							2	
4,300																							1						1	
3,500																							1							
2,800																						1	2						7	
700																			1					1	1	1			1	
500																						1	2	4	1	2	1	1	4	
400																		1			1	2	2	9		3			3	2
60																			3				1			4		1	3	

APPENDIX I

PALYNOMORPH INFLUX DATA FOR SELECTED TAXA

Table I-1 Palynomorph Influx Data For Selected Taxa

$gr \cdot cm^{-2} \cdot yr^{-1}$

Depth (cm)	Carya	Quercus	Fraxinus	Ostrya/Carpinus	Picea	Pinus	Salix	Cyperaceae	Gramineae	Ambrosia
95	603	4536	419	262	26	642	288	367	1075	2543
100	354	4122	499	124	0	374	312	166	978	1520
105	404	4395	403	142	0	356	309	237	855	1544
110	363	4788	338	97	48	302	193	193	1040	1765
115	469	5627	527	88	0	586	293	263	1348	2198
120	564	5643	752	94	0	658	345	345	1442	2508
125	1425	12048	971	194	0	680	1036	1101	1943	4210
130	2174	14637	1001	385	0	874	1309	1232	2542	3698
135	1824	22107	1073	429	0	1180	1502	1717	3756	3648
140	840	6881	1000	280	100	540	720	1080	2040	280
145	1172	5922	370	185	0	370	308	648	2036	62
150	355	3457	493	118	39	247	257	395	711	39
155	430	4935	683	76	0	228	506	177	1771	126
160	773	5548	667	27	0	240	267	133	2214	133
165	147	1503	353	33	0	53	107	107	419	41
170	107	1521	258	9	0	0	427	89	178	98
175	299	1817	268	41	0	67	413	62	403	134
180	152	1968	458	107	30	122	1418	76	198	61
185	239	2583	410	51	26	17	1471	68	307	17
190	308	3536	830	142	47	24	1471	189	142	71
195	166	2195	190	95	47	23	534	237	83	59
200	107	1281	205	151	160	98	489	213	80	62
205	68	1307	51	529	25	17	17	213	85	51
210	158	1186	95	597	424	60	17	181	43	61
215	37	552	23	260	399	18	0	194	23	28
220	14	502	100	303	100	16	0	182	93	17
225	70	925	269	164	1557	269	12	234	176	47
227	86	1006	375	235	1263	123	22	279	161	64
230	72	760	480	136	516	43	36	251	100	7
232	11	602	388	107	372	79	51	163	56	28
235	307	2922	234	487	649	252	162	739	307	90
237	289	2838	289	689	385	96	32	417	192	144
240	30	430	430	58	1633	220	10	655	137	39
242	345	3068	490	454	327	91	381	488	181	54
245	113	2027	408	148	704	179	74	420	86	111
247	6	2512	162	45	946	225	6	349	141	28
250	10	279	93	50	918	248	19	509	161	25

Table I-1 (continued)

Depth (cm)	Carya	Quercus	Fraxinus	Ostrya/ Carpinus	Picea	Pinus	Salix	Cyperaceae	Gramineae	Ambrosia type
255	27	458	116	48	985	178	68	287	96	34
260	8	120	58	4	786	208	8	328	96	8
270	5	105	63	14	840	341	14	485	110	19
275	0	24	134	16	1414	687	47	980	134	63
280	8	204	122	24	1325	732	16	932	294	24
310	0	134	64	32	1023	652	6	531	166	13
340	9	232	102	28	1252	1094	46	816	148	9
370	7	77	63	35	991	900	14	604	162	14
400	0	209	84	63	1296	1327	10	481	219	10
430	0	118	39	23	1035	1081	8	314	78	8
460	0	153	19	29	1307	1317	9	630	229	9
490	0	98	18	71	1513	872	27	142	62	26
520	0	132	33	99	2479	1405	0	363	231	33
550	0	76	0	76	5425	2155	76	482	253	25
580	15	106	45	45	2484	1843	0	242	181	45
610	0	113	57	42	2277	1682	14	269	127	0
640	18	303	89	107	2983	1817	36	267	214	35
670	0	180	40	160	4031	1544	40	220	60	40
700	0	153	22	131	3844	2402	0	196	109	0
710	0	306	50	255	1650	5708	25	127	127	25
715	45	714	45	446	3660	8437	89	491	89	89

VITA

Gary Richard Wilkins was born in Fort Hood, Texas on August 27, 1950. He attended California State College in Pennsylvania from 1968 to 1972, receiving a B.A. in Anthropology. In 1972 he began work on a M.A. in Anthropology at the University of Arkansas, Fayetteville. Summer employment with the Archeology Section of the West Virginia Geological Survey in 1974 led to a staff position until 1978, during which his M.A. in Anthropology was completed.

In 1978 he re-entered graduate school in Anthropology at the University of Tennessee, Knoxville. Subsequently he transferred to the Geology Department and began work on a M.S. in Geology.

He was married to Pamela Christian in March 1982 in Memphis, Tennessee.