Journal of the Iowa Academy of Science: JIAS

Volume 97 | Number

Article 14

1990

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Recommended Citation

Baker, R. G.; Chumbley, C. A.; Witinok, P. M.; and Kim, H. K. (1990) "Holocene Vegetational Changes in Eastern Iowa," *Journal of the Iowa Academy of Science: JIAS, 97(4),* 167-177.
Available at: https://scholarworks.uni.edu/jias/vol97/iss4/14

Jour. Iowa Acad. Sci. 97(4):167-177, 1990

Holocene Vegetational Changes in Eastern Iowa[1]

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Pollen and plant macrofossil analysis from three sites along an east-west transect in southeastern Iowa provide evidence for Holocene vegetational development. Colo Marsh at the west end of the transect is relatively complete, with a late-glacial spruce zone ending about 11,500 yr B.P.; a deciduous forest zone from about 11,500 to 8300; a prairie zone from 8300 to 4500, and prairie with oak from 4500 to presettlement times.

Sediments from the site at the Indian Creek Nature Center, midway in the transect, date only from about 6000 to 1600 yrs B.P. This site also was dominantly prairie from 6000 (and probably before) to 4500 yr B.P. Oak and hickory were present from 4500 to 3500, and were joined by more mesic trees from 3500 to 1600 yr B.P.

Mud Creek occupies a very gently sloping drainage basin at the east end of the transect; the site there includes three dated levels ranging in age from about 9300 and 5500 yr B.P. The vegetation during that entire time was apparently mesic deciduous forest with abundant basswood.

Apparently an important vegetational boundary existed in eastern Iowa during early and middle Holocene time. In western and central Iowa prairie was dominant and climate was driest between about 8300 and 4500 yr B.P. At this same time, mesic deciduous forest prevailed in eastern Iowa.

INDEX DESCRIPTORS: Holocene, paleocology, vegetational history, palynology, plant macrofossils, Iowa.

The Holocene vegetational history is poorly known beyond Wisconsinan glacial boundaries. Most vegetational reconstructions in this region are from localities in glaciated areas, where such conventional pollen sites as lakes, marshes and bogs are numerous. Although sites in unglaciated areas are present, they are not abundant and have been seldom explored. Examples of these atypical sites are beaver-pond deposits, oxbow-lake sediments, marshes in abandoned river channels and upland ponds formed by dune sands or blowouts. Sites such as these are often not ideal sites for either pollen or plant macrofossils (Jacobson and Bradshaw, 1981; Janssen, 1966) because 1) Preservation may not be as good as in kettle lakes, 2) records are often of shorter duration, and 3) hiatuses are more common. Nevertheless, these sites often contain valuable records of vegetational history (e.g. Baker et al., 1986).

This paper reports on pollen and plant macrofossil analyses from three sites along an east-west transect in southern Iowa. The transect crosses a diffuse boundary in presettlement vegetation between prairie and mixed oak forest on the east and prairie on the west (Figure 1). Colo Marsh (Colo Bog of Brush, 1967) is a small kettle depression just within the Wisconsinan ice border near Des Moines. The surrounding area is now open farmland with nearby prairie remnants, and it was unforested and presumably prairie in presettlement times (Iowa State Planning Board, 1935). The site at the Indian Creek Nature Center is a small upland depression near Cedar Rapids, Iowa (Figure 1). It may have formed when sand dunes dammed drainages along the Cedar River during late-Wisconsinan time. It is 0.4 km from the Cedar River, is surrounded by dense *Quercus-Ulmus-Tilia* (oak-elm-basswood) forest at present, and apparently was forested in the 1800's (Iowa State Planning Board, 1935). The paleoecology of the Mud Creek area (Figure 1) was first investigated by Kramer (1972), who collected from several exposures along the creek but obtained only one radiocarbon date. The exposure investigated in this paper consists of three superimposed sets of floodplain-pond sediments. The shallow valley at Mud Creek is cut into pre-Illinoian drift. The area is presently open cultivated land and was unforested in the 1800's (Iowa State Planning Board, 1935).

METHODS

Colo Marsh was cored using a modified Livingstone sampler. Cores were wrapped in Saran Wrap and aluminum foil and stored at room temperature. At Indian Creek Nature Center, samples were collected from the upper 70 cm by digging a hole. Below 70 cm the silts were cored using the Livingstone corer. Sediment monoliths from the

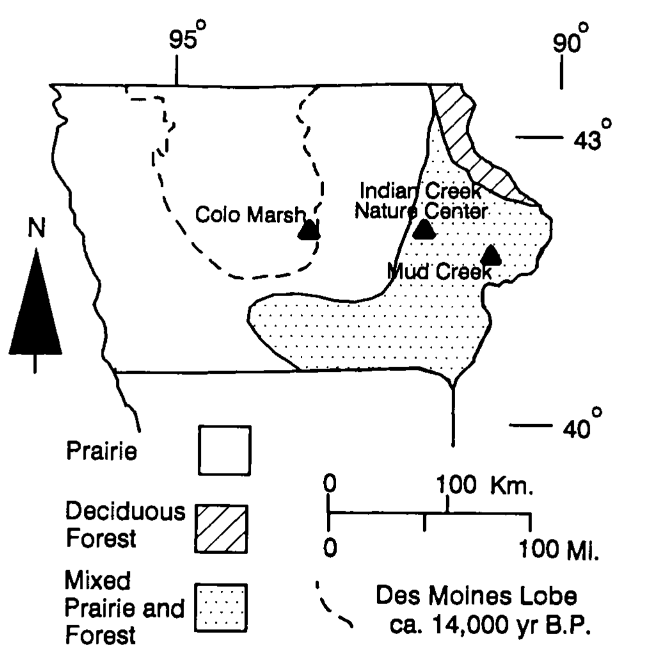

Fig. 1. Map showing locations of sites, late Wisconsinan glacial boundary and presettlement vegetation.

[1]Iowa Quaternary Studies Group Contribution no. 31

Contribution No. 442 from Iowa Lakeside Laboratory

upper 70 cm were placed in zip-lock bags, whereas the cores were wrapped in Saran wrap and aluminum foil. At Mud Creek, monoliths were dug from a cutbank exposure and stored in zip-lock bags.

Pollen samples were processed using techniques modified from Faegri and Iversen (1975). Samples were treated with KOH, HCl, HF, acetolysis solution, and a 2% solution of Clorox, floated in $ZnCl_2$, and screened through a 7 μ sieve. Processed samples were mounted in silicone oil and pollen was identified using the reference collection at the University of Iowa Geology Department. Plant macrofossils were washed through 0.5 and 0.106 mm screens, hand-picked under a dissecting microscope, and stored in glycerin. They were identified using the reference collection in the Department of Geology. Pollen analyses are plotted as percentages (and concentrations at the Indian Creek Nature Center), and the diagrams were zoned using stratigraphically constrained minimum variance cluster analysis (Grimm, 1987). Macrofossils were plotted in numbers of specimens/liter of sediment.

RESULTS

Colo Marsh

Zone 1 at Colo Marsh contains 65-80 percent *Picea* (spruce) pollen. Pollen of *Larix* (larch) also reaches its maximum for the site, and pollen of deciduous trees is sparsely present (Figure 2). A date of 11,570 ± 140 yr B.P. (years before present) (Beta 14236) was obtained near the top of this zone. In zone 2 *Picea* pollen percentages decline and are replaced by successive maxima of *Fraxinus nigra* (black ash), *Abies* (fir), *Betula* (birch), *Ostrya-Carpinus* (ironwood-blue beech), *Quercus*, and *Ulmus* pollen. *Carya* (hickory), *Juglans* (walnut and butternut), *Acer* (maple), and *Tilia* pollen also reach low peaks in this zone. This zone dates between 8300 ± 100 (Beta-14235) and 11,570 yr B.P. Zone 3 is characterized by a sharp decline in all arboreal taxa, and the highest percentages of Chenopodiineae (chenopods; up to 80 percent) in the sequence. Radiocarbon dates of 8300 and 4490 ± 80 yr B.P. bracket this zone. *Quercus* pollen percentages rise in zone 4, Chenopodiineae percentages drop to intermediate levels, *Ambrosia* (ragweed) returns to slightly higher percentages, and Gramineae (grass) and Cyperaceae (sedge) reach their peaks. This zone dates from 4490 yr B.P. to the present.

The pollen zones are superimpsoed on the macrofossil diagram to show how changes on the two diagrams correlate (Figure 3). Except for needles of *Larix*, macrofossils in the lower two zones are of aquatic plants. Those in zone 3 are weedy annual plants (*Chenopodium* [goosefoot] and *Amaranthus* [amaranth] and wet-ground plants (*Scirpus validus* Vahl-type [including *S. acutus* Muhl; bullrush] and *Rumex* [dock]). Aquatic-plant macrofossils again dominate in zone 4, where aquatic diversity is greatest.

Indian Creek Nature Center

Zone 1 is characterized by very high percentages of Chenopodiineae (40-75%) and Gramineae pollen (15-20%), and the lowest pollen concentrations on the diagram (though pollen concentrations are exceedingly high at this site; Figures 4, 5). The sediment representing this zone is highly compact gray silt. Although the base of these sediments was not reached, the zone began at least 5820 ± 80 yr B.P.

Zone 2 is distinguished by a peak in Gramineae pollen percentages (50-60%) and concentrations (up to 6×10^5 grains/cm^3). Total pollen concentration for this zone is over 1×10^6 grains/cm^3. *Quercus* pollen reaches its first peak in concentration, but the large Gramineae peak suppresses oak percentages in zone 2. Sediment in this zone is organic silt, and if we assume constant sedimentation rates, it was deposited between about 4500 and 3500 yr B.P.

Zone 3 is marked by maxima in pollen percentages and concentrations of deciduous trees, (especially *Quercus*). The sediment deposited during this interval is sedge and moss peat. The time represented by this zone is roughly 3500 to 1600 yr B.P., when the wetland was drained by headward erosion of a gully.

Selected plant macrofossils are plotted in Figure 6. Unfortunately, few of these macrofossils represent diagnostic upland plants. The timing of changes in the macrofossils correspond fairly well with those in pollen percentages. Macrofossils in pollen zone 1 are poorly preserved, and therefore other species that probably were present may have left no record of their presence. The remaining taxa include plants of mineral-rich wet soils, such as Alismataceae (water plantain family) and *Penthorum sedoides* L. (ditch stonecrop), and the aquatic alga *Chara* (muskgrass, a green algae).

In pollen zone 2, a suite of shallow-water aquatic and wet ground plant macrofossils is dominant. *Brasenia schreberi* Gmel. (water shield), *Potamogeton* (pondweed) and *Naias gracillima* (A. Br.) Magnus (slender naiad) represent shallow-water aquatic plants. *Scirpus validus*-type, *S. heterochaetus* Chase (slender bullrush), *S. fluviatilis* (Torr.) Gray (river bullrush), *Alisma subcordatum* Raf. (water plantain), *Eleocharis palustris* (L.) R. & S. (spikerush), *Sagittaria latifolia* Willd. (broad-leaved arrowhead) are common wet-ground species. In addition, macrofossils of fen and marsh species such as *Dulichium arundinaceum* (L.) Britt. (three-way sedge), *Menyanthes trifoliata* L. (buckbean) and *Triadenum fraseri* (Spach) G1 (Marsh St. John's-wort) are present and increase towards the top of the zone. A few macrofossils of weedy colonizers (*Amaranthus*, *Oxalis*, [wood-sorrel] *Urtica dioica* L. [nettle], *Monarda fistulosa* L. [wild bergamot] and *Verbena hastata* L. ([vervain] and prairie taxa (*Lobelia spicata* Lam. [spiked lobelia], and *Rudbeckia subtomentosa* Pursh [coneflower] are also present.

In zone 3 the aquatic elements and most of the wet-ground and fen elements disappear, (probably because of poor preservation of macrofossils in this zone), and only *Triadenum fraseri* and *Carex* (sedge) spp. remain abundant. Intervals of *Spagnum* peat occur in this zone; such peatlands are currently rare in Iowa (Conard 1952; Grant and Thorn, 1955; Peck, 1978). Fruits of the forest understory species, *Eupatorium rugosum* Houtt (white snakeroot) appear only at the top of this zone.

Mud Creek

Mud Creek occupies a drainage basin with very gentle slopes. The fossiliferous sediments were exposed in a cutbank, where three separate sets of floodplain-pond fillings are superimposed on one another. These sediments probably accumulated in an oxbow lake or beaver-dam pond. A hiatus is likely between the sediments of each level, so no pollen or macrofossil zones were delimited. Pollen was relatively well preserved in the sandy silts of the lower levels, but poorly preserved in the overlying dark organic silts (Figure 7). The upper silts were considerably above creek level and were more oxidized than the lower silts.

Pollen analyses from three levels show that trees and shrubs have relatively high pollen percentages. *Quercus*, *Ulmus* and *Tilia* pollen each reach about 20% in one of the three levels, with *Tilia* increasing upward to 40%. Nonarboreal pollen is also present, especially Gramineae and *Ambrosia*. Three radiocarbon dates, one from each level, give the times represented by each pollen sample: 5480 ±80, 6820 ± 90, and 9310 ± 90 yrs B.P. (Table 1, Figure 7).

Plant macrofossils at Mud Creek were abundant in the lower sandy silts, but nearly absent in the upper organic silts. Bud sclaes of *Ulmus american* L. (American elm) and fruits of *Tilia americana* L. are relatively abundant as macrofossils, but no macrofossils of *Quercus* were found. Oak is a predominantly upland tree in the Midwest, and is rarely found as a macrofossil. Fruits of *Carpinus caroliniana* Walt. (hornbeam), *Ostrya virginiana* (Mill.) K. Koch (ironwood) and wood of *Juglans* sp. show that other forest trees were present. Shady forest understory plants include *Aralia racemosa* L. (spikenard), *Campanula americana* L. (tall bellflower), *Menispermum canadense* L. (moonseed)

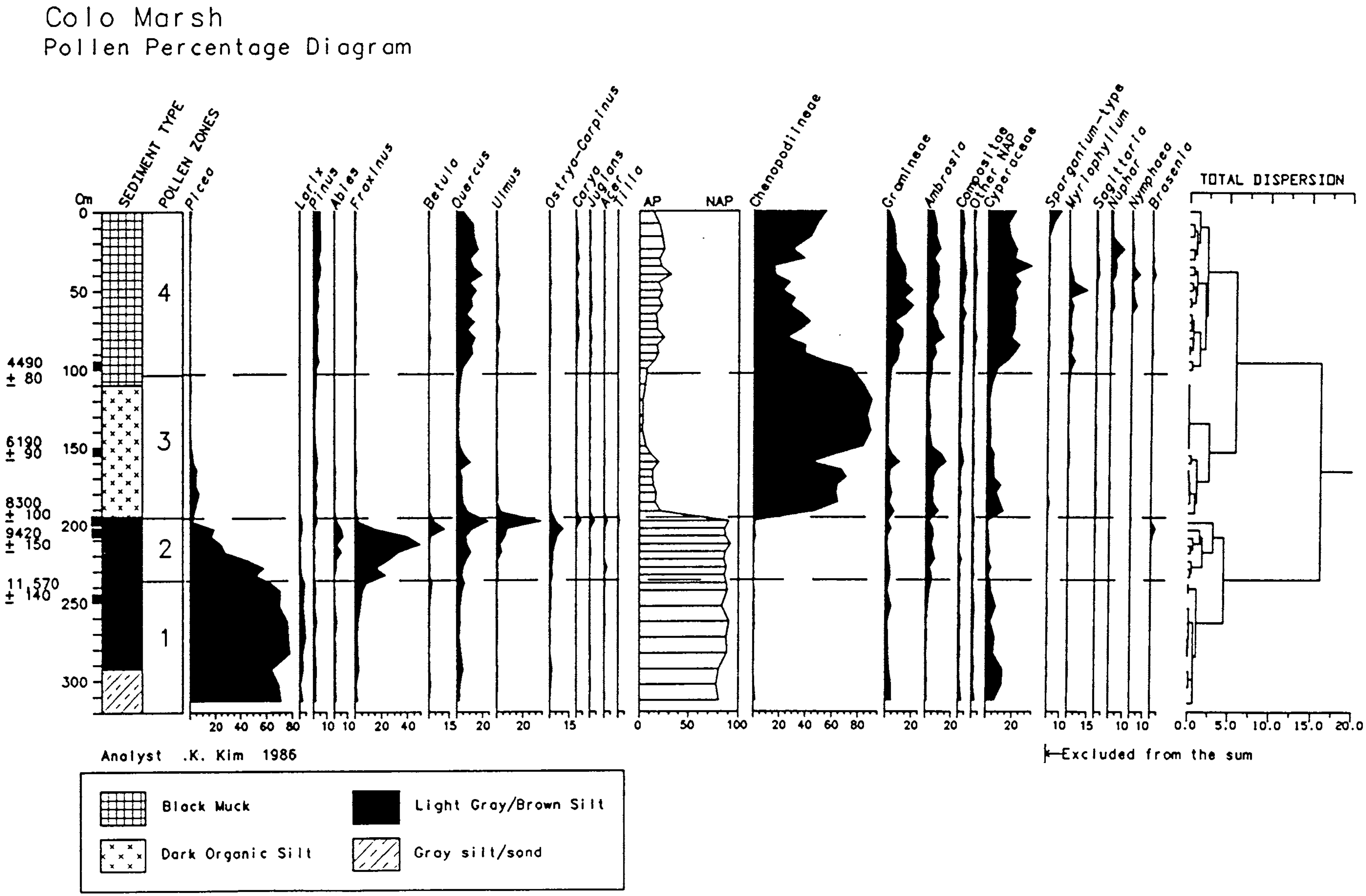

Fig. 2. Pollen percentage diagram from Colo Marsh.

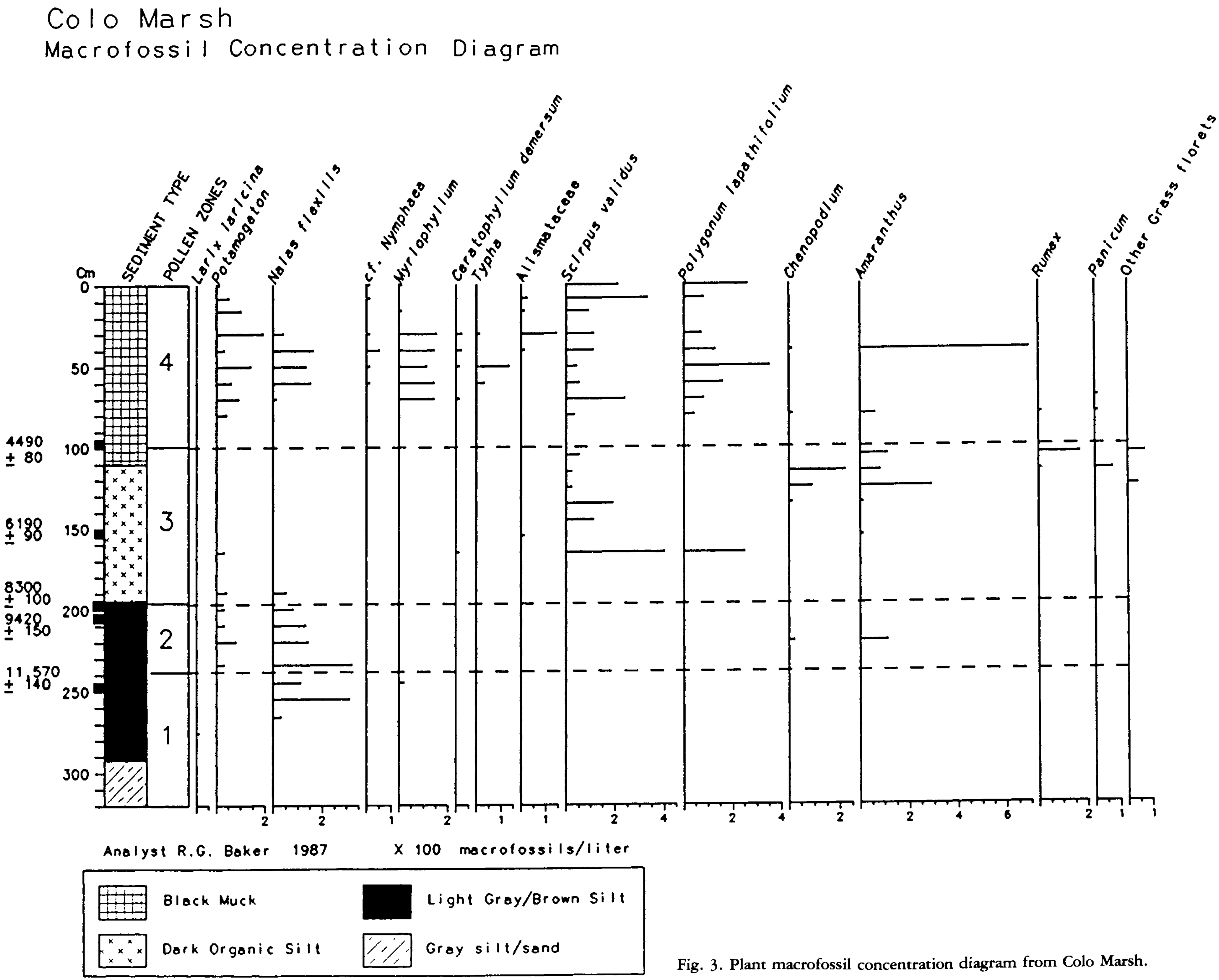

Fig. 3. Plant macrofossil concentration diagram from Colo Marsh.

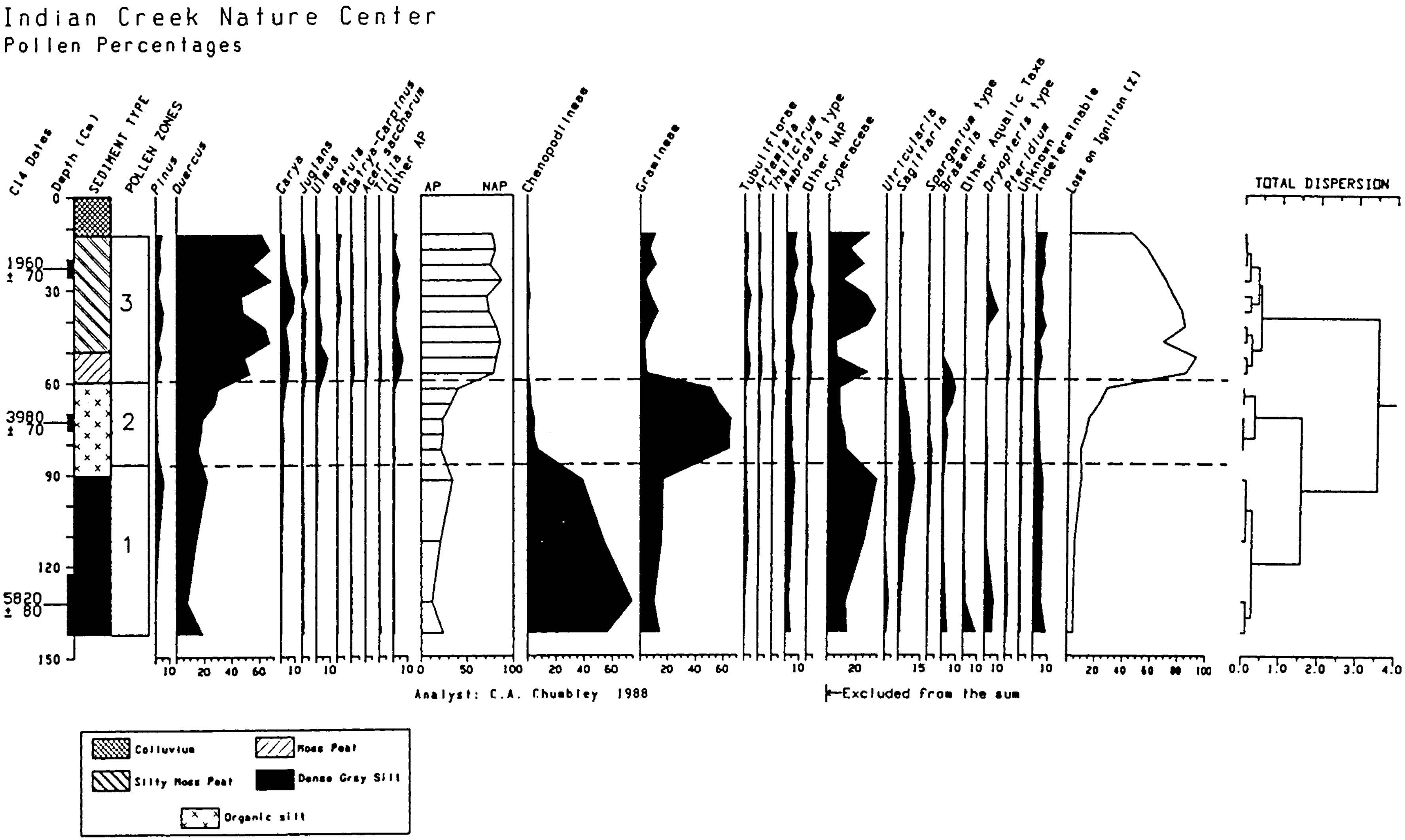

Fig. 4. Pollen percentage diagram from Indian Creek Nature Center.

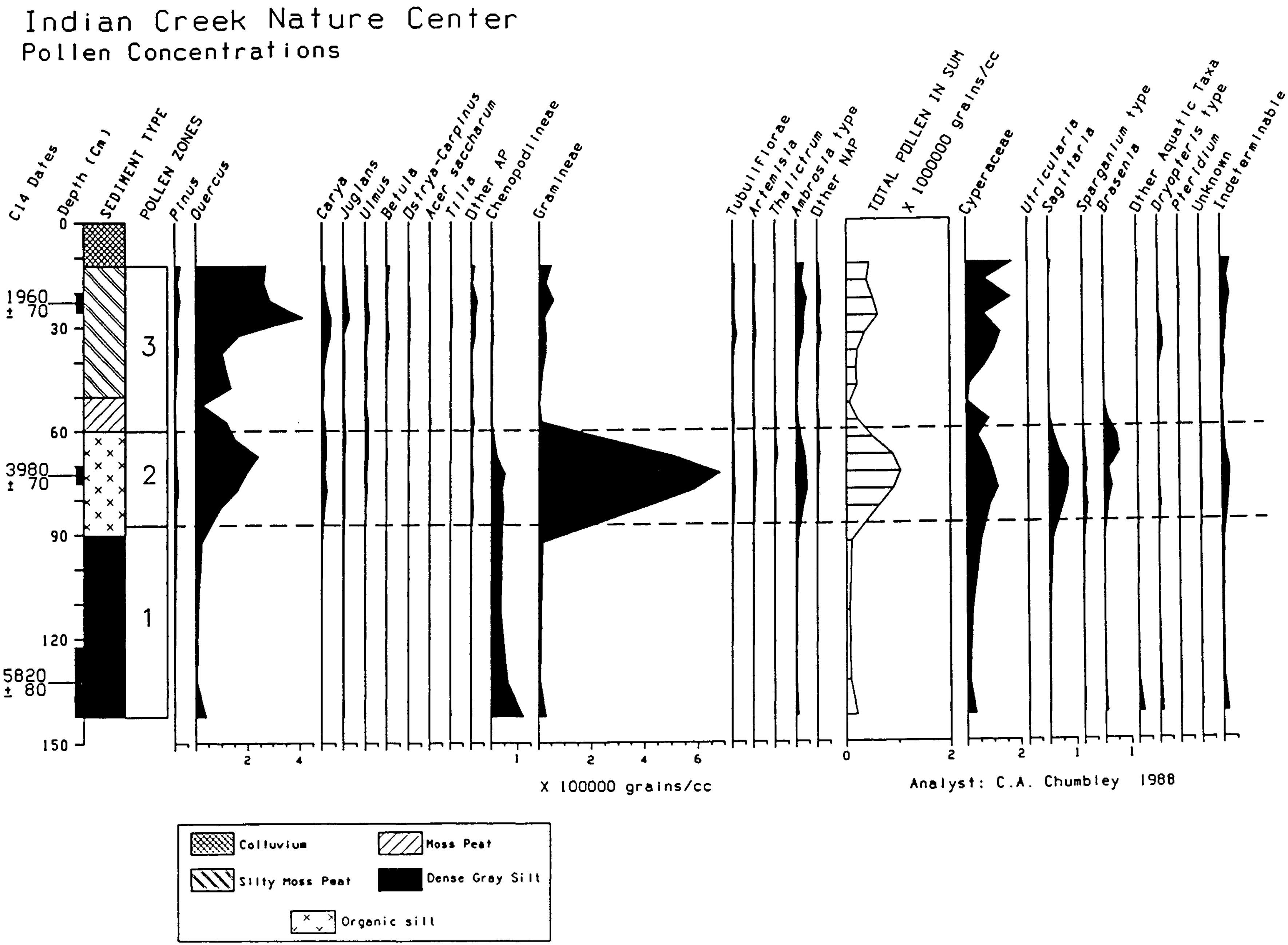

Fig. 5. Pollen concentration diagram from Indian Creek Nature Center.

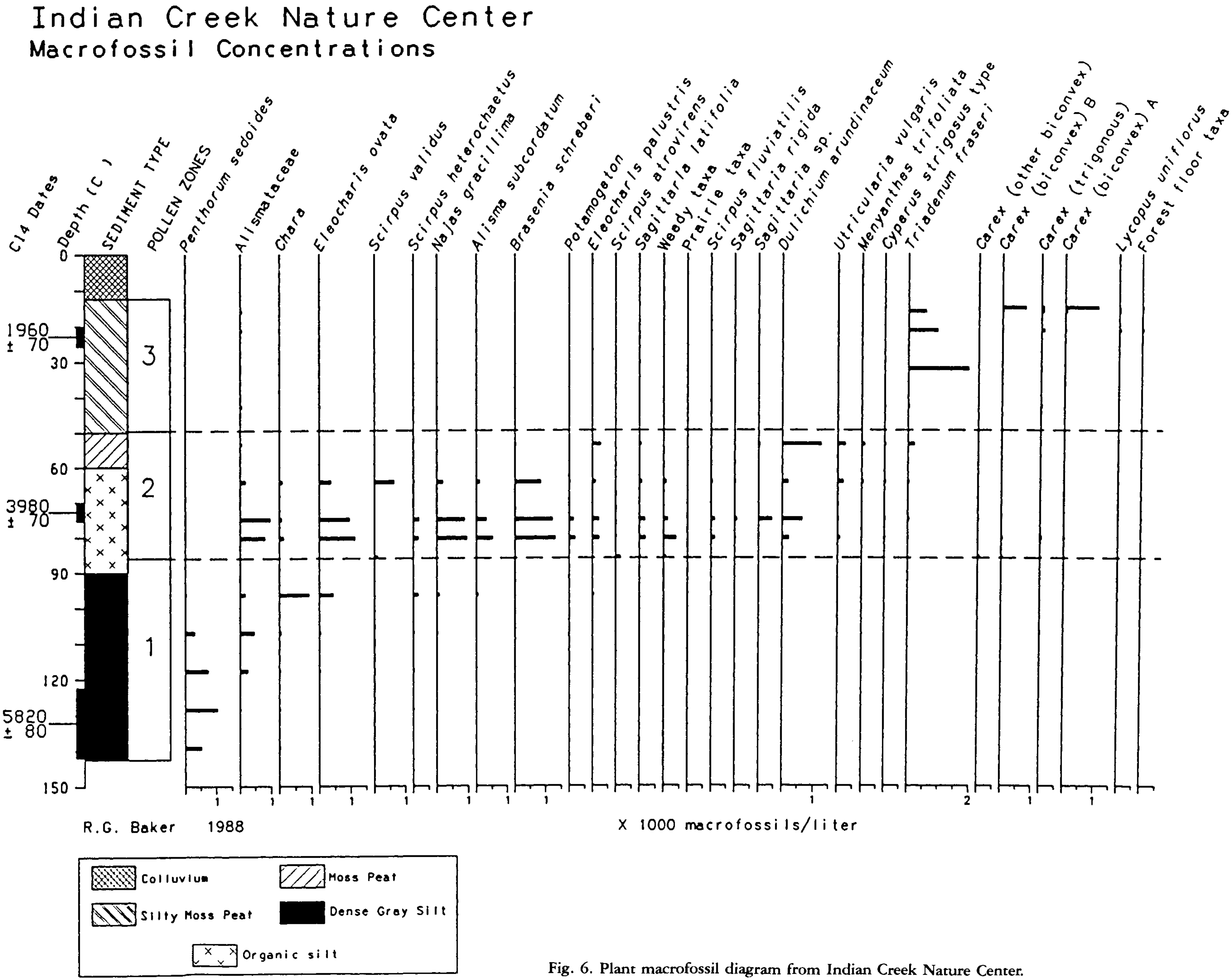

Fig. 6. Plant macrofossil diagram from Indian Creek Nature Center.

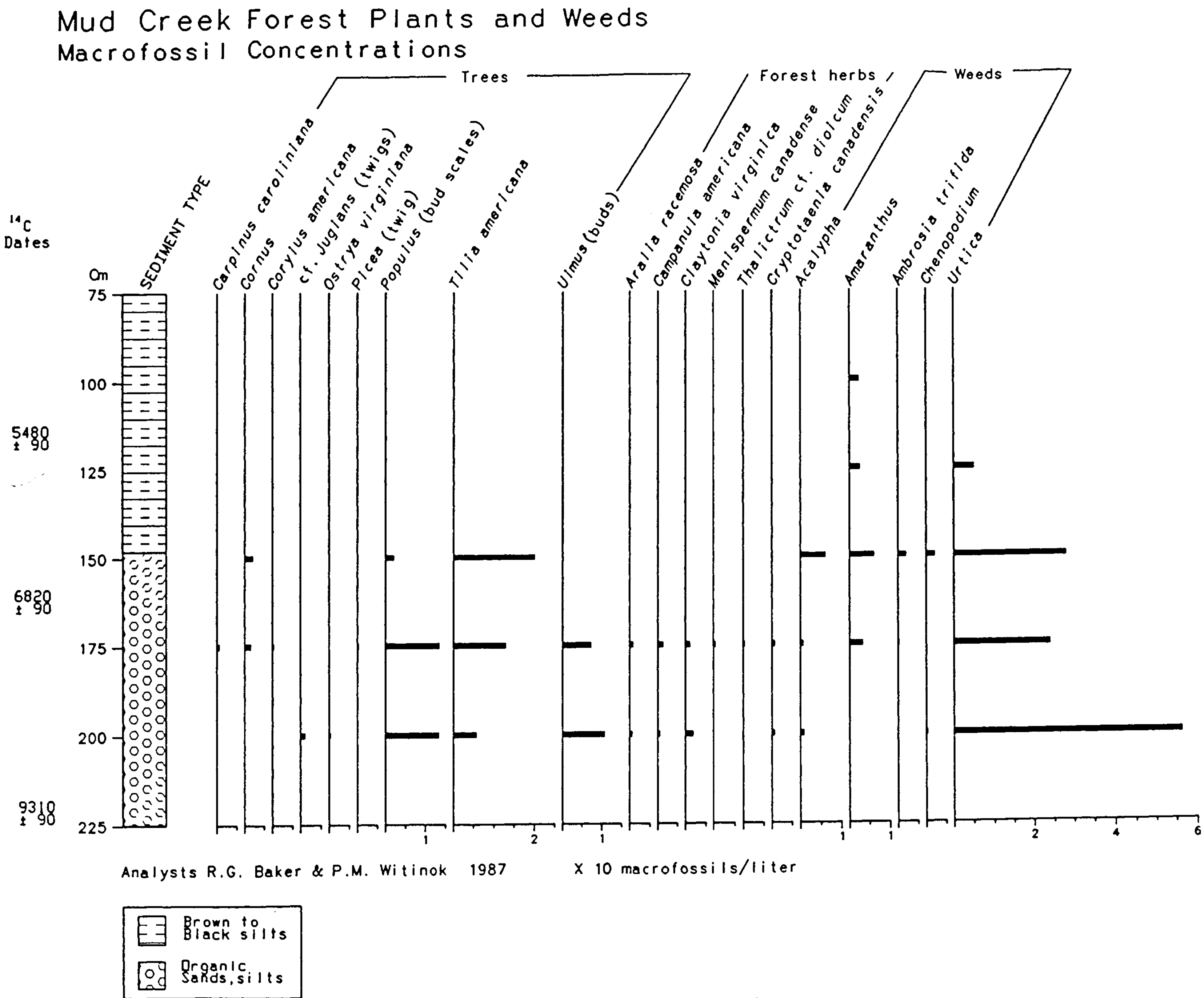

Fig. 8. Plant macrofossil diagram from Mud Creek.

Table 1. Radiocarbon dates from the Colo Marsh, Indian Creek Nature Center and Mud Creek.

DEPTH (CM)	RADIOCARBON YEARS B.P.	LAB NUMBER
Colo Marsh		
95-100	4,490 ± 80	Beta-14233
150-155	6,190 ± 90	Beta-14234
195-200	8,300 ± 100	Beta-14235
202-207	9,420 ± 150	Beta-15007
245-250	11,570 ± 140	Beta-14236
Indian Creek Nature Center		
20-25	1,960 ± 70	Beta-21012
70-75	3,980 ± 70	Beta-21013
123-142	5,820 ± 80	Beta-32478
Mud Creek		
117	5,480 ± 80	Beta-7341
150-175	6,820 ± 90	Beta-25837
223	9,310 ± 90	Beta-7342

and *Thalictrum,* probably *T. dioicum* L. (meadow rue) (Figure 8). Weedy taxa include *Acalypha* (three-seeded mercury), *Amaranthus* (amaranth), *Ambrosia trifida* L. (giant ragweed), *Chenopodium* and *Urtica dioica* Wet-ground taxa are also abundant, especially the sandy silts.

DISCUSSION

Correlation of these sequences is dependent on reliable radiocarbon dates. The dates from Colo and the Indian Creek Nature Center are bulk-sediment dates, whereas those from Mud Creek are wood dates. Bulk-sediment dates are more subject to contamination from pre-Quaternary carbon and from rootlets than wood dates. However, all materials were pre-treated to remove carbonates and rootlets, and all dates correlate well with the closest other sites inthe area. There is no reason to doubt the validity of any of the radiocarbon dates.

The Colo Marsh pollen sequence is comparable with those of other small marshes on the Des Moines Lobe (Durkee, 1971; Kim, 1986). From the time of deglaciation (probably about 13,000 yr B.P.) to about 11,000 yr B.P. a *Picea-Larix* forest was present in the Colo area (Figure 2), and over much of the state (Baker et al., 1980; Chumbley, 1989; Kim, 1986; Van Zant, 1979). A small pond existed during the later stages of this time, and *Naias flexilis* (Willd.) R. & S. (naiad) was the dominant aquatic plant (Figure 3). As climate became warmer in zone 2, *Abies* and a succession of deciduous trees occupied the area between about 11,000 and 8300 yr B.P. *Potamogeton* became established in the pond. About 8300 yr B.P. the forest abruptly disappeared, and prairie elements became established around Colo Marsh. Water levels in the marsh fell, and aquatic plants virtually disappeared. They were replaced by marsh and wetland plants including *Scirpus validus* and/or *S. acutus* and *Polygonum lapathifolium* L. (smartweed), and weedy annual plants such as *Chenopodium* and *Amaranthus* (Figure 3).

Holocene climate was warmest and driest in the Colo Marsh vicinity between about 8300 and 4500 yr B.P., when prairie and weedy elements replaced deciduous forest, and the water levels dropped, converting the pond to a weedy marsh. Subsequently cooler and wetter conditions prevailed, *Quercus* returned to the region, probably in a savanna or along valley walls, and water levels rose to support a rich aquatic flora in the marsh.

This pattern is supported by dated organic layers in an upland drainage basin near Ames, Iowa, where prairie elements were present at 5490 ± 110 yr B.P. (Beta-16616), but forest elements were dominant at 2660 ± 90 (Beta 19099) (Van Nest and Bettis, in press). pollen diagram from a marsh near Jewell, Iowa gives a similar sequence of events (Kim, 1986).

At the Indian Creek Nature Center, the early part of the record was not sampled, but the mid-Holocene warm period was manifest from about 6000 to perhaps 4500 yrs B.P. Prairie or possibly oak savanna was probably the dominant vegetation at the site during this time, and the local water table was low enough that only mineral sediments were deposited and a few wet-ground taxa were present. After about 4500 yr B.P. climate here, as at Colo Marsh, became more humid, oak arrived, deposition of organic sediments began, and the lowland swale was converted to a pond, probably with a marginal fen.

By about 3500 yr B.P. mesic forest became established, with *Quercus, Ulmus, Carya, Juglans* spp., *Ostrya* or *Carpinus, Acer saccharum* Marsh (sugar maple) and *Tilia americana.* These changes probably were caused by a continuation of the trend toward more humid climate. Peat deposition continued, but several fen elements disappeared. These wetland changes may have begun as the head of a gully encroached on the drainage basin. The changes in climate and vegetation are parallel those at Colo Marsh.

At Mud Creek, climate was apparently relatively cool and moist at the three times represented by the pollen and macrofossils. Mesic deciduous forest elements were strongly dominant in both the pollen and plant macrofossils from these deposits. Dense forest existed at 9300, 6800 and 5500 yr B.P., and presumably in between those times. The dominance of *Tilia,* a mesic, fire-intolerant species, suggests that the site was not at the edge of the prairie, where *Quercus macrocarpa* Michx. (bur oak) typically buffered midwestern forests from prairie fires in presettlement times (Chumbley, 1989; Grimm, 1984). A similar sequence from northeastern Iowa (Chmbley, 1989; Chumbley et al., 1990) is much more complete, and supports the timeing of deciduous forest dominance.

Figure 9 illustrates the discrpeancy between the western two sites and Mud Creek. The timing and direction of changes in eastern Iowa contrast sharply with those in central Iowa. When prairie was dominant at Colo Marsh and Indian Creek Nature Center between about 8300 and 4500 yr B.P., mesic deciduous forest prevailed at Mud Creek. Forest elements returned to central Iowa only after about 4500 yr B.P.

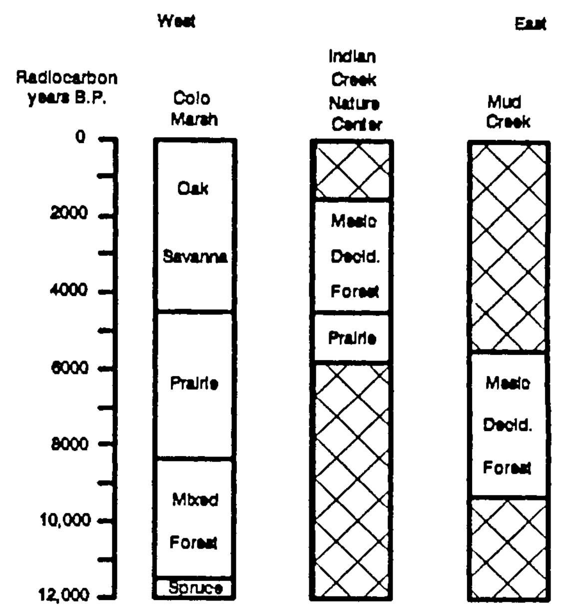

Fig. 9. Comparison of the Holocene vegetation at Colo Marsh, Indian Creek Nature Center and Mud Creek.

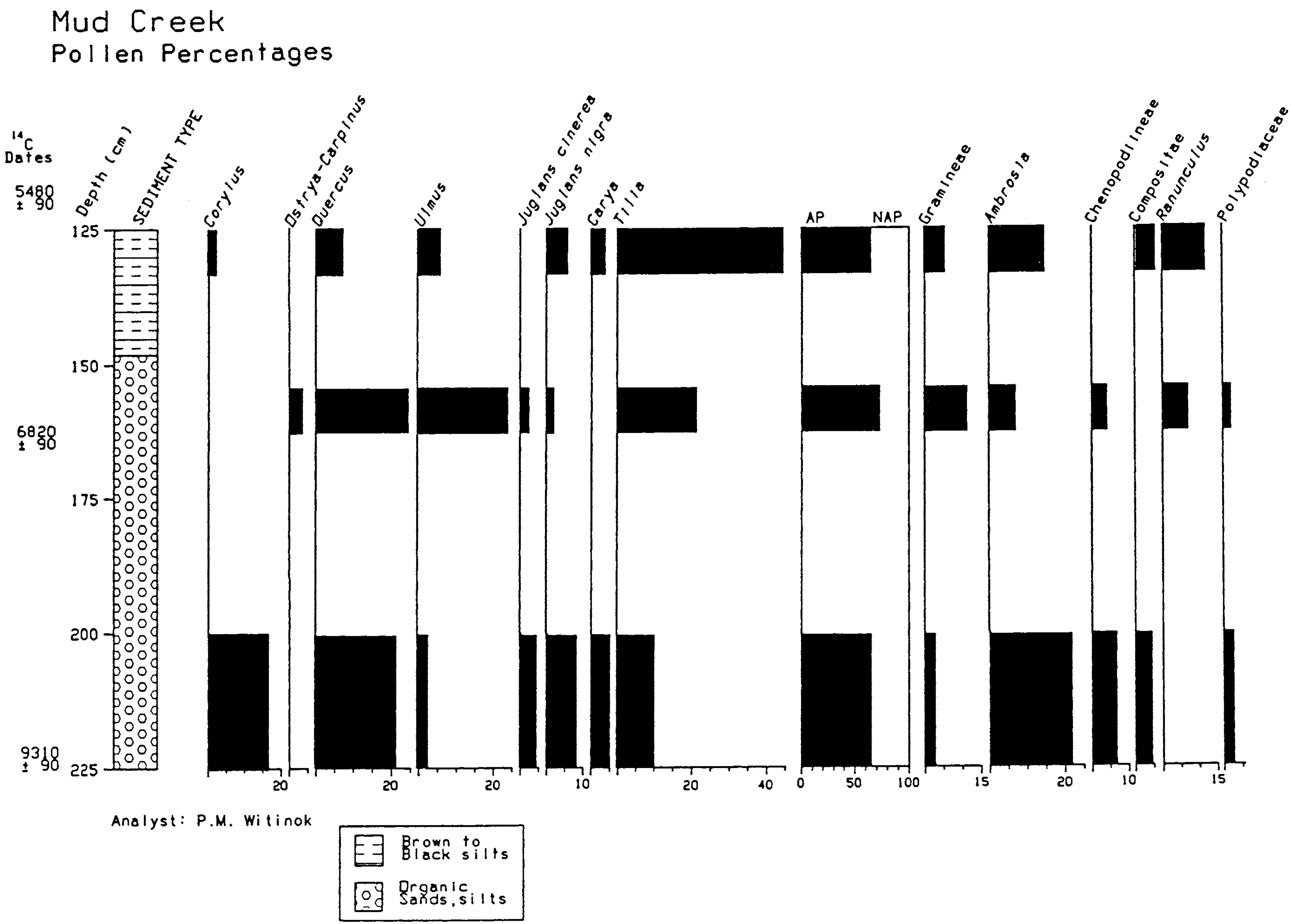

Fig. 7. Pollen percentage diagram from Mud Creek.

Transeau (1935) used the term prairie peninsula for the eastward extension of prairie into Illinois, Indiana and Ohio. This extension was assumed to have occurred during the middle Holocene warm period. Previous work in Minnesota, South Dakota and northwestern Iowa (McAndrews, 1966, Van Zant, 1979; Waddington, 1969; Watts and Bright, 1968; Wright et al., 1963) indicated that prairie incursion began earliest in the west (ca. 10,000 yr B.P.) and latest in eastern Minnesota (about 7000 yr B.P.). Prairies remained in he Dakotas but disappeared earliest in eastern Minnesota (about 5000 yr B.P.). Sites in central and western Iowa follow this trend (Kim, 1986; Van Zant, 1979).

By comparison, sites in Illinois (King, 1981) and Wisconsin (Winkler et al., 1986) show little evidence of prairie invasion, but Webb et al., (1983) map the prairie border farther east into Illinois at 3000 than at 6000 yr B.P. Climate models based on pollen data (Bartlein et al., 1984) also suggest that 1) mid-Holocene precipitation decreases were greatest in the west and almost non-existent in the east, and 2) that mean annual temperatures were slightly cooler 6000 yr B.P. than they are at present in eastern Iowa, southern Wisconsin and Illinois. However, these models of past vegetation and climate are all projected across Iowa, where almost no data were available.

The prairie-forest border is presently coincident with boundary conditions separating predominantly dry Pacific air masses from Arctic airmasses to the northeast and maritime tropical (Guld of Mexico) or atlantic airmasses from the southeast (Bryson, 1966). Past shifts inthese airmass boundaries have been traced using pollen data (Bartlein et al., 1984; Webb and Bryson, 1982). The transect of pollen sites reported here suggests that the Pacific airmasses were dominant in central Iowa in the early and middle Holocene, when Arctic and maritime tropical still prevailed in eastern Iowa. Pacific air masses probably shifted southweard during the middle Holocene, causing an increase in the frequency and severity of drought and a shift from forest to prairie in eastern Iowa. A return to more humid conditions in the late Holocene over all of Iowa suggests that dominance of Pacific air decreased at that time.

ACKNOWLEDGEMENTS

We thank E.A. Bettis III and J. Littke for help in coring the Colo Marsh site, Jeff Nekola for finding and help in sampling the Indian Creek Nature Center Site, and for helpful comments on the manuscript, and L.D. Drake and C.M. Hudak for help in sampling the Mud Creek site. Mr. Rich Patterson, Director of the Indiana Creek Nature Center, gave permission for us to sample on Nature Center property. Reviews by L.J. Maher and E.C. Grimm improved the manuscript. Work on this project was partially supported by NSF Grant ATM-8806482.

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