Published by the Canadian Botanical Association/ Association Botanique du Canada as a supplement to the CBA/ABC Bulletin, Vol. 9, no. 1. January 1976.

FOSSIL HISTORY OF MAN'S IMPACT ON THE CANADIAN FLORA: AN EXAMPLE FROM SOUTHERN ONTARIO

John H. McAndrews,
Department of Botany,
University of Toronto
and
Department of Mineralogy and Geology,
Royal Ontario Museum,
Toronto, Ontario.

In 1941 the late J. Iversen published his famous "landnam" (land settlement) paper describing the fossil record of neolithic farmers in Denmark. In several pollen diagrams from peat deposits he found a relative increase of the pioneering trees Betula, Alnus and Corylus. Pollen of the weeds Plantago and Rumex appeared simultaneously with cereal-type Gramineae pollen. Subsequent more detailed pollen analyses in western Europe show that forest clearance, grazing and cultivation by these early agriculturists is radiocarbon dated to about 3,000 B.C. (Pilcher et al. 1971).

In Canada a good place to study the fossil history of man's impact on the flora is in an area such as southern Ontario (fig. 1) where the original forests have been largely destroyed and replaced by introduced species adapted to agriculture and urban settlement. In addition this is the only area of Canada that supported prehistoric Indian agriculture (Moodie and Kaye 1969). Pollen analyses of sediments of two lakes yield a record of both historic and prehistoric agriculture.

Van Nostrand Lake lies in an ice block depression or kettle hole about 20 miles north of Toronto. It is surrounded by cultivated fields (fig. 2). The pollen diagram (fig. 3) from this lake is zoned largely on tree pollen (McAndrews 1973). The only indication of abundant weed pollen is zone 8 which is dominated by Ambrosia and Gramineae with small amounts of Rumex and Plantago. Zone 8 must represent modern agricultural disturbance because the weed pollen extends to the surface of the accumulating sediment and the plants are abundant in the surrounding fields. Zone 8 also contains abundant Pinus strobus pollen, but Pinus rises in abundance just before Ambrosia and this defines the base of zone 7. Zone 8, the Ambrosia zone, dates from sometime after European contact in the 17th century, but radiocarbon dating is too imprecise for such young, carbonate-rich sediments (McAndrews 1969). Recent reports of lakes depositing annual laminations or varves (Tippett 1964, Ludlam 1969, Craig 1970) led to the discovery of such varves in Crawford Lake where a detailed chronology of pollen zones 6, 7 and 8 was developed.

Crawford Lake lies in a collapse basin in the dolomite bedrock of the Niagara Escarpment about 35 miles west of Toronto. It has a surface area of 2.5 ha and a maximum depth of 24 m. This morphometry accounts for the meromixis of the lake and the consequent oxygen-poor bottom water that excludes sediment-disturbing bottom fauna. Carbonate precipitated during the summer forms white lamina that alternates with black lamina of winter deposited organic matter. The lake is surrounded with farmland and a mixed forest dominated by sugar maple (Acer saccharum), with beech (Fagus grandifolia), birch (Betula papyrifera, B. lutea), oak (Quercus spp.), hemlock (Tsuga canadensis), cedar (Thuja occidentalis), ironwood (Ostrya virginiana) and white pine (Pinus strobus) (fig. 4). Cut pine stumps are common in the forest around the lake and pine stump fences border nearby fields.

Sampling the sediments of Crawford Lake with a piston sampler caused the upper loose varves to mix together and consequently a freezing sampler was adapted (Swain 1973). The freezing sampler ("frigid finger") is a closed pipe filled with dry ice. The pipe is lowered with a rope into the upper meter of sediment and left for 20 minutes before being pulled up. Varved sediment together with the overlying 20 cm of water adhere as a 3 cm thick frozen rind to the outside of the tube. The sediment is slipped from the tube after thawing the inner surface of the rind by pouring hot water into the pipe. The varves were compact downward to less than 1 mm thick. Pollen analyses were done at contiguous intervals of 5, 10 or 25 years. Figure 5 shows a pollen diagram summarizing 125 analyses. The varve count is precise to 1300 A.D. (Boyko 1973) but less certain back to 200 A.D. The diagram contains the pollen zones 6, 7 and 8 of Van Nostrand Lake. Zone 6 represents a forest dominated by maple and beech with lesser amounts of other deciduous trees and cedar and hemlock. In zone 7 Fagus and especially Acer decline and are succeeded at first by Quercus and then by Pinus to form a mixed conifer-deciduous forest. In zone 8 there is a marked decrease in Pinus and a relative increase in Betula, Ulmus and Thuja reflecting the logging of pine, and forest succession by disturbance adapted tree species. Zone 8 is dominated by Ambrosia and Gramineae with small amounts of Rumex, Plantago and other weed pollen. The bottom of zone 8, placed where Ambrosia pollen rises above 1%, is in the interval 1846-1851 A.D. and dates European impact in the area surrounding the lake. This date corresponds with forest clearance immediately around the lake as inferred from colonial patent records (Boyko 1973). Pinus does not show a decrease until the 1870's, a date that corresponds with the operation of a sawmill on the shore of the lake. Pollen of European introduced weeds such as Plantago lanceolata, P. major, Melilotus and Echium vulgare are confined to post-1846 levels, although Rumex acetosella appears as early as 1820. The Gramineae peak dating from 1300 to

1500 A.D. contains several large grains that can only be those of Zea mays. Portulaca oleracea pollen and seeds are also present during this interval. This weed, together with maize pollen, suggests nearby prehistoric Indian maize fields (Byrne and McAndrews 1975).

The maize and Portulaca fossils led to the discovery of an Iroquoian Indian village 150 m north of the lake and subsequent excavation yielded charred maize kernels as well as pottery that indicates a village date of about 1380 A.D. (Finlayson et al. 1973). Because the longevity of the village was perhaps only 20 years, it is probable that the maize, weedy grass and Portulaca pollen came from other fields in the vicinity of Crawford Lake rather than only from the fields of the excavated village. Although Indians practised agriculture in southern Ontario before 1300 A.D. (Wright 1972) there is no pollen record of it in Crawford Lake. Indian agriculture around Crawford Lake involved forest clearance and forest succession on abandoned fields. The Indian agricultural period corresponds with the pollen zone 6-7 transition that is interpreted as a succession from maple and beech to oak and pine. Maple and beech form a slow-growing, stable forest community in contrast to oak, particularly Quercus rubra, and white pine that are fast-growing trees which pioneer succession in forest clearings. Thus zone 7 is interpreted as reflecting forest succession following the impact of Indian agriculture. On the other hand, white pine has its main distribution northward and the succession to pine forest could be interpreted as due to southward migration caused by climatic cooling. However, a little pine charcoal was present in the Crawford Lake archaeological site indicating that pine was present in the vicinity of Crawford Lake before zone 7 and thus the increase of pine pollen was probably not related to southward migration.

One of the striking differences between the European and Indian agricultural periods is the virtual absence of Ambrosia pollen during the Indian period. Calculation of Ambrosia influx during the European period is about 1,000 per square cm per year in contrast to less than 10 per square cm per year for the preceding time even though Indian fields would have been a suitable habitat for ragweed. Ambrosia influx in Minnesota for immediate pre-European time is about 1,500 per square cm per year (Waddington 1969). Ragweed species are adapted to floodplain and prairy communities in Minnesota and adjacent states and seeds occur in mid-Holocene sediments of Kansas (Gruger 1973) and South Dakota (Watts and Bright 1969). No such high pollen values, or seeds, have been reported from Ontario and the occasional occurrence of the pollen can most easily be explained as wind carriage from the west. Bassett and Terasmae (1962) regard ragweed as native to Ontario but its failure to colonize Indian fields indicates that the species dates from 19th century introduction from the west.

In summary, southern Ontario has proved to be ideal for the detailed study of plant fossils related to human impact on the flora. Maize and Portulaca were introduced by prehistoric Indian agriculturists whose forest clearance activities initiated a succession from maple and beech to oak and pine. Our studies also indicate that European forest clearance, agriculture and logging did not make an impact until the mid-19th century and that ragweed was introduced at this time.

REFERENCES CITED

Bassett, I.J. and Terasmae, J. 1962. Ragweeds, Ambrosia species, in Canada and their history in postglacial time. Can. J. Bot. 40: 141-150.

Boyko, M. 1973. European impact on the vegetation around Crawford Lake in southern Ontario. M.Sc. Thesis, Department of Botany, University of Toronto. 115 p.

Byrne, A.R. and McAndrews, J.H. 1975. Pre-Columbian purslane (Portulaca oleracea L.) in the New World. Nature 253: 726-727.

Craig, A.J. 1970. Pollen influx to laminated sediments: a pollen diagram from northeast Minnesota. Ecology 53: 46-57.

Finlayson, W.D., Byrne, A.R. and McAndrews, J.H. 1973. Iroquoian settlement and subsistance patterns near Crawford Lake, Ontario. Bull. Can. Archaeological Assoc. 5: 134-136.

Gruger, J. 1973. Studies on the late Quaternary vegetation history of northeastern Kansas. Geol. Soc. Amer. Bull. 84: 239-250.

Iversen, J. 1941. Land occupation in Denmark's stone age. Danmarks Geol. Unders. 2 Rk. Nr. 66, 68 p.

Ludlam, S.D. 1969. Fayetteville Green Lake, New York. III. The laminated sediments. Limnol. Oceanog. 14: 848-857.

McAndrews, J.H. 1973. Pollen analysis of the sediments of the Great Lakes of North America. In Holocene Palynology and Marine Palynology; Proc. III Internat. Palynol. Congr., Moskow: Acad. Sci. USSR. pp. 76-80.

______________. 1969. Paleobotany of a wild rice lake in Minnesota. Can. J. Bot. 47: 1671-1679.

Moodie, D.W. and Kaye, B. 1969. The northern limit of Indian agriculture in North America. Geogr. Rev. 59: 513-529.

Pilcher, J.R., Smith, A.G., Pearson, G.W. and Crowder, A. 1971. Land clearance in the Irish neolithic: new evidence and interpretation. Science 172: 560-562.

Rowe, J. 1972. Forest regions of Canada. Dept. Environment, Can. Forestry Serv. Publ. No. 1300. 172 p.

Swain, A.M. 1973. A history of fire and vegetation in northwestern Minnesota as recorded in lake sediments. Quaternary Res. 3: 383-396.

Tippett, R. 1964. An investigation into the nature of the layering of deep-water sediments in two eastern Ontario lakes. Can. J. Bot. 42: 1693-1709.

Waddington, J.C.B. 1969. A stratigraphic record of the pollen influx to a lake in the Big Woods of Minnesota. Geol. Soc. Amer. Spec. Paper 123. 263-282.

Watts, W.A. and Bright, R.C. 1968. Pollen, seed and mollusk analysis of a sediment core from Pickeral Lake, northeastern South Dakota. Geol. Soc. Amer. Bull. 79: 855-876.

Wright, J.V. 1972. Ontario prehistory. National Mus. Canada. 120 p.

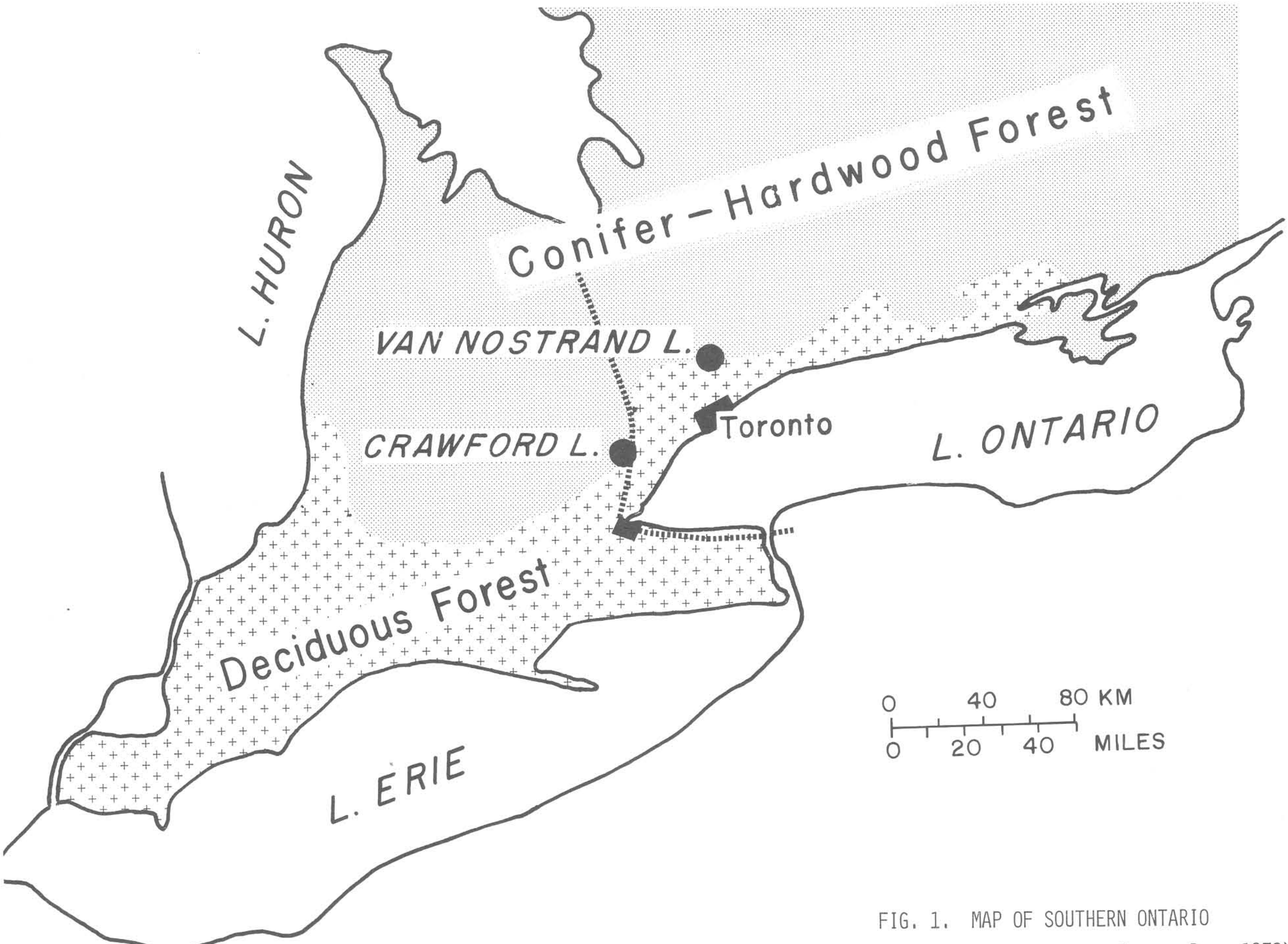

FIG. 1. MAP OF SOUTHERN ONTARIO

SHOWING NATURAL FOREST REGIONS (AFTER ROWE 1972)
THE DASHED LINE IS THE NIAGARA ESCARPMENT.

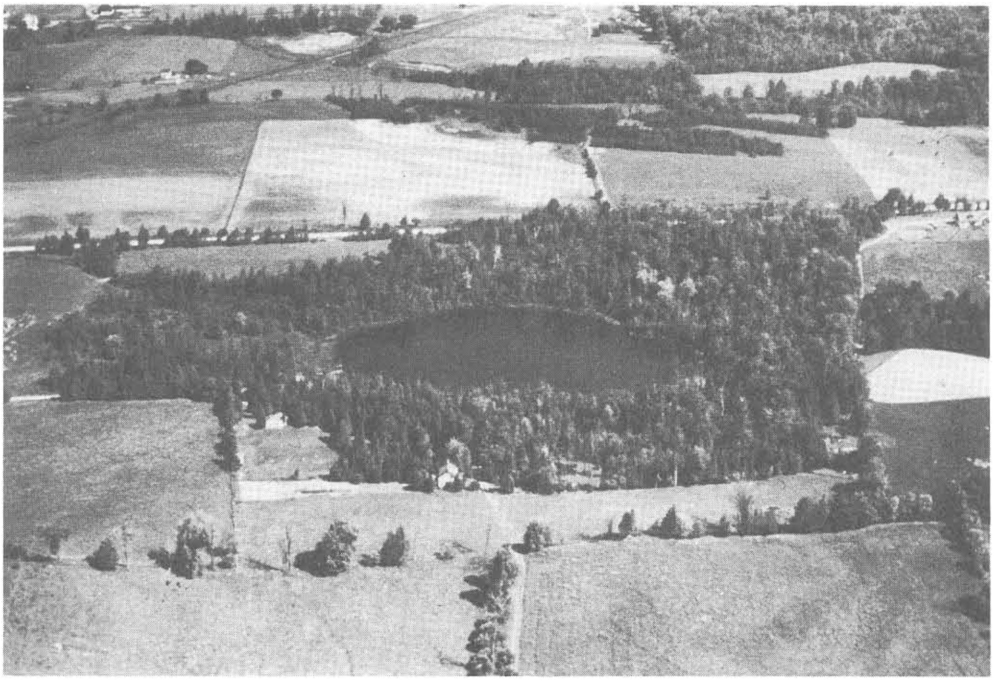

FIG. 2. AERIAL VIEW OF VAN NOSTRAND LAKE
TAKEN IN 1969.

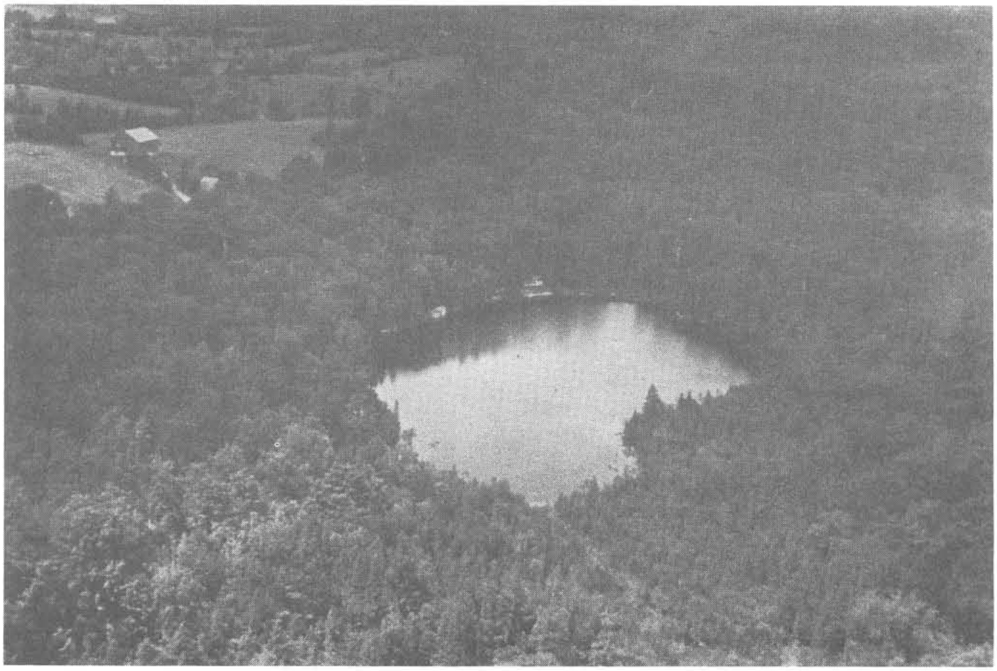

FIG. 4. AERIAL VIEW OF CRAWFORD LAKE
TAKEN IN 1972. THE FARM BUILDING IN THE UPPER LEFT IS ON THE SITE OF THE 14TH CENTURY INDIAN VILLAGE.

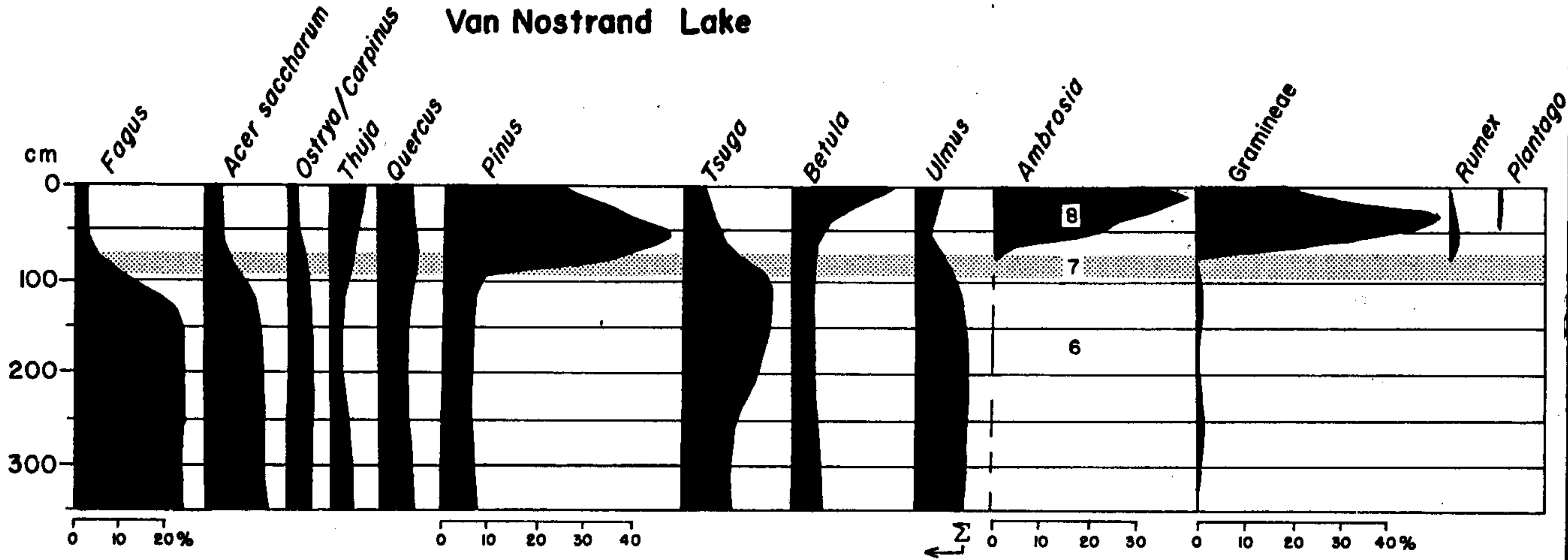

FIG. 3. POLLEN DIAGRAM FROM VAN NOSTRAND LAKE

ONLY THE MORE IMPORTANT TAXA ARE SHOWN. THE POLLEN SUM USED FOR PERCENTAGE CALCULATION INCLUDES ONLY POLLEN OF WOODY PLANTS. ZONE 8 IS THE PERIOD OF EUROPEAN SETTLEMENT.

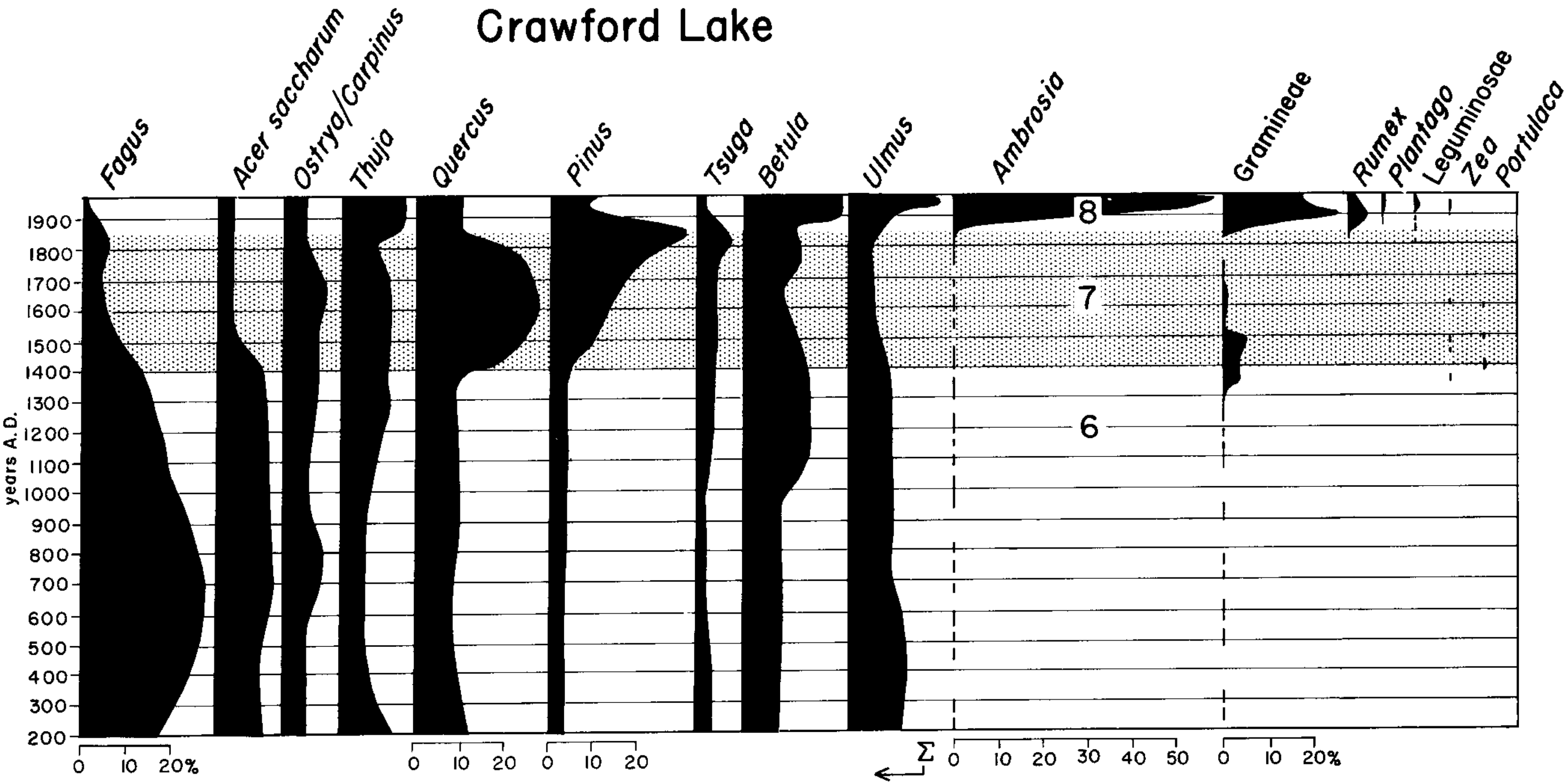

FIG. 5. POLLEN DIAGRAM FROM CRAWFORD LAKE

DRAWN IN THE SAME FORMAT AS THAT OF VAN NOSTRAND LAKE EXCEPT THAT THE VERTICAL AXIS REPRESENTING 83 CM. OF SEDIMENT IS GIVEN IN YEARS A.D.