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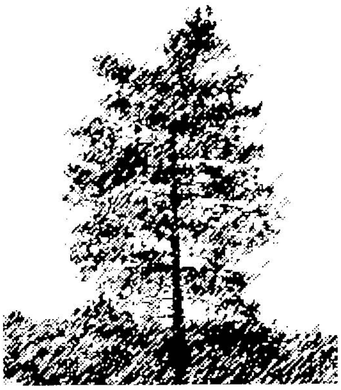


Chapter 3

The Ice Retreats and Michigan's Forests Return

THE FORESTS THAT COVER present-day Michigan (chapter 1) were born principally from fire. In contrast, the original forests of the state, which date back nearly 13,000 years, were given birth by ice. These two very different natural phenomena—wildfire and glacial ice—are both awesomely destructive natural disturbances. Yet when they have had their day and subside both leave behind a landscape that is ripe for biological renewal. In the case of glacial ice, this renewal process—primary succession—is very slow in developing because it occurs on a virgin, sterile spoil. Secondary succession following wildfire is different. Fire does not obliterate life but only temporarily suspends it, so the renewal usually occurs very quickly. In chapter 7 we describe the nineteenth- and early-twentieth-century purging of the state by fire and the consequences of that holocaust; chapters 8 and 9 describe the postfire recovery. In this chapter we look much farther back to depict the events that followed the demise of the last great Ice Age, which set the stage for the establishment of forests on the newly exposed Michigan peninsulas.

What would life be like under a sheet of ice half a mile thick? In fact, there would be no life except for the few microbes adapted to exist in an environment that is inhospitable in the extreme. Yet 18,000 years before present (B.P.) the place we now call Michigan was in exactly that condition—a sterile wasteland buried under a thick, frozen mantle. The soils that support Michigan's present-day forests were still rocks being scoured and ground to a fine grain by the force of this slowly moving, icy behemoth. The land itself, crushed under the awesome weight of the glacier, was flattened and depressed, like a mattress deformed under a large, sleeping body. On the glacier's surface few sounds of birds, animals, or life of any kind could be heard over the relentless howling of the arctic wind. The continental glaciers of Antarctica are a modern-day equivalent of this scene, but 18 millennia ago in Michigan there were no penguins to provide comic relief.

That frigid landscape represented the last stand of the Pleistocene Epoch, an age of ice that may have lasted for 2 million years. The Pleistocene was perhaps the greatest cold spell the earth has ever known; at its zenith fully one-third of the land surface of the globe was covered with glacial ice (Dorr and Eschman 1970). The Wisconsin glacier, a lobe of the vast Laurentide ice cap that extended over most of Canada and the northern regions of the United States, was the last of the Pleistocene ice mantles that completely covered Michigan. At its culmination the Wisconsin glacier reached as far south as southern Indiana and Ohio (see fig. 1.4). About 15,000 B.P. the climate began to warm and the glacier slowly retreated northward as the ice melted. The highlands of the central part of the Lower Peninsula were exposed first because the ice was thinner there. But the great glacier did not yield willingly; periods of retreat were followed by temporary advances driven by climatic cooling and heavy snowfalls. For example, the Port Huron Moraine (see Port Huron Border, fig. 1.4) was deposited about 13,000 B.P. by a minor glacial advance back into the ice-free Lower Peninsula. This moraine is one of the most prominent geologic features of the state (Wayne and Zumberge 1965). About 1,150 years later the whole Lower Peninsula was again free of ice; but subsequent glacial surges—the Valders advance—once again covered the northern part of it (Dorr and Eschman 1970). Accompanying these alternating retreats and advances of the glacier were major fluctuations in the levels of the glacial Great Lakes.

The gradually warming climate was an overpowering force, and the glacier could not long hold the ground it had regained. All of Michigan finally broke free of the bondage of the Wisconsin glacier about 10,000 years B.P., although at that time most of eastern Canada was still covered with ice. Geologists have acknowledged this liberation from millions of years of ice as the beginning of a whole new geologic age—the Holocene Epoch, the one in which we live. The Pleistocene-Holocene transition was one of the monumental events in the history of the earth. It also marked the beginning of a remarkable biological renewal in our state.

Although the land left in the wake of the Pleistocene's glacial mauling was raw and barren, it harbored a remarkable potential to support life. The deposits of glacial till described in chapter 1—moraines, drumlins, kames, eskers, till plains, outwash plains—and the lacustrine muck left behind by receding meltwater lakes were in reality crude, undeveloped soils. As such, they only awaited the arrival of something that would grow in them. It did not take long. Windborne seeds and spores quickly began to fall on the virgin earth. When these pioneering plant propagules germinated and their fresh sprouts took a tentative hold on the new land, the stage was set for the eventual establishment of a new forest. Plants provide food and cover, so the green immigrants attracted creatures large and small, which began to explore the newly exposed landscape. Among these creatures were Michigan's first human settlers, who braved the harsh postglacial environment in search of new territory. But before we go any further with this history, a review of the scientific methods used to reconstruct Michigan's postglacial forest renewal is necessary.

The Science of Paleoecology

Can there be any hope of success in a scientific quest to deduce forest conditions thousands of years ago? A paleoecologist—one who studies the dynamics of ancient plant and animal communities—would answer this question with a cautious yes. Clues do exist all around us that, if interpreted carefully, enable paleoecologists to construct an image of conditions during a time long past. True, the images are often crude in construction and not sharply focused, but this is only because the clues are so fragmentary and difficult to interpret.

The most abundant clue to the ecological past is the fossil. Fossils are of two kinds. Macrofossils are the hard parts of organisms that persist long enough to become fossilized—bones, teeth, shells, and the exoskeletons of insects, for example. Many macrofossils exist only as fragments, although occasionally the complete skeleton of an organism is found. Plant parts such as leaves, twigs, wood, and seeds also can become fossilized. Together, macrofossils can provide a compelling—if incomplete—picture of the life forms that existed in an ancient period. Much more common are microfossils, so-called because they must be viewed under a microscope. Microfossils consist of pollen, spores, and the remains of microorganisms such as diatoms or foraminifera. Our knowledge of the ancient history of forests is based almost entirely on the study of fossil pollen and spores, a branch of science known as palynology (Pielou 1991).

Besides its pervasiveness and longevity, pollen is valuable for paleoecological studies because most plants produce a recognizable pollen grain (fig. 3.1). If you know what to look for, pine, tamarack, maple, ragweed, and grass pollen, for example, can be easily distinguished from one another. Unfortunately, the resolution of pollen usually is insufficient to identify individual species within a genus. Fossilized pollen grains can be identified as coming from a pine, for example, but whether the species was a red pine or a jack pine cannot be reliably ascertained.

The prime location for ancient pollen prospecting is a lake, bog, or wet depression. Each year pollen rains down on the surface of these wetlands and then sinks to the bottom, where it becomes part of an accumulating sediment. In an average year as many as 40,000 pollen grains may settle on each square inch of lake bottom in a forested area. In cold, open tundras, however, the amount of pollen rain is much less (Pielou 1991). Some of the pollen decays, but much of it persists. By taking cores from the sediment that has accumulated in a lake or bog and systematically isolating the pollen from it, a palynologist can roughly reconstruct the vegetation of the surrounding area. Depending on the depth of the sediment cores, these reconstructions can span a period from several decades to thousands of years. If the core goes all the way to bedrock or the underlying gla-

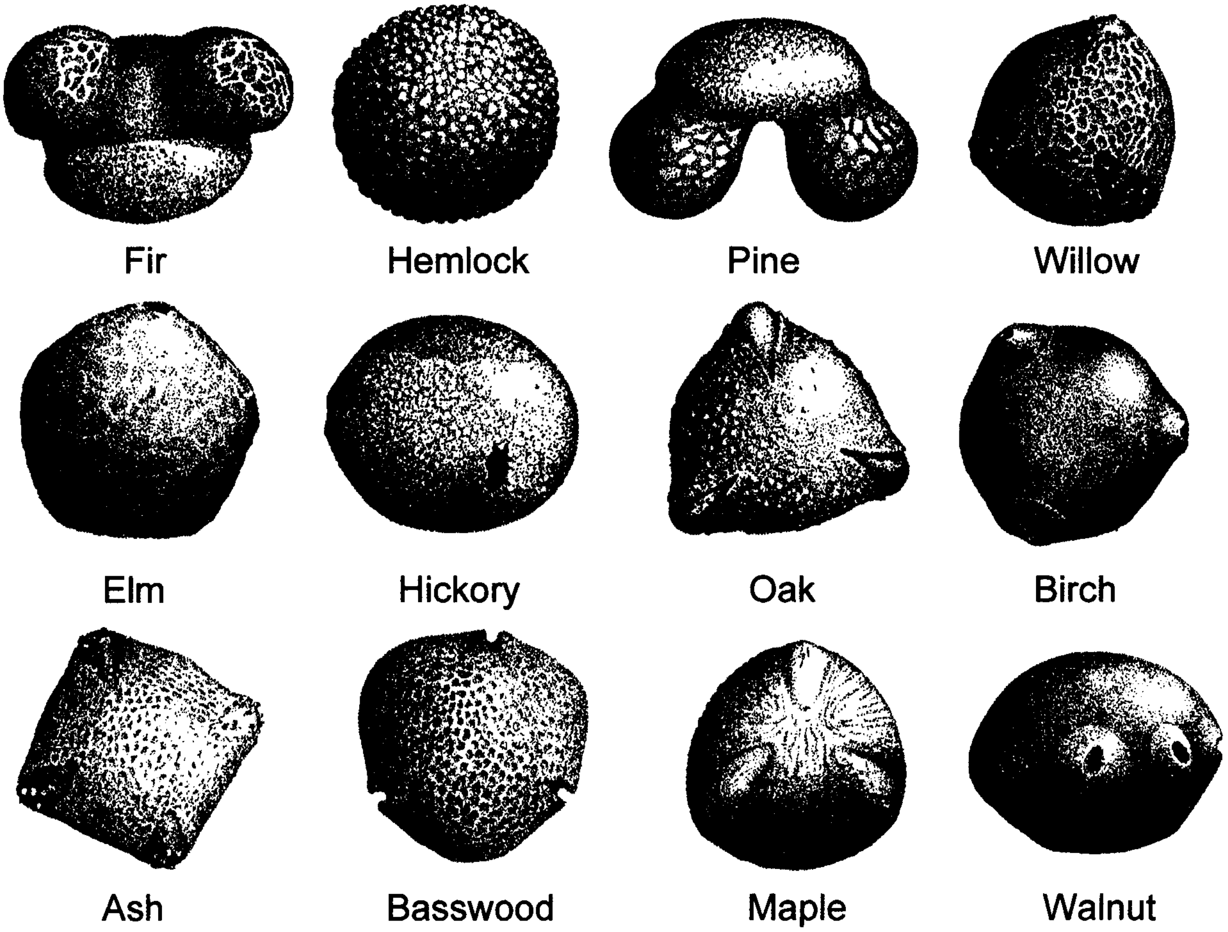


Fig. 3.1. Pollen grains of several Michigan tree genera, each one having a distinct, recognizable form. (Redrawn from Wodehouse 1935.)

cial deposit, a potential exists for reconstructing the entire Holocene vegetation record for an area. The Wisconsin glacier left behind many lakes and ponds in Michigan in the wake of its retreat, many of which have filled and become bogs or wetlands, so many opportunities for reading the pollen record exist.

Unlike tree rings, the yearly sediment deposits in a wetland are not clearly distinguishable, so a palynologist cannot simply count layers backward. Therefore, a method for dating the different depths in a core must be used. Sediment layers are commonly analyzed for their content of a naturally occurring radioactive isotope of carbon (^{14}C). This isotope decays at a known rate; half of a quantity of ^{14}C will decay to nonradioactive ^{12}C in 5,730 years. So based on the amount of radioactive carbon in living pollen grains compared to that of pollen grains long dead, the date of death of those ancient pollen grains can be estimated, sometimes within a few hundred years. Like sediment analysis, this technique has serious pitfalls. But if these pitfalls are understood accurate dating of fossils can be achieved, especially using the latest technology for ^{14}C detection. One of the ways in which ^{14}C dating has been verified is by using it to estimate the age of wood in the core of very old trees and timbers. A few of the bristlecone pines growing at timberline in the eastern Sierra Nevada in California, for example, are nearly 5,000 years old based on tree ring counts. The age of the ancient core wood of these trees has been accurately cross-checked using ^{14}C analysis (Pielou 1991).

The result of a sediment core analysis is a pollen diagram. These diagrams portray pollen of a particular species or plant group in a layer of sediment as a percentage of total pollen in that layer (fig. 3.2) or less commonly as pollen influx (grains per square centimeter per year). These diagrams provide an intriguing picture of the dynamics of vegetation in an area over the course of thousands of years. The reading and interpretation of these diagrams is not straightforward, however; great care must be taken to avoid drawing erroneous conclusions. E. C. Pielou (1991) discussed the major problems of pollen diagram interpretation in her book *After the Ice Age,* and we summarize them below.

- Not all pollen extracted from sediment cores can be accurately identified. For example, the pollen of junipers and that of white cedar are indistinguishable. Species in the same genus (pines, spruces, birches, maples, etc.) often produce very similar pollen. Fortunately, fossil leaves, cones, or seeds, which often are found in sediment cores, can corroborate pollen evidence and aid in species identification (Davis 1981).
- The rain of pollen does not accurately reflect the relative abundance of vegetation that produced it. Some plants produce more pollen than others, so the deck is stacked in their favor. Wind-pollinated

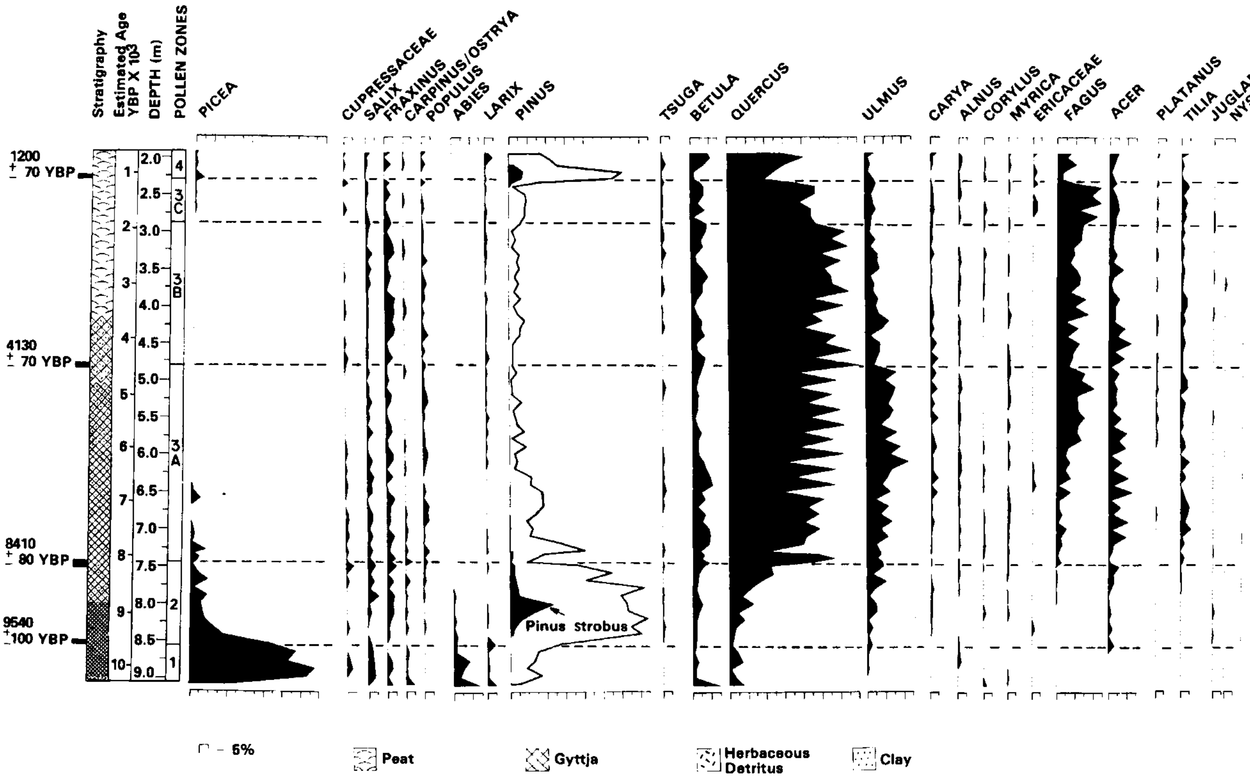


Fig. 3.2. Percentage pollen diagram (woody species only) based on a core taken from a bog in Lapeer County in Michigan's Thumb. Vertical scale: YBP = years before present. Horizontal scale (*top*): genus names of tree pollen. Horizontal scale (*bottom*): each tic mark = percentage of total pollen at a particular depth in the core. See the sidebar for a discussion of the 10,000-year story it tells. (Reprinted from Bailey and Ahearn 1981.)

A Michigan Bog Tells a Long Story

The fascinating pollen diagram shown in figure 3.2 was constructed by R. E. Bailey and P. J. Ahearn (1981) from sediment cores taken from a sphagnum bog located in Lapeer County in the lower part of Michigan's Thumb. The bog is part of Eastern Michigan University's Kresge Environmental Education Center. The diagram shows a dynamic chronology of vegetation in this part of the state over a period of more than 10,000 years. The lower Thumb was freed of glacial ice sometime after 13,800 years B.P., and we first look in on it more than 3,000 years later when a forest of spruce (*Picea*), fir (*Abies*), pine (*Pinus;* probably jack pine), and tamarack (*Larix*), along with subboreal hardwoods, became established. The exact spatial structure of these or subsequent communities, however, cannot be determined from this diagram. It is likely that the tree communities around the bog represented a transition from the open spruce parkland that developed behind the retreating glacier to the closed forest typical of more southern boreal communities. White spruce, jack pine, paper birch, oaks, and ironwood probably were found on the uplands, with black spruce, balsam fir, tamarack, white cedar, black ash, and willows growing in the wetter areas.

Beginning about 9,500 years B.P., a radical change in community composition occurred. Areas in the vicinity of the bog became dominated by pine forests, mostly jack and red pines but also some white pine (*Pinus strobus*). Presumably the climate became warmer and drier, causing the boreal conifers that dominated earlier to migrate northward. As time passed oaks (*Quercus*) and elms (*Ulmus*) also became more important. Gradually, beginning about 8,500 years B.P., pine pollen became less common—though still important—and hardwood pollen increased. During a period lasting several thousand years, oaks, along with pines and birches (*Betula*), probably dominated the dry-mesic uplands, with elms, beech (*Fagus*), ashes (*Fraxinus*), maples (*Acer*), and basswood (*Tilia*) growing in mesic or wet-mesic habitats. Aspen probably was present in all habitats, but its pollen does not fossilize and is absent in sediment cores. The sudden increase in pine pollen, including that of long-absent white pine, about 1,200 years ago, accompanied by a reappearance of spruce pollen and a decline in several mesic hardwood pollens, probably indicates that a large, intense forest fire burned over the Thumb. The history of the late nineteenth century (chapter 7) supports the contention that this area of the state was indeed prone to catastrophic wildfires. Pines and spruces are well adapted to disperse seed into large burned areas, explaining their reappearance. The pollen chronology ends as hardwoods began a comeback about a millennium ago.

species such as pines or birches produce far more pollen than insect-pollinated species such as willows or basswood. Size is a factor also; trees and tall shrubs produce greater quantities of pollen (and they travel farther) than do low herbaceous plants or grass. The increase in pollen rain generally is so large when a new tree species arrives at a particular place, however, that some of the errors in interpretation can be overcome.

- The pollen record provides few clues to the structure of the community that produced it. Pollen percentages at any one time (or depth in the core) roughly approximate a population count of parent trees in the vicinity of the site but provide few clues as to how they were arranged (Davis 1981). Did birch or willow pollen, for example, originate from trees or shrubs? Both life forms exist in these two genera. Grass pollen can originate from a tundra or a prairie—which one was it? Pollen from spruce trees and tundra plants may be mixed in the same sediment, but that does not necessarily mean that they grew together. More likely this particular pollen spectrum indicates that patches of trees were scattered in a matrix of tundra.

- Not all pollen preserves well in sediments. The pollen of poplar and tamarack, for example, is relatively fragile and decays rapidly. Many paleoecologists now believe that only a small percentage of the plants that grew in an area leave behind fossil pollen.

- The pollen rain may change over time, but the composition of the vegetation may not. For example, suppose a mature white pine forest that produces abundant pollen is killed by a catastrophic fire. A stand of young white pine quickly succeeds it, but it produces little pollen until it becomes reproductively mature. This gap in pollen rain does not mean that white pine disappeared for a period; rather the structure of the forest simply changed temporarily.

One way to overcome some of these difficulties in interpretation is to find a modern plant community that has a pollen spectrum similar to that of the ancient community. We can then infer that the ancient vegetation was similar to its present-day counterpart in composition and structure. For example, the Labrador tundra is a modern-day equivalent of the tundra that grew just south of the Wisconsin glacier. This solution to the pollen puzzle is not perfect, however—no modern equivalent of an ancient community may exist because the assemblages of plants that grew together after the glacier retreated may have differed widely from those of modern communities. One reason for this is that different species migrated northward following the retreating glacier at different speeds. Spruce moved northward very rapidly, but some of the species that grow with it today lagged behind and may not have become part of the overall spruce community for a long time.

Based largely on the pollen record, a general picture of the recolonization of ancient Michigan by forests and other vegetation during the decline of the Pleistocene Ice Age and the beginning of the Holocene Epoch has been constructed. This picture is kaleidoscopic, as the warming climate, weathering of the glacial till into primitive soil, and successive arrival of different species of plants and animals produced a continually—albeit slowly—changing mosaic of communities. The crucial point is that the till and lacustrine deposits left behind by the glacier did not stand barren for long—primary succession did its work well.

A Post-Pleistocene Chronology of Forests

The starting point for any paleoecological chronology of Michigan is the Wisconsin glacier at its farthest advance, which occurred at about 18,000 B.P. At this time the limiting factor for plant growth along the moraines and outwash that bordered the glacier was the severe climate; whatever vegetation existed there had to be hardy. The incessant winds blasting off the southern front of the glacier—frequently of gale force—would have given new meaning to the term *wind chill*. Permafrost—a layer of soil frozen throughout the year—must also have existed several inches to several feet below the soil surface, limiting tree growth. Yet because the glacial ice front was far south in Indiana and Ohio, summers probably were warm, though certainly not by modern standards. This presumed environment plus the pollen record indicate that the glacier was mostly bordered by a bleak tundra landscape. These open, treeless communities consisted of grasses, sedges, herbs, and low shrubs such as blueberry, wormwood (*Artemisia*), dwarf birches, and dwarf willows, all tenuously clinging to the raw soil. Ponds, potholes, and other wet areas punctuated this landscape. Occasional large meltwater lakes also occurred. On steep, eroded slopes and in areas periodically flooded by glacial meltwater streams, the landscape must have been barren (Kapp 1999). This Pleistocene landscape also contained patchy forests, mostly of spruce. In some places clumps of these trees probably grew right up to the glacial margin.

South of the tundra, extending to a latitude of approximately 34°N, was the boreal forest. Also called taiga, this forest assemblage was dominated by conifers adapted to cold temperatures and short growing seasons (Delcourt and Delcourt 1987). Spruces grew in the open, parklike northern parts of this forest—white spruce on the uplands and black spruce in wetter areas (fig. 3.3). Moss covered the forest floor. Muskeg, a forest characterized by dwarf trees resembling bonsai and an accumulating layer of undecomposed organic matter (peat), occurred in very wet, boggy areas. In the more southern reaches of the boreal forest, tree cover was more dense and trees were taller, with balsam fir, jack pine, and white cedar becoming more common. White birch, willow, alder, and poplars often were mixed with these boreal conifers. The boreal forest graded southward into a relatively narrow band of mixed conifer–northern hardwood forest dominated by white pine, red pine, hemlock, spruce, fir, oak, birch, elm, ash, hornbeam, maple, and beech (Delcourt and Delcourt 1987). In some places this forest was rich in species and complex in structure, while in others only a few species were found. Still farther south was a largely evergreen forest dominated by southern pines, bald cypress, tupelo, and sweet gum. The vegetation of the Florida Peninsula was probably sand dune scrub and tropical evergreens.

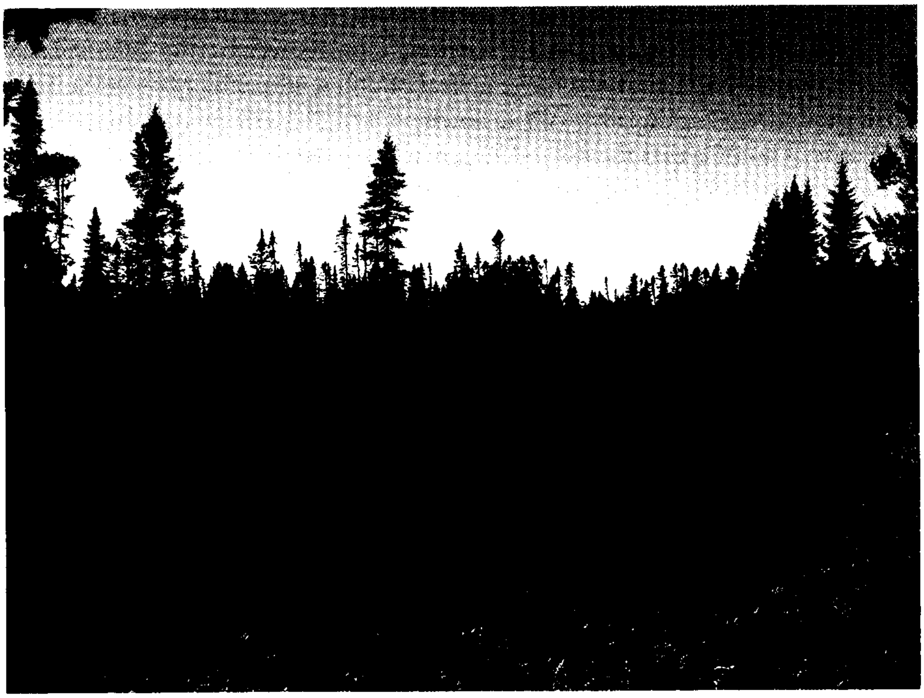


Fig. 3.3. A stand of boreal spruce, an example of a type of forest that first colonized Michigan following the Pleistocene glaciation.

This north-south gradient of vegetation types was simply the highly compressed forerunner of a broad and varied forest belt that today extends all the way from the tree line in northern Canada to the extreme southern United States. The ancient boreal forests and especially the mixed conifer–northern hardwood forests were the progenitors of the forests that cover Michigan today.

As the melting glacier beat its sluggish northward retreat, the tundra-dominated landscape on its fringe crept behind. The seed and other propagules of tundra plants slowly colonized the newly exposed till, especially in areas where clay or silt deposits were left behind. Plants such as alder "fix" atmospheric nitrogen into usable forms and build up this important element in the soil. Nitrogen fixers were especially important colonizers on the raw, low-fertility glacial soil. Areas that were tundra during the farthest advance of the glacier but now stood many miles south of the receding glacial margin—and were consequently warmer and drier—were no longer suitable habitat for tundra plants. The tree-dominated boreal communities that lay south of the tundra slowly moved into the abandoned territory and so on down the line of forest communities. By about 13,800 B.P. a considerable portion of south-central Michigan had emerged from the ice, although lobes of the glacier still extended over the basins of the Great Lakes into Indiana and Ohio. Most of the newly exposed land was tundra, but parklands of spruce were queued up just south of the Michigan border awaiting entry (Kapp 1999; fig. 3.4).

Chasing a retreating glacier—even in slow, slow motion—is risky business. During periods of exceptionally cold temperatures and high snowfall the glacier advanced and reclaimed territory it had recently abandoned. During these periods the whole process of northward plant succession halted or was reversed. A slow glacial advance would have gradually killed off less hardy plants, and perma-

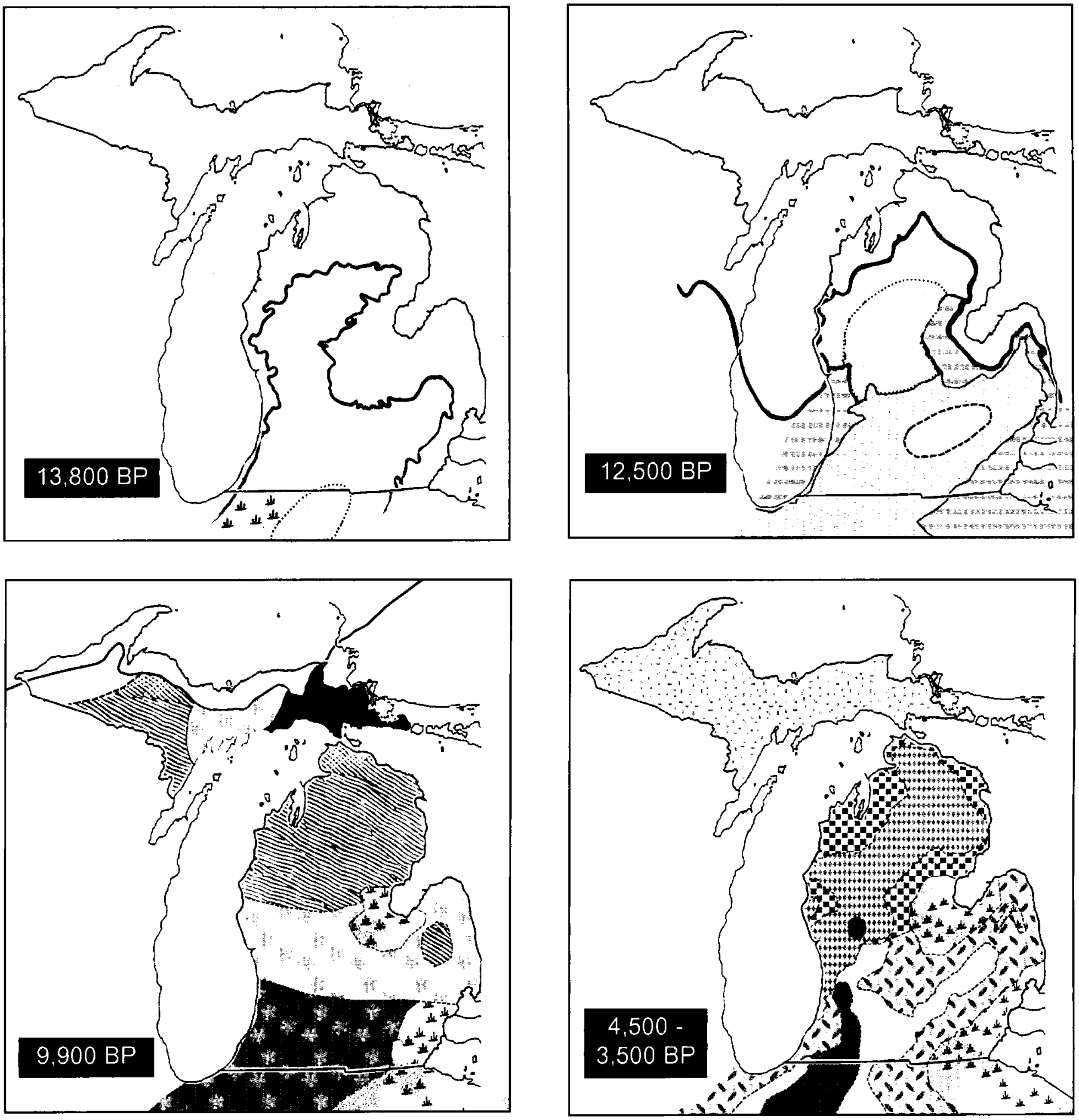


Fig. 3.4. The retreat of the Pleistocene glacier began a 10,000-year sequence of forest migration into Michigan. The first scattered spruces in a matrix of tundra slowly evolved to a complex forest mosaic. B.P. = years before present. (Redrawn from Kapp 1999.)

frost would have inhibited tree growth, widening the belt of tundra and pushing it south. Occasionally the ice surged forward so fast (in glacial terms) that living forests were overrun and buried (Pielou 1991). Such was the ebb and flow of the glacial retreat. In the end the glacier was doomed and plants slowly won over the territory for good.

Much of the Lower Peninsula was ice free 12,500 years ago (Kapp 1999; fig. 3.4). A narrow belt of tundra now occupied just the land directly south of the glacial margin, with boreal parkland below it. The southern Lower Peninsula consisted of closed boreal (spruce-pine) forest, with an island of tundra in its midst. After the passage of another 2,600 years the glacial margin had receded almost to the shore of Lake Superior in the Upper Peninsula (Kapp 1999; fig. 3.4). Boreal conifers still dominated in the north, but now the southern part of the state was occupied by more complex conifer-hardwood forests. At last, after the interminable Pleistocene deep freeze, the greening of Michigan was nearly complete, and, aside from some remnant tundra and marshland, most of the green was forest. To this day that forest has not yielded, save to the exploitative will of the human species, a force of destruction nearly as powerful as a glacier.

Patterns of Tree Migration into Michigan

At this point we need to consider the northward migration of individual tree species. Although the broad forest belts that were squeezed into the land south of the Wisconsin glacier marched northward as the ice retreated, the advance was not synchronous. The route of movement northward of individual species within these forest belts was dictated largely by the location of the enclave(s) into which they had been pushed by the most southerly advance of the Laurentide ice sheet. These glacial holding areas, known as refugia, varied widely in location and extent (table 3.1). According to the pollen records, the spruces were widely distributed from east to west in the boreal band that lay south of the glacial margin. Oaks and ashes also occurred over a large east-west area but south of the boreal forest. Other species were pushed farther south into smaller enclaves, for example, hemlock and walnut. Several species or species groups—tamarack, birch, and basswood—existed in geographically isolated western and eastern refugia.

The rate of movement of species groups into the biological void created by the retreat of the glacier also differed substantially (Davis 1981). The reasons for these differences in rate of migration are not well understood. Heavy seeded trees—such as oaks or hickories—might be expected to migrate more slowly than trees with light seeds that can be carried for long distances by the wind—such as spruces or hemlock. But this explanation does not fit what appears to have happened (fig. 3.5). For example, the two fastest moving species groups were jack/red pine and oaks; pine seeds are very light and wind carried, whereas oak acorns are among the heaviest tree seeds. This discrepancy can be explained by considering that wind is not the only seed vector; oak acorns can be carried into new territory by certain birds and rodents. In addition, the ability of seeds

Table 3.1.

Location of the Refugia of Some Michigan Tree Species Groups during the Farthest Advance of the Wisconsin Glacier, 18,000–16,000 B.P.

Species Group	*Location of Refugia*	*Approximate Area*[a]
Conifers		
Balsam fir (*Abies*)	Coastal portions of Virginia and North Carolina west to the continental interior, especially the eastern part of this range	544
Cedars and junipers (*Thuja* and *Juniperus*)	Central Atlantic Seaboard; west of the Appalachian Mountains between 36°N and 40°N latitude	216
Tamarack (*Larix*)	Lower Mississippi alluvial valley; western Pennsylvania	<35
Spruce (*Picea*)	Ice margin south to 34°N, from the Atlantic Seaboard to the continental interior	977
Pine (*Pinus*)	Ozark Mountains and east of the Mississippi Valley between 33°N and 40°N	598
Hemlock (*Tsuga*) and white pine (*Pinus strobus*)	East Coast and lower slopes of the southern Appalachian Mountains	23
Hardwoods		
Maple (*Acer*)	Central Kentucky south to the Gulf of Mexico and west across the Gulf coastal plain (Mississippi Valley)	579
Birch (*Betula*)	Maryland, Delaware, and Virginia seaboard; north-central Louisiana	120
Hickory (*Carya*)	Atlantic and Gulf coastal plains south of 35°N	606
Beech (*Fagus*)	Eastern and central Gulf coastal plain and northern half of Florida	232
Ash (*Fraxinus*)	Northern North Carolina west to the continental interior (but not the southern Appalachian Mountains, eastern Tennessee, and the Atlantic coastal plain)	830
Walnut (*Juglans*)	North-central Louisiana and southwestern Tennessee	<40
Aspen and cottonwood (*Populus*)	Ozark Plateau of central Missouri southeast to the Alabama coastal plain	262
Oak (*Quercus*)	South of 34°N, from the Atlantic Seaboard to the continental interior	1,042
Basswood (*Tilia*)	South-central Alabama; eastern Texas	54

Source: From Delcourt and Delcourt 1987.

[a] In thousands of square miles.

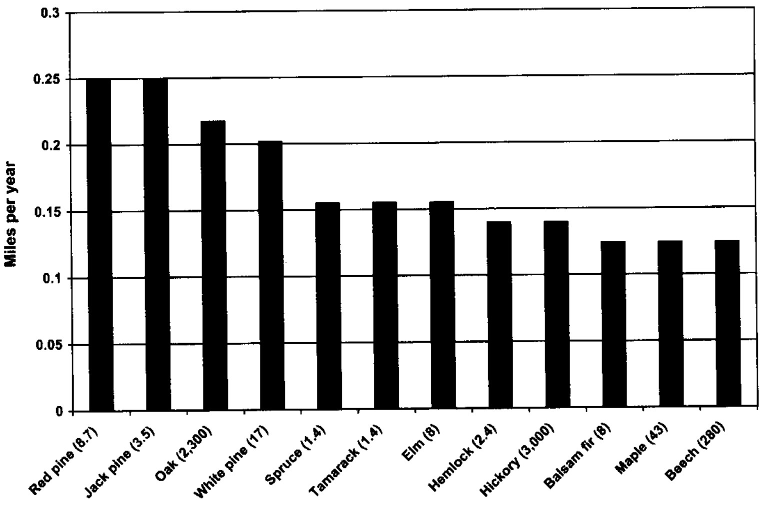


Fig. 3.5. Average rates of northward range extension from their refugia for 11 tree species. The number following each tree name is the average weight of seeds in milligrams. (Adapted from Davis 1981.)

to successfully germinate and compete with plants already established in an area was probably a more important factor than seed size per se.

Climate also affected the rate of migration. Species such as beech and hemlock, which are adapted to mesic or wet-mesic conditions, did not move northward or actually lost ground during warm, dry, postglacial intervals that occurred 3,500 to 4,500 years ago. Then, during the wet, cold period from the thirteenth to the nineteenth centuries known as the Little Ice Age, their rate of migration increased (Kapp 1999).

The arrival times of different species groups in Michigan spanned many thousands of years. Within a human generation the vegetative changes resulting from these migrations would have hardly been noticeable. The boreal conifers were the first to arrive, migrating directly north from their refugia (Davis 1981; fig. 3.6). Spruces, tamarack, and balsam fir followed right behind the glacier, reaching the Upper Peninsula by 10,000 B.P. The pines took a more indirect route—up the East Coast of the United States and then westward into Michigan. Jack and red pine arrived about 11,500 years ago, with white pine following about 1,500 years later. Hemlock, which entered the state 9,000 years ago, is a relative newcomer among the conifers, and its progression northward through the state was relatively slow.

Hardwoods arrived later than most of the conifers, with oaks in the vanguard and elm close behind (Davis 1981; fig. 3.7). Both groups edged into the Lower Peninsula about 11,000 years ago. A thousand years later maples and hickories became part of the southern Michigan flora. Whereas the migration of hickories stopped in midstate, the more hardy maples continued to move north and west. Beech is a very recent (in paleobotanical terms) immigrant to the state, having arrived just over 7,000 years ago. Unlike its northern tree associates, the migration of beech stopped 4,000 years ago about halfway across the Upper Peninsula. Today the mesic northern hardwood forests of the western highlands of Michigan are strangely devoid of this singular species. The reason for the termination of beech's westward migration has never been satisfactorily explained.

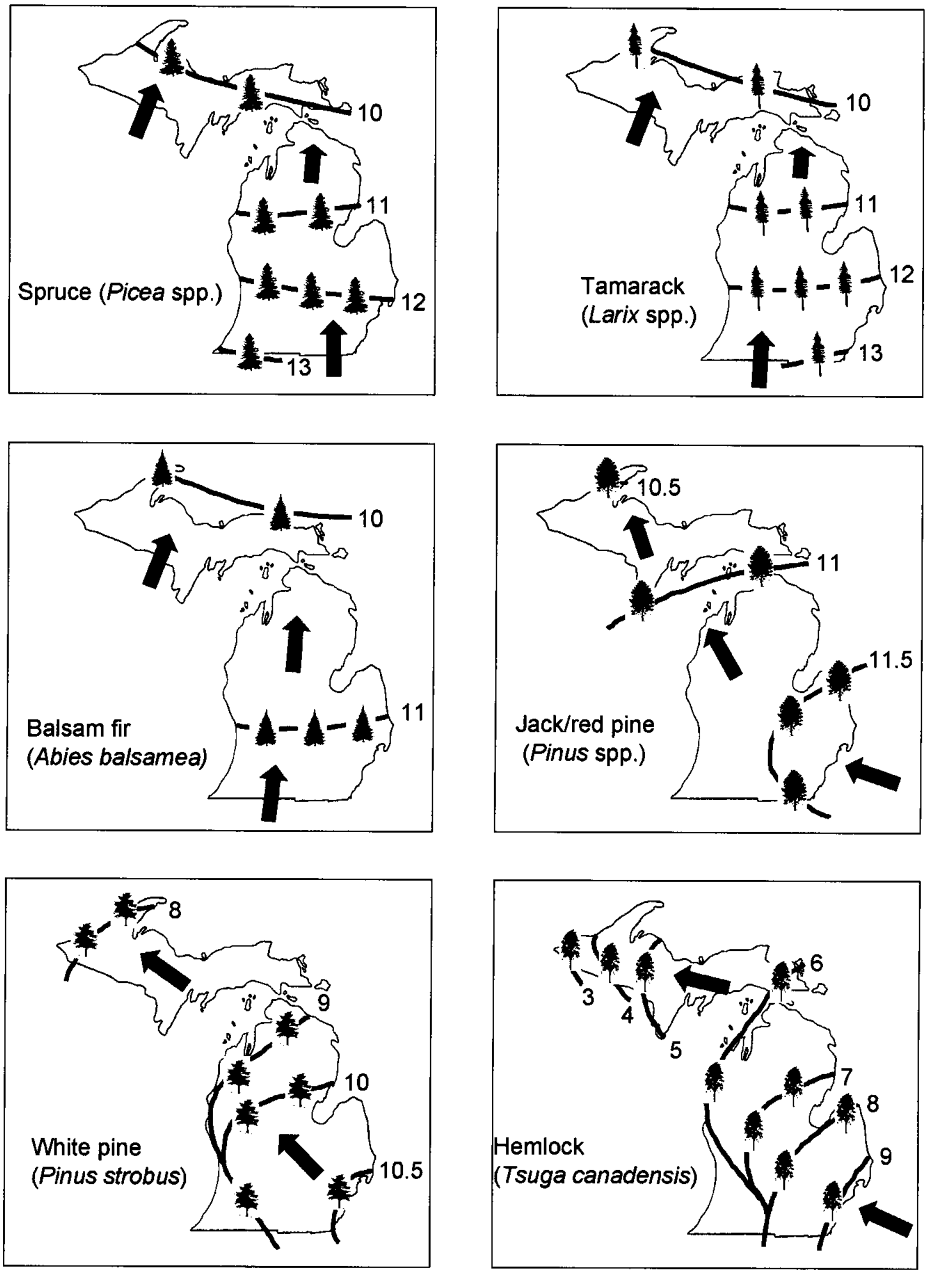


Fig. 3.6. The postglacial migration of six conifer species into and through Michigan. Isolines represent thousands of years before present (B.P.). (Adapted from Davis 1981.)

By the fourth millennium B.P. most of the species that now occupy Michigan had migrated into the state from their glacial refugia. Across the state the forest probably resembled what was present at the time of European settlement in the early 1800s (Kapp 1999; fig. 3.4). The borders of the various forest types, however, changed during the intervening 4,000 years as the climate varied. The period from 4,500 to 3,500 B.P., for example, was the warmest and driest since the Wisconsin glacier began its northward retreat. But thereafter the climate slowly became more cool and moist during the Little Ice Age. This cool spell set in motion an expansion of the beech-maple forest in the southern part of the state at the expense of both the oak-hickory type and the prairie-oak savanna. White

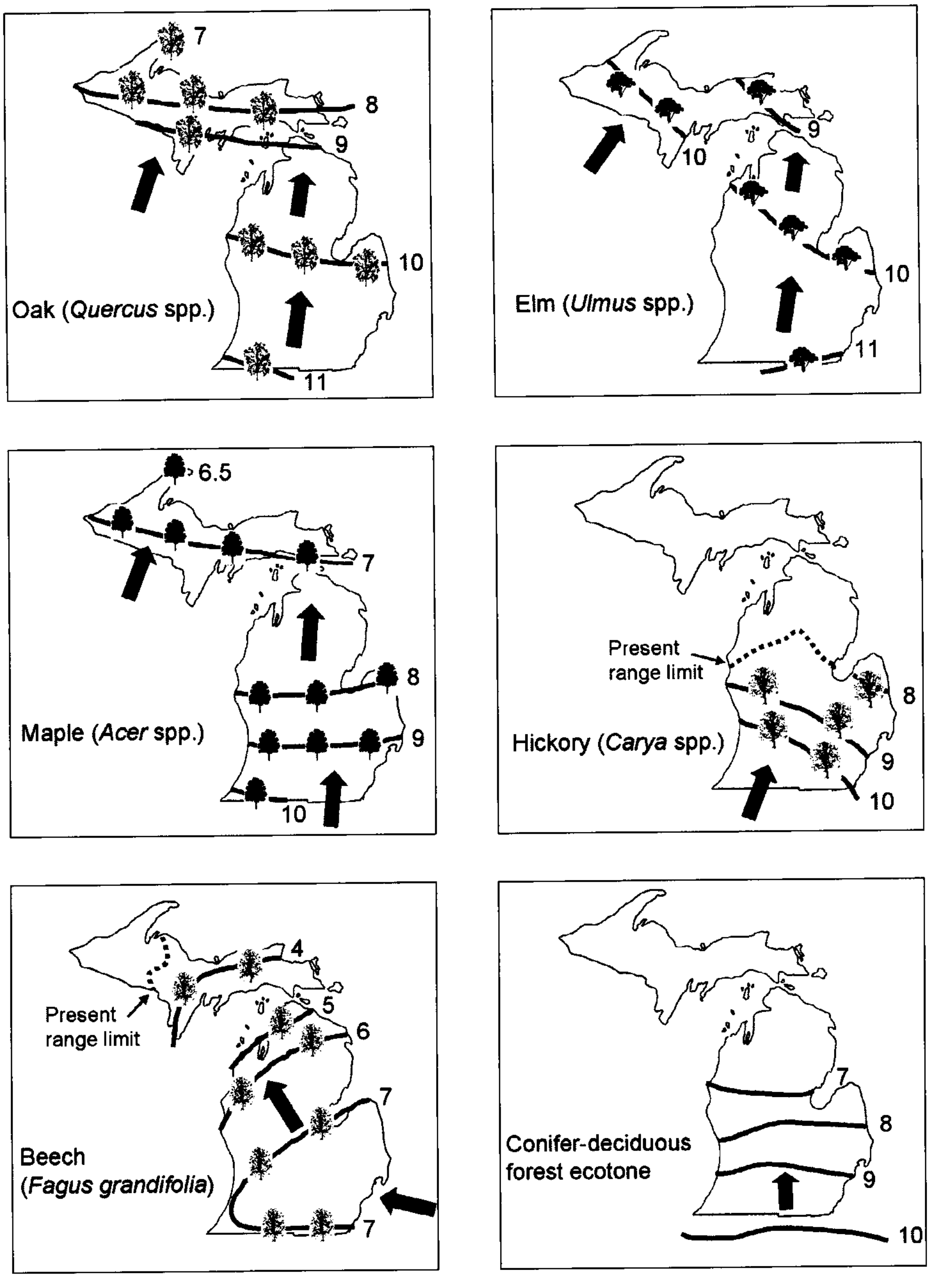


Fig. 3.7. The postglacial migration of five hardwood species into and through Michigan. Isolines represent thousands of years before present (B.P.). The conifer-deciduous ecotone defines the approximate transition zone from hardwood-dominated to conifer-dominated forests. (Adapted from Davis 1981.)

pine became more prevalent in the mid-Michigan pine–mixed hardwood forest during the Little Ice Age (Kapp 1999).

Animals Follow the Trees

The fossil record has much to tell us about plants. But there also are tantalizing hints in the form of excavated bones and other fossil artifacts suggesting that an amazing assortment of creatures—both two- and four-legged—roamed the early Michigan landscape. In fact, the fossil record of animals indicates that a diversity of fauna existed that is far beyond our imagination. Many of these fantastic creatures were forest animals or they inhabited the forest-tundra interface. Sadly, and for reasons unknown to us, many of them vanished during the transition from the Pleistocene to the Holocene.

Although Michigan's current population of mammals comprises a wonderful assortment of interesting and beneficial creatures, it pales in comparison with its Pleistocene counterpart. The large mammals—the so-called megafauna—are particularly interesting (Dorr and Eschman 1970). Most prominent among the megafauna, not only because of their colossal size but because of their frequency in the fossil record, are American mastodonts and Jefferson mammoths. These hairy, elephantlike animals apparently were present in large numbers as the front of the Wisconsin glacier receded northward into Lower Michigan. Mastodont bones have been excavated at 211 sites and mammoth bones at 49 sites in Michigan (Holman 1995). These numbers probably represent the relative size of the populations of these two animals during the 4,000 years they lived together in Michigan. All of the bones have been uncovered south of the so-called Mason-Quimbly line, which extends westward across the tip of the Thumb and from Tawas City to just north of Muskegon. Mammoths were creatures of sparsely forested or open country, where they fed primarily on grasses and small tundra plants. We can envision them grazing contentedly on a grassy till plain with the icy front of the glacier looming ominously in the background. Mastodonts, on the other hand, were adapted to more diverse habitats, but they were primarily woodland dwellers (fig. 3.8). Their diet consisted of tree leaves and needles, twigs, and swamp plants (Holman 1995). Both creatures were attracted to ancient Michigan by seeps from the extensive salt deposits that underlie the southern part of the state. This dependence on salt may partially explain why these animals did not migrate to salt-free northern Michigan when it became free of ice.

As strange as these magnificent creatures appear to us, even stranger is their sudden disappearance about 10,000 years ago. Not only did mammoths and mastodonts disappear, but many other fantastic Michigan creatures apparently ceased to exist at about this time. This catastrophic event was part of a worldwide episode of animal extinctions that rivaled the demise of the dinosaurs. Short-faced bears, giant beavers (which were the size of a black bear!), the flat-headed peccary, Scott's moose, Toronto deer, and woodland musk ox all roamed the Michigan landscape vacated by the glacier . . . and then they disappeared forever. Grizzly bear, caribou, bison, and barren ground musk ox were extirpated in Michigan around the same time, although they still exist today in western or northern North America (Holman 1995).

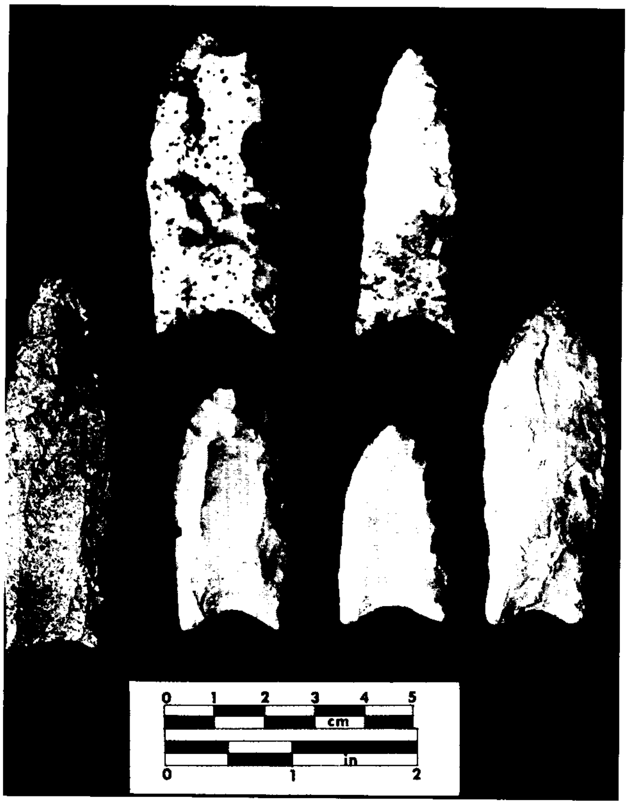
Several hypotheses have been proposed to explain the demise of the Pleis-

Fig. 3.8. Giants among Michigan's early Holocene fauna, American mastodonts browse their way through an early Holocene (postglacial) spruce-hardwood forest. (Reprinted from Dorr and Eschman 1970, 368.)

tocene megafauna, but none is entirely satisfactory. Most likely a combination of events pushed these creatures over the brink. Climatic change may have been a factor. Glaciers, like large bodies of water, moderate climatic extremes. When the Wisconsin glacier receded, summers became shorter but hotter and winters longer and colder. This change could have upset the reproductive cycle of large animals to the point where viable populations could not be maintained. As the land gradually dried and water tables dropped following the glacial melting, drinking water, and especially the saline water these large mammals craved, may have come into short supply—megafauna put megademands on the environment. The gradual forestation of Michigan would have eliminated the mammoth's grassland or tundra habitat, and the animals would have moved on. However, this ecological shift does not explain why the mammoth failed to follow the tundra into the Upper Peninsula, nor does it explain its demise elsewhere in the vast grasslands of western North America. New diseases may have been introduced into megafaunal herds by animals that migrated from Asia to North America across the Bering Strait, which was dry during the late Pleistocene. Eventually this pestilence could have spread to Michigan.

There is one final piece in the extinction puzzle. A fierce predator roamed the postglacial landscape, and it could have affected these large animals in a major way. This predator was extremely dangerous not only because it could kill but because it could think. Archaeological evidence has clearly established that Paleo-Indian people moved into southern Michigan during the last vestiges of the Pleistocene glaciation. They were not primitive human beings—that is, "cave men"—but modern *Homo sapiens* like us. But unlike modern Michigan residents they would have known the trumpet blast of an angry bull mastodont or the bite of the arctic wind sweeping off a glacier.

Fig. 3.9. Paleo-Indian (Clovis) fluted biface points have been found at more than 100 sites in southern Michigan. Could they have been used to hunt mastodonts and other megafauna to extinction? (Reprinted from Dorr and Eschman 1970, 385.)



These aboriginal people are identified by one of the few clues we have to their existence—the singular fluted projectile points (also known as fluted bifaces) that they used to arm their primitive weapons (fig. 3.9). Paleo-Indians also are called Clovis people because some of the first fluted points found in North America were located near Clovis, New Mexico. Apparently, Clovis people were widespread on the continent. There are more than 100 records of fluted points in Michigan, all from the Lower Peninsula south of the Mason-Quimbly line (Holman 1995). These Michigan artifacts are sometimes called Gainey points, named for the site in Genesee County where they first were found.

Attached to a projectile or spear, the fluted points used by Paleo-Indians were formidable weapons for the time. The points found in Michigan were made from chert, a flintlike rock (Shott and Wright 1999). The flaked edges of a new chert point were razor sharp and easily sliced through flesh. The groove down the middle—the flute—promoted bleeding and helped bring down big game. Clovis hunters probably could have killed large animals such as mastodonts and mammoths using spears tipped with fluted points, although it would not have been easy. If an animal were mired in a bog or had broken through the ice of a lake or pond, though, they would have been easier prey. But not one fluted point has been found at any of the 260 mastodont or mammoth sites in Michigan; in fact, not so much as a chip of flint has been uncovered at these sites (Holman 1995). The Pleasant Lake mastodont site near Ann Arbor shows evidence of human butchering, although no stone tools were found on the site (Shott and Wright 1999). Nonetheless, the issue boils down to this: why would Paleo-Indian people choose to regularly hunt huge, dangerous animals when herds of more compliant caribou, bison, moose, musk ox, deer, elk, and peccary also were there for the taking? In fact, some archaeologists argue that caribou were their preferred prey (Shott and Wright 1999).

Because these early hunters were such effective predators, one popular hypothesis presupposes that they almost single-handedly drove Pleistocene megafauna to extinction. Could small roving bands of people armed with primitive—though deadly—weapons extirpate more than a dozen Michigan species, not to mention countless others throughout North America? This feat would be unprecedented in the history of the world. Furthermore, several species of little value to humans also perished at the same time as the more desirable megafauna. Although this hypothesis has been vigorously defended by its proponents (Martin 1990), we find it rather far-fetched. If, however, the megafaunal herds were decimated by climatic change, water or salt shortages, loss of habitat, and disease, hunting pressure from humans certainly could have contributed to their demise.

Humans Populate the New Land

Archaeological evidence indicates that Paleo-Indian occupation of Michigan began sometime after 12,000 B.P. (Anderson 1991; Shott and Wright 1999) (fig. 3.10). Where did these early Michigan humans originate? The short-term answer seems clear enough. The highest concentrations of fluted points are from an area in the east-central United States encompassing the valleys of the Mississippi, Ohio, and Tennessee Rivers. In some counties in this area more than 100 fluted points have been found (Anderson 1991). Just as plants migrated north from their refugia as the glacier melted, so animals moved in to eat the newly established plants, and nomadic Paleo-Indians shadowed the herds looking for good hunting. Unlike most of today's visitors to Michigan, these people were not sightseeing; they were hungry and looking for food.

The longer-term origin of humans in North America begs a totally satisfactory explanation. The archaeologist Frederick Hadleigh West (1983) summed up the problem: "At its best, the archeological record consists of fragments and filaments allowing partial reconstructions and always permitting degrees of dissent and variant interpretation." In the case of Paleo-Indian people, the only way to trace their origins has been their tools, and sites where they have been found are not abundant. The most popular hypothesis resulting from this research is that humans emigrated from Northeast Asia across the Bering Land Bridge during

Fig. 3.10. Paleo-Indian people moved into southern Michigan, almost 12,000 years ago on the heels of the retreating Wisconsin glacier. They found abundant game in the tundra and scrubby forests that grew in the glacial soil. (Courtesy of the Michigan Historical Museum.)

the late Pleistocene. Recently, comparative molecular genetic studies of mitochondrial DNA in Northeast Asian and American Indian populations has provided compelling new evidence to back up this contention (Schurr 2000). Based on these DNA comparisons the ancestors of modern Indian people most likely came from northern China, southeastern Siberia, Mongolia, or even Japan and Korea. These migrations probably occurred in multiple waves during periods of favorable climate. The people then fairly rapidly dispersed throughout the North and South American continents as the Laurentide ice cap shrank. Some archaeologists contend that this emigration began at a minimum of 30,000 to 40,000 years ago, but evidence for this early arrival date is scanty and the issue is contentious (West 1983).

The Bering Land Bridge hypothesis is accepted by most serious students of the subject, but other migration routes of humans to North America have been proposed. Could early humans have arrived by boat from Asia, Polynesia, or Europe? Could there have been a Pleistocene land or ice bridge between Europe and North America that would have permitted migration? These explanations are no less plausible than humans traversing the frigid, barren wastes of northern Siberia and Alaska, and then over several rugged mountain ranges, all in a quest for better hunting grounds that they had no reason to believe existed. Nonetheless, the overwhelming contribution of Asiatic peoples to the peopling of North America is not seriously disputed.

Although the alternate hypotheses to the Bering Land Bridge are nearly impossible to test and are ridiculed by some archaeologists, a few intriguing shreds of evidence lend them credence. For example, there is the Kennewick Man, whose remains were found in 1996 on the banks of the Columbia River in Washington state (Preston 1997). This remarkable skeleton of a 40- to 55-year-old male is nearly complete, and it has been radiocarbon dated at roughly 9,300 to 9,600 years old. The Kennewick Man was five feet nine inches in height, especially tall for his time. He had the broken tip of a spear point lodged in his pelvis. His bone structure is distinctly Caucasoid, not the Mongoloid structure characteristic of the northeastern Asian people who migrated across the Bering Land Bridge. *Caucasoid* is a broad descriptive term applied to biological features originating from an area stretching from Europe to South Asia. Where exactly did the Kennewick Man or his ancestors come from? Three prominent university laboratories tried to extract DNA from his bones to answer that question, but none was successful. Meanwhile the Confederated Tribes of the Umatilla petitioned the federal government under the Native American Graves Protection and Repatriation Act to allow them to rebury the bones. In September 2000 then secretary of the interior Bruce Babbitt decided to give the bones to the five tribes that claimed them, precluding further study. But that decision was challenged in court by scientists. Resolution of this contentious issue is pending.

Other evidence points to diverse human origins in North America. The bifaced fluted points linked so closely with Paleo-Indians are identical to late-Pleistocene fluted points uncovered in Europe. Not only do the points look the same, but the flaking technology used to make them appears to be identical (Preston 1997). These distinctly fluted points have not been found in Siberia, so the technology apparently did not originate there and traverse the Bering Land Bridge (Anderson 1991). Additionally, other Clovis weapons and tools have almost identical European counterparts. Are these intriguing facts evidence of east to west migration from Europe or are they simply an example of parallel evolution of toolmaking by unrelated cultures separated by thousands of miles? No one will ever know for sure. Molecular genetic analysis also suggests that a portion of the mitochondrial DNA of modern North American Indians originated in Europe (Schurr 2000).

American Indian oral tradition speaks to the issue of human origins in North America, although archaeologists pay it little heed. The Native American author and scholar Vine Deloria Jr. (1997) argues that Indians are aggressive critics of the Bering Land Bridge doctrine because it does not reflect any of the memories or traditions passed down by word of mouth over many generations. Most of these tales presuppose that Indian people were present in North America prior to the onset of glaciation, and many of their creation stories tell of beginnings during a period of ice or under tundralike conditions. Oral traditions of several tribes also speak of an ancient race of pale-skinned "giants" (people of large stature) who lived among them and sometimes were their competitors. The stories relate that the giants abruptly disappeared just before the mammoths and mastodonts expired in an epidemic. These giants—ancestors of the Kennewick Man?—could have brought the technology for making fluted points with them from Europe. If they did, that was all they left behind. The cultures of the indigenous people of North America, from the Clovis people to the native tribal groups encountered by the first explorers from the Old World, were uniquely American and showed no European influence.

By the beginning of the Holocene Epoch—around 10,000 B.P.—Michigan was well on the way to becoming a forested land, and it was inhabited by an incredible diversity of creatures. Although many of these animals quickly plunged into extinction, a rich legacy of animals and plants remained to support the Indian cultures that evolved from their Clovis beginnings. In the next chapter we fast-forward in time to the period just before Europeans entered Michigan in force and examine the myriad ways in which indigenous Indian peoples used the forests they inhabited.