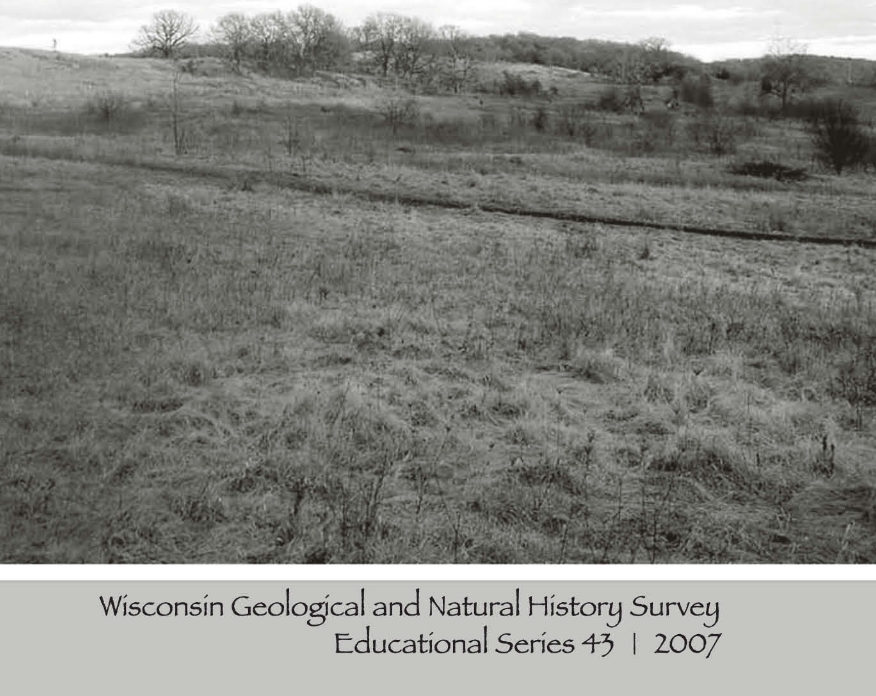
# Landscapes of Dane County, Wisconsin

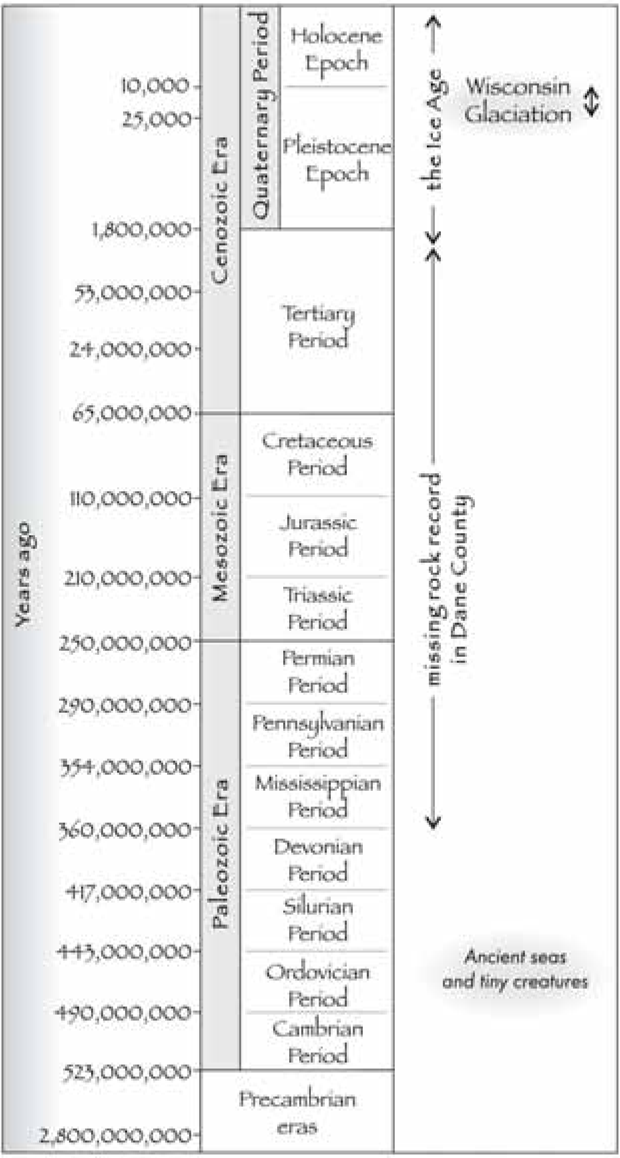
David M. Mickelson

Susan L. Hunt, illustrator



Wisconsin Geological and Natural History Survey
Educational Series 43 | 2007

# Geologic time scale



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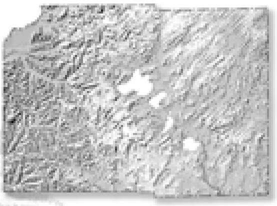
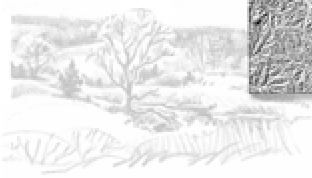
*The Survey conducts earth-science surveys, field studies, and research. We provide objective scientific information about the geology, mineral resources, water resources, soil, and biology of Wisconsin. We collect, interpret, disseminate, and archive natural resource information. We communicate the results of our activities through publications, technical talks, and responses to inquiries from the public. These activities support informed decision making by government, industry, business, and individual citizens of Wisconsin.*

# Contents





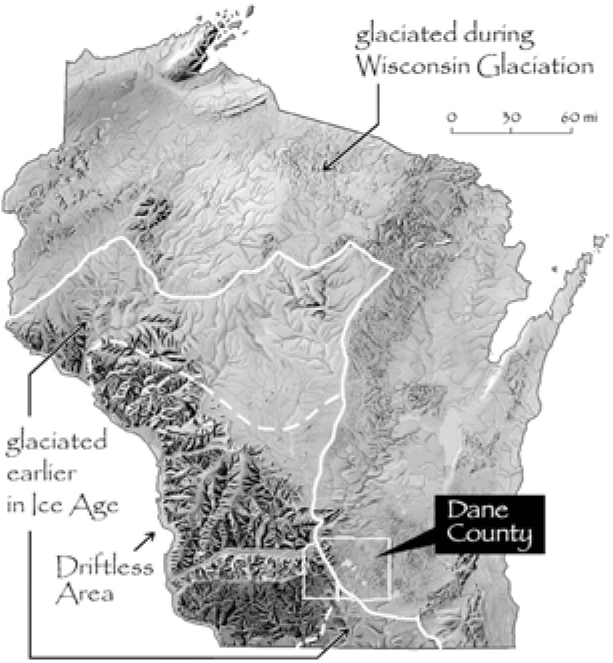


# One county, diverse landscapes

Whatever your mode of transportation—on foot, or by bicycle or car—you have probably noticed how varied the landscapes across Dane County are. In some places, the land looks rugged; in others, it's smoother and more gently rolling. What you are seeing is the impact of very different geologic processes upon the landscape. Some of these processes took place over vast expanses of geologic time, which the time scale on the inside front cover can help you visualize, and others are the product of more recent events.

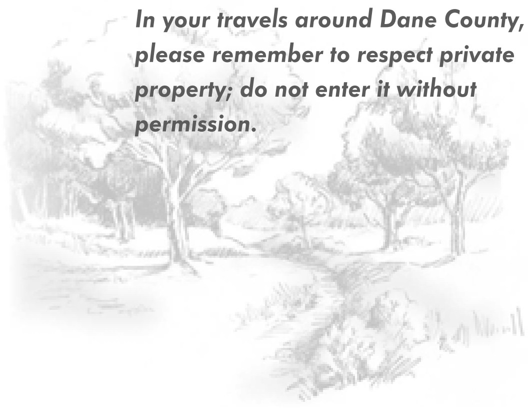
The land surface of part of Dane County is the product of millions of years of *weathering*—the breakdown of minerals and rocks—and the resulting erosion of the mineral grains. Erosion has produced a well developed network of stream valleys with sharp-crested ridges; this is best seen in western Dane County. This part of the county has been called the *Driftless Area* because it lacks what geologists used to call *drift,* deposits left by a glacier. But during cold periods of the past 2.4 million years (the *Ice Age),* glaciers did sweep in and out of parts of Wisconsin. During the most recent *Wisconsin Glaciation,* which began approximately 25,000 years ago and lasted almost 15,000 years, ice blanketed central and eastern Dane County with a cover of comparatively young material.

In this booklet, you will learn about the geologic heritage of Dane County as preserved in parks and other natural areas. You will traverse the craggy landscape of the Driftless Area and the parts of the county where glaciation has subdued the landscape. Locations of parks and scenic places are numbered in the text; the map in the back pocket shows these areas in relation to county landforms.




A shaded relief map of Wisconsin highlights the dramatic differences between the Driftless Area in the southwest, which is characterized by dendritic (tree-like) drainage and steep hillslopes, and the glaciated part of the state, which has more subtle topography. Dane County straddles the glaciated and unglaciated areas.

***In your travels around Dane County, please remember to respect private property; do not enter it without permission.***



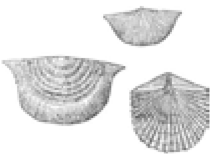
# In the beginning

*Ancient seas and tiny creatures*


What we now know as Dane County looked very different hundreds of millions of years ago during the Cambrian Period (approximately 523 million to 490 million years ago)—a shallow tropical sea extended to the southeast, south, and west; to the north lay approximately 1,000 miles of eroding continent. The gently rolling landscape had only a few primitive plants; at that time, the only animals were sea-dwelling *invertebrates* (creatures without backbones).

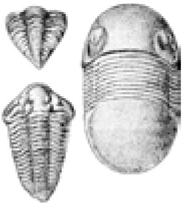
Streams from the north picked up bits of the eroding landscape and carried them into the sea. Many minerals dissolved in the water; only the most resistant minerals, primarily quartz, were finally delivered as sand grains to the coastline. These grains were progressively buried by more and more weathered pieces shed from the huge land mass to the north and were eventually loosely cemented into a sedimentary rock called *sandstone*.

Sometimes the delivery of sand was diverted or severely restricted, leaving tropical seas teeming with bacteria, algae, and many now-extinct invertebrate animals. The shells of many of these organisms were made of calcium carbonate; when they



The stalked crinoid, or "sea lily" (left), brachiopods (above left), and trilobites (next page, upper right) once lived in what is now Dane County.

died, their shells settled to the ocean floor in shallow environments and collect to form *limestone*. In southern Wisconsin, part of the calcium carbonate was later replaced by magnesium, producing a mineral as well as a rock made up of that mineral; both are called *dolomite*. Thin beds of dolomite are sandwiched between sandstone layers formed during the Cambrian.



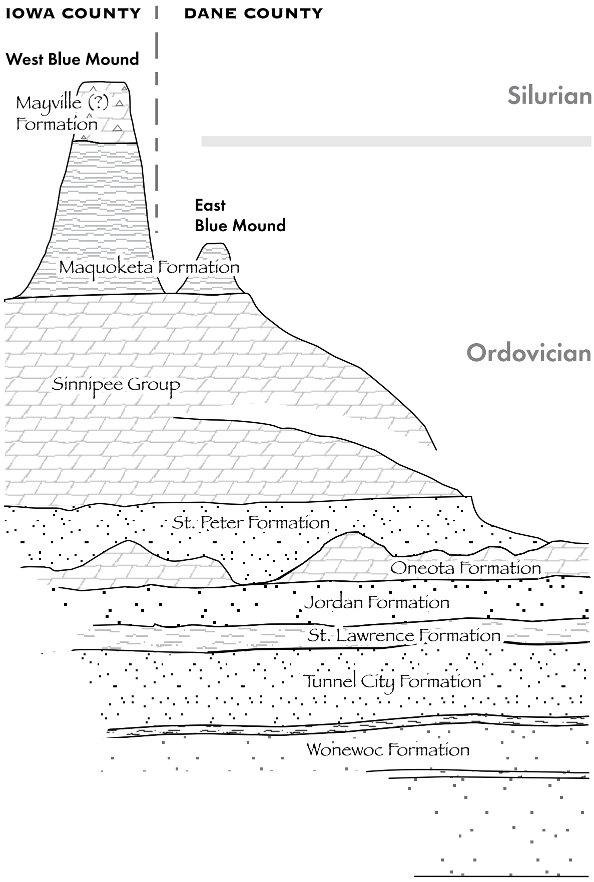
It was not until the Ordovician (approximately 490 million to 443 million years ago) that thick masses of dolomite became dominant in the tropical sea. Then, photosynthetic bacteria formed colonies and produced head-shaped masses called *stromatolites;* their fossils are especially abundant in the dolomitic rock unit that geologists call the Oneota Formation. (Figure spread on p. 6–7 shows named rock units.) Sea level then dropped and this area was eroded by rivers, only to be inundated again by the sea, which deposited a rich supply of sand. The sand was eventually formed into quartz sandstone, called the St. Peter Formation.

Later in the Ordovician, individual corals, sponges, brachiopods, and crinoids abounded in the sea, and dolomite again became dominant. The resulting rocks, especially those of the Sinnipee Group, contain the most interesting fossil-bearing rocks in Dane County.

Stromatolite mounds were plentiful in the Ordovician sea.

## A missing link

By the Silurian (443 million to 417 million years ago), the tropical sea was dotted with coral reefs. We know this sea persisted for more than 30 million years, especially in eastern and southern Wisconsin. Dane County, however, has no record of Silurian rocks—or *any* rocks deposited in the succeeding 400 million years.

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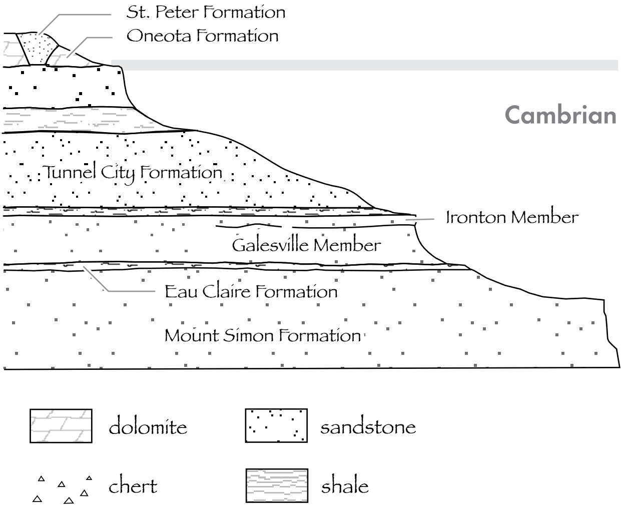
You might be surprised to learn that rocks have names more formal than just "dolomite" or "sandstone." Geologists use the distinctive characteristics of rock units to classify them into *groups,* which consist of two or more *formations,* which may consist of two or more *members.*

The missing rock record can be reconstructed from sedimentary rocks found in surrounding areas. For example, the silicified dolomite that forms the top of West Blue Mound in Iowa County provides a basis for determining what rock layers were probably originally present in Dane County. Rocks in the eastern, southern, and western United States tell us that during the later Paleozoic (see geologic time scale), the climate was, for the most part, humid and warm. In the late Paleozoic and Mesozoic, reptiles dominated the landscape. In the drier climates of the late Mesozoic and early Cenozoic, mammals must have roamed our area, but all traces of them are gone.

Erosion that began in the mid-Paleozoic and continued for approximately 400 million years produced a landscape across much of the state that was not unlike that of the Driftless Area today. Throughout much of that time, drainage was probably northward into what is now Hudson Bay.



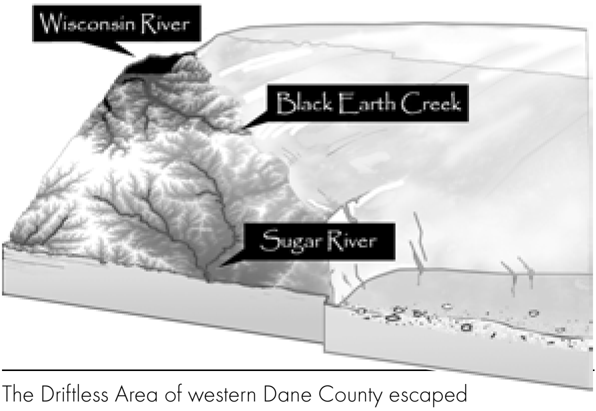
# Ridges and valleys

*The Driftless Area*

Deep valleys with steep slopes cut by running water dominate the southwestern Dane County landscape, the Driftless Area.

Even though glaciers never encroached upon the Driftless Area, the impacts of the Ice Age on it were substantial. Black Earth Creek and the Wisconsin and Sugar Rivers carried vast amounts of glacial meltwater, and their valleys now contain thick *outwash,* sand and gravel that was deposited by wide, braided streams. At the time of the glacial maximum, the climate was cold, and tundra plants dominated the ridgetops and slopes. Spruce, protected from the bitter winds blowing off the ice sheet, probably survived in valley bottoms. Clouds of silt-sized dust, called *loess,* windswept from the floodplains of meltwater rivers, particularly the Mississippi, settled on the land surface of southern Wisconsin.

Summer thawing of frozen ground produced severe erosion on slopes—much more than takes place today. Some rocks, such as solid, unweathered dolomite and




The Driftless Area of western Dane County escaped glaciation; its landscape evolved from millions of years of erosion.

Rugged bedrock ridges alternate with narrow, winding valleys throughout the Driftless Area.

well cemented sandstone, resisted the forces of erosion and now form steep cliffs. Softer sandstone and weathered dolomite slope gently. *Outcrops* (exposures) of both rock types can be seen along river valleys and in roadcuts.

Erosion since the mid-Paleozoic was accompanied by a slight flexing upward of the rocks in southern Wisconsin, but our area did not experience mountain building as the eastern and western United States did. For example, as a result of the upwarping, the rocks in the Driftless Area now tilt slightly southward, and differential erosion of these gently tilted rocks has produced *cuestas,* broad ridges that are steeper on one side than another. The Military Ridge cuesta, which extends from Madison to the Mississippi River, is mostly capped by resistant dolomite. Its steep northern slope, which exposes several rock types, was produced by *downcutting* (downward erosion) of the Wisconsin River. The Pecatonica and Sugar Rivers flow southward from Military Ridge along a much gentler slope that is roughly parallel to the tilted rock layers.

No natural lakes lie in the Driftless Area of Dane County because the long period of stream erosion that produced the steep slopes and deep valleys removed any natural dams that might have once existed.

Stops 1–6

## Exploring the Driftless Area

**Military Ridge Trail** (see map) follows the route of an old military road and rail connection between Madison and towns to the west. The trail follows the drainage divide between the Wisconsin River to the north and the Sugar and Pecatonica Rivers to the south. West of Verona, the trail follows the flat, marshy Sugar River valley, which was dammed by outwash, forming a lake when ice spread to its maximum reach into Dane County (approximately 20,000 years ago). Small roadcuts expose sandstone and dolomite westward to the county line. **Klevenville Quarry** (1) (inactive, but private property), on Riley Road, exposes St. Peter sandstone that was used in local foundries. **Stewart County Park** (2)**,** on the north side of Mount Horeb, is in a deep tributary valley of the Wisconsin River; the dolomite exposed here is part of the fossil-rich Sinnipee Group. Like all lakes in the Driftless Area, Stewart Lake is an impoundment. **Brigham County Park** (3) lies atop East Blue Mound, which is capped by loess and dolomite of the Maquoketa Formation. **Blue Mounds State Park** (4) includes West Blue Mound, the highest point in southern Wisconsin (1,720 feet above sea level), just west of the Dane County line. It, too, has a loess cap, but it rests on Silurian dolomite. Much of the dolomite has been replaced by the very resistant silica called *chert*. Note the quartz crystals in openings in the silicified boulders. Probably many of the boulders in the woods below the summit moved

A topographic map detail reveals the dendritic pattern of the Driftless Area.

Donald Rock in Donald County Park escaped many of the ravages of glaciation and towers 110 feet over the surrounding landscape.

downslope when the ground was permanently frozen (except for a seasonally thawed active layer near the surface), tundra grass and shrubs covered the landscape, and the glacier was only 10 miles to the east. Small *sinkholes* (areas that collapsed as a result of water dissolving minerals from the dolomite) are marked by clumps of trees on the flat surface just east of the park entrance. **Cave of the Mounds** (5), to the east, formed in the Sinnipee dolomite that underlies this flat surface. To the south, **Donald County Park** (6) has a good example of a natural rock tower. Composed of St. Peter sandstone, the tower stands above the countryside because the sandstone at the top is slightly better cemented than rock around it, protecting it from erosion. This is classic Driftless Area topography, developed by stream erosion during the more than 400 million years between the Silurian and the Quaternary Periods.

# Glaciers make their mark

Approximately 60 million years ago, the Earth began to cool; this eventually led to the formation of huge continental ice sheets in the northern hemisphere about 2.4 million years ago. Many ice sheets surged into and ebbed from our area, but most of the early record is missing, eroded away by subsequent ice advances. Only the most recent glaciation, the Wisconsin Glaciation, has left a visible imprint on our landscape—and a major imprint it is. The glacier smoothed the land, scraping off hilltops and filling in valleys.

Snow and ice accumulated east and west of Hudson Bay, eventually forming an enormous glacier, called the Laurentide Ice Sheet, which moved into our area from the northeast about 25,000 years ago. The sheet was diverted into tongue-like projections called *lobes*. Funneled by the lowlands of Green Bay and Lake Winnebago, the Green Bay Lobe flowed southwestward until it covered the eastern two-thirds of Dane County.

The glacier crept across a landscape covered by low-growing tundra vegetation and a few spruce trees and populated with mammoths, mastodons, musk oxen, and other large mammals. Although the winters were extremely cold, the short summers were warm enough to allow melting along the edge of the ice.

Approximately 20,000 years ago, when the melting of the ice near the glacier edge equaled the amount of ice being carried to the margin, a balance was reached and the margin stabilized. But even as it sat on the land, the glacier modified the landscape by


Lobes of the Laurentide Ice Sheet kept an icy grip on our area for thousands of years. The map above shows the lobes approximately 20,000 years ago, during their maximum reach into Wisconsin.

eroding rock and soil and transporting the resulting rock, sand, silt, and clay southwestward toward the glacier edge.

When the climate began to warm approximately 15,000 years ago, and melting finally exceeded ice flow toward the margin, the glacier shrank back toward the northeast, leaving behind distinctive landforms in parts of Dane County.

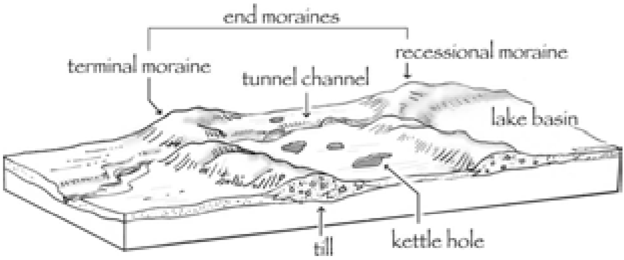
## Features formed near the ice margin

*Moraines and tunnel channels*

The glacier scoured the underlying landscape, and, like a conveyor belt, carried a mixture of boulders, sand, silt, and clay called *till* to the ice margin. There, till accumulated in low, rough-surfaced ridges, called *end moraines.* The end moraine that marks the farthest extent of ice (thus sometimes called a *terminal moraine)* into Dane County is named the **Johnstown moraine** (see map). Just behind it, to the northeast, is the Milton moraine, also an end moraine, but built during a period of ice-margin stability after the ice began to recede (sometimes termed a *recessional moraine).* Both moraines are pockmarked with abundant closed depressions, many 10 to 50 feet deep, called *kettle holes.* These kettle holes formed as isolated masses of ice—buried in the accumulating sediment—finally melted, and the debris that had covered the ice collapsed. The interwoven small hills are called *hummocks;* such hummocky topography is typical of end moraines.

Water from the melting glacier also played a role in shaping our landscape. Research has shown that modern glaciers vary considerably in how far below the melting point they are. Ones that are well below freezing, especially at their bed, have very little geologic impact upon the landscape. If the temperature is just at the melting point, water can lubricate the base of the ice, and a glacier can slide along its bed, eroding sediment and rock. This produces *striations,* or scratches, on the underlying rock. Because striations are etched on many freshly exposed rock outcrops in the moraine

Striations show the direction of glacial movement.




Certain types of features are typically formed by glaciers near their edges. Note the till composition of the moraines.

zone in Dane County, geologists know that at some time the bed of the glacier was at the melting point. It seems likely, however, that during much of the time the glacier was at or near its maximum position, the bed was frozen in a zone that was 5 to 10 miles wide near the ice margin, damming the drainage of meltwater from under the glacier. When water did escape from under the ice, it cut *tunnel channels*—large caverns that were gouged partly into the ice and partly into the glacier's bed—through which water flowed, sometimes with great force, breaking the ice dam. These channels carried huge volumes of water for short periods of time, perhaps only days, before water pressure was reduced and the tunnel closed. The meltwater floods were likely short-lived, but they had a great impact on our landscape. The tunnel channels are now valleys that are partly filled with sand and gravel.

Smaller channels formed as water produced by surface melting flowed along, away from, and sometimes under the thin ice near the glacier margin. Broad streams having channels with a braided pattern flowed away from the glacier in pre-existing valleys toward the Wisconsin and Rock Rivers. These rivers carried large amounts of sand and gravel outwash derived from debris-rich ice and till at the ice margin. This material accumulated to thicknesses of more than 200 feet in major valleys such as Black Earth Creek, the Sugar River, and the Yahara River.

Stops 7–12

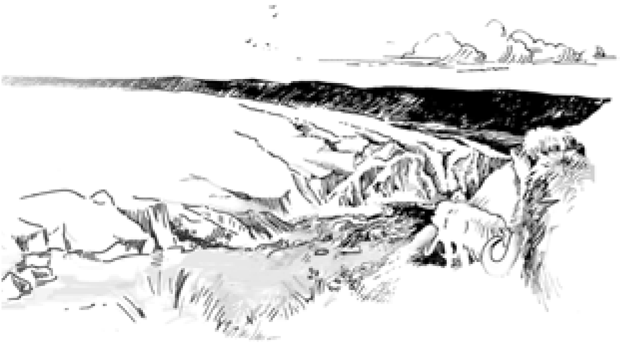
## Exploring the Moraine Zone

*North of Black Earth Creek*

The **Ice Age Trail** (see map) follows the terminal moraine zone discontinuously across the county. Because new segments may be added to the trail, an updated trail map will aid your exploration. The trail connects several of the parks mentioned below.

When the glacier was building the Johnstown moraine, broad outwash streams choked with gravel and sand flowed to the west and south. Stand at the overlook at **Festge County Park** (7) and picture a sunny summer day 15,000 years ago, when the whole foreground would have been covered with fast-flowing, crisscrossing river channels too deep to wade. The glacier was a mountain of ice extending about 1 mile beyond the quarry to the east. The hills on which you are standing, and those across the valley, were not covered by ice, but by tundra grasses, sedges, and low shrubs, with only scattered patches of spruce, birch, and willow. Mammoths and musk ox grazed this nearly barren landscape.

A similar scene, but on a grander scale, can be imagined from the high viewpoint in **Phil's Woods** (8).

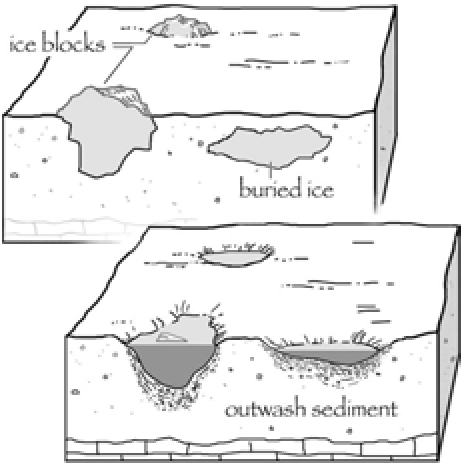


Mammoths foraged for food in the relatively barren tundra near the glacier.

Millions of years of stream erosion, not glaciation, formed the hills and valleys here. Glacial ice filled much of the lowland directly to the north and east of the point where you are standing. The edge of the glacier crossed the Wisconsin River at the Lake Wisconsin dam, which can be seen in the distance to the northeast. The ice front in this part of the county did not carry enough debris to build a moraine. Instead, only a scattering of *erratics* (large boulders that the glacier carried hundreds of miles from north and east of Lake Superior; some are scattered along the path in Phil's Woods) and their absence farther west, indicate that the ice stopped on this hill.

On the skyline to the north in Sauk County are the Baraboo Hills, which are composed of Precambrian quartzite that is very resistant to erosion. The hills that are closer are softer Cambrian sandstone. Note their rounded summits and compare them to the flatter dolomite-topped ridges to the west. Sauk Prairie (just across the Wisconsin River) lies on a huge outwash plain that extends from the sandstone hills to the river. The outwash plain also reaches from Sauk Prairie southwestward down the Wisconsin River valley, where it merges with outwash of Black Earth Creek near Mazomanie. **Walking Iron County Park** (9) occupies this low surface. Peat has accumulated along the poorly drained modern floodplain of postglacial Black Earth Creek. Higher outwash surfaces, called *terraces,* are found away from the floodplain. The terrace surfaces are remnants of the former beds of outwash streams, abandoned as Black Earth Creek and the Wisconsin River eroded their beds after the glacier began to recede. The dry, sandy soils of these terraces harbor prickly pear cactus and abundant pasque flowers, which bloom in early spring.

Just behind the Johnstown moraine, **Fish Lake** (10) and Crystal Lake occupy kettle holes. When the glacier was at its maximum expanse, this valley was occupied by a large tunnel channel that discharged water to the ice margin at Sauk Prairie. Lodi Marsh, the bottom of this tunnel channel, can be viewed from the **Lodi Marsh segment of the Ice Age Trail** (11). As the flow of water decreased, gravel was deposited along much of the valley bottom. Another huge tunnel channel extends from Norway Grove, beneath Waunakee Marsh, to the Milton moraine just west of Lake Brandenberg. The narrow roadcut through which Highway 19 passes about 0.25 mile west of the lake must have contained a gigantic fountain of water when water under high pressure in the tunnel channel poured out at the ice margin and rushed westward down the valley. **Indian Lake County Park** (12) occupies a kettle that formed after a buried ice block melted. Trails in the park traverse smaller kettles and ridges. The steep valley walls are Cambrian bedrock.




How kettle lakes form.

Stops 13–19

## Exploring the moraine zone

*South of Black Earth Creek*

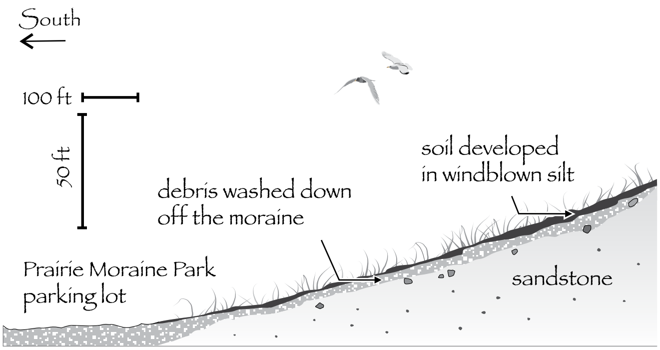
A good place to walk along the Johnstown moraine is at the **Cross Plains Unit of the Ice Age Scientific Reserve** (13). *(This is undeveloped and has no parking area. Use care!)* Follow the path northwestward from the intersection of Old Sauk Pass and Cleveland Road (be careful of poison ivy) and climb onto this low, erratic-strewn ridge. Only 20 to 50 feet of the relief is due to the moraine. The much greater drop into Black Earth Creek valley to the north is a slope that is mostly bedrock. Imagine being able to step onto the ice edge here at the moraine crest and to walk all the way to the Arctic, Atlantic, or Pacific Ocean on glacial ice.

Along the south side of the moraine, water drained toward the west, parallel to the front of the moraine. Walk westward along the moraine to a deep channel called Wilkie gorge. The flowing water turned sharply here and dove beneath the ice. The channel was cut quickly through the Oneota Formation dolomite as meltwater rushed under the ice and flowed into Black Earth Creek valley and finally out from beneath the ice at Cross Plains. *(Please do not climb the steep slopes of the gorge because sensitive vegetation will be destroyed!)* The Johnstown moraine lies just east of and parallel to Timber Lane where it intersects with Mineral Point Road. When the glacier sat here, outwash streams flowed downslope across the present position of Timber Lane into a low area now called **Shoveler Sink** (14), just west of Timber Lane, and then north along the ice margin.

Hummocky terrain of the Johnstown moraine can also be hiked at **Prairie Moraine County Park** (15). Park in the lot off Wesner Lane, which intersects with

Highway PB 0.75 mile south of Highway M. The St. Peter sandstone crops out near the road in front of the moraine and in the dog park. Note the scatter of boulders and the somewhat hummocky surface as you walk north, up the front of the Johnstown moraine to its crest. The view to the north is across Mill Creek valley, which is underlain by sand and gravel outwash deposited by a large braided river flowing toward the southwest when the glacier sat at the Milton moraine, about 1.5 miles northeast. From Prairie Moraine Park, the Verona segment of the Ice Age Trail follows the moraine to north of Whalen Road, where it turns northeastward and parallels Mill Creek valley to **Badger Prairie County Park** (16). The hill immediately east of the park entrance is an old landfill, but other hills are natural bedrock covered with thin glacial deposits.

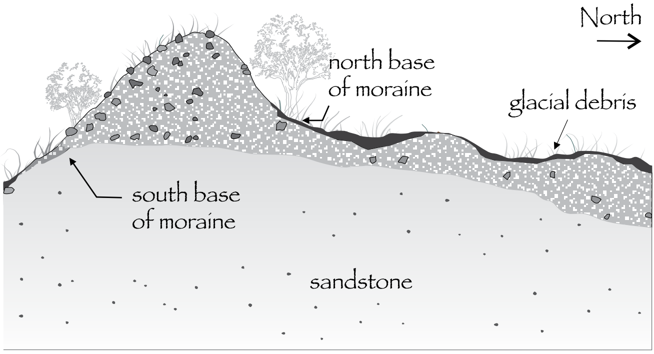
The **Milton moraine** is a ridge a few hundred yards northeast of the intersection of Highways 18 and 151 and PD. The quarries east and west of that intersection supply dolomite (Sinnipee Group) aggregate for roads and buildings in the Madison area. St. Peter sandstone is exposed low in the valley walls. *(View from a distance. This is private land, and active quarries are dangerous!)* The Milton moraine is also an




The Johnstown moraine is a prominent feature of Prairie Moraine Park.

obvious ridge across Mineral Point Road about 0.5 mile east of West Towne Shopping Center, which is built on outwash. Another good place to see the Milton moraine is along Highway M between Oregon and Verona. The moraine is the wooded ridge crossed by Highway 14 just north of the Highway M exit north of Oregon. The hummocky surface of the Johnstown moraine shows up well in the golf course along Highway 14 about 1 mile north of Evansville in Rock County. The southernmost segment of the Ice Age Trail in Dane County is in the **Brooklyn Wildlife Area** (17), where the trail follows outwash from the Johnstown moraine. Except for the view to the north where the crest of the Johnstown moraine can be seen, the hills have a cover of thin till that was deposited during advances of glaciers prior to the Late Wisconsin.

The trails in the western part of the **University of Wisconsin–Madison Arboretum** (18) cut across a small moraine that formed later than the Milton moraine; several other small moraines can be seen in eastern Dane County. However, many hills in the end moraine region of Dane County are made of bedrock. For instance, **Elver Park** (19) hills are bedrock only slightly modified by glaciers.




Note its narrow crest and the hummocky topography on its north side.

## Lakes in the Yahara valley

*Remnants of a glacial lake*

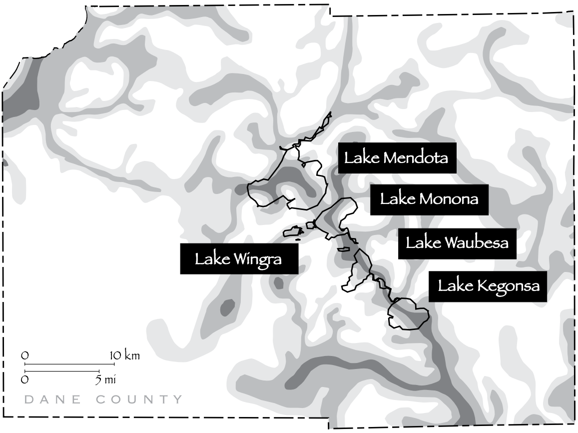
In central Dane County a large valley—the preglacial Yahara valley—extended beneath the area of our present Lakes Mendota, Monona, Wingra, Waubesa, and Kegonsa. It was a deep valley—it now contains glacial deposits that are more than 300 feet thick.

When ice stood at the Johnstown and Milton moraines (see map), meltwater flowed westward, down Black Earth Creek valley and other valleys into the Wisconsin River. As the glacial margin receded northeastward over the drainage divide into the Yahara–Rock River basin, meltwater was trapped between the drainage divide and the ice edge. Glacial Lake Middleton formed where the city of Middleton, its industrial park, and airport are today. The level of this lake was about 940 feet above sea level. At first, drainage continued to the west down Black Earth Creek, but as the ice edge continued to recede into the basin that is now occupied by Lake Mendota, water was able to find its way along the ice margin to the south and down the Yahara River valley. The bed of glacial Lake Middleton became a marsh as the water level dropped to about 860 feet above sea level (about 15 feet higher than the present level of Lake Mendota), and another lake, glacial Lake Yahara, grew along the edge of the receding ice.

As the ice margin continued to melt back, glacial Lake Yahara expanded into much of the preglacial Yahara River basin not already filled by glacial deposits. It extended from Middleton to Cherokee Marsh and Truax Field to encompass the area now under our lakes and surrounding marshes and lowlands as far south as Stoughton. Remnants of the floor of the lake can be seen in the nearly flat landscape throughout central

Dane County. More than 60 feet of fine sand and silt accumulated in parts of this lake basin; the material was carried in by outwash streams draining southwestward. Excavations in low areas of central Madison and south to Stoughton expose this silt and sand lake deposit, which in many places is covered with peat that accumulated since the lake shrank to the five lakes of the present day.

Geologists have no precise record of when glacial Lake Yahara drained, but it may have lasted for several thousand years, slowly dropping to the level of today's Yahara lakes as the Yahara River eroded its bed. The glacial lake probably existed when Paleo-Indians hunted this area; artifacts have been found along the old shorelines. All the hills in the central Yahara valley south to Stoughton as well as the hills in the isthmus area of Madison, such as the hill on which the Capitol stands, were islands in glacial Lake Yahara.




Tinted areas in the map above indicate the thickness of glacial deposits in Dane County—the darkest areas have the thickest sediment. The Yahara River valley was so deep that it was not completely filled, and the five Yahara lakes occupy the low, unfilled areas.

Stops 20–37

# Exploring the Yahara Valley

Wetlands were much more extensive at the time Europeans settled in the Yahara valley in the 1830s than they are today. These wetlands began to be drained for agricultural use around the 1850s; as more land was needed for development, people filled in low areas to "improve" them.

If you peek in excavations in the low areas of Madison and south to Stoughton, you will see that they expose sand and silt deposited in ancient Lake Yahara, covered with a few feet of peat. **Marshall Park** (20) in Middleton and **Warner** (21), **Vilas** (22), **Quann** (23), **Brittingham** (24), **Tenney** (25), **Olbrich** (26), and **Law** (27) **Parks** in Madison lie on sediment of this former lake. Only a few former beaches are visible, but note the boulder concentrations at an elevation of about 860 feet above sea level along parts of **Picnic Point** (28), the **Lakeshore Path** (see map) along the lake west of Park Street,

Marshes such as this one covered much of Dane County prior to European settlement.

and in the wooded part of **Olin–Turville Park** (29). All these places have experienced human activity, so it is likely that these lakeshore boulders have been moved. Boulders are concentrated at the edge of the tree line along the west edge of a marsh west of the Yahara River and south of the Beltline Highway. The boulders and an old sandy beach, now covered by vegetation, indicate that the level of glacial Lake Yahara dropped from about 860 feet to about 852 feet above sea level soon after the glacier receded.

Northeast of Madison, **Cherokee Marsh** (30) lies on Lake Yahara sediments, and a few remnants of shoreline remain in this area. Northeast of the Cherokee Marsh parking lot at the north end of Sherman Avenue, a large hill of Cambrian sandstone shaped somewhat by the glacier was an island in the lake. Boulders from what was probably a shoreline of glacial Lake Yahara are also evident in the University of Wisconsin–Madison Arboretum near Big Spring at an elevation between 850 and 860 feet. South of Madison, much of the **Nine Springs E-Way** (see map) part of **Capital Springs Centennial Park** (31), east of Fish Hatchery Road, was a bay of glacial Lake Yahara. **Lake Farm County Park** (32) is also underlain by glacial Lake Yahara sediments. The low hills south of Libby Road are drumlins. (See the next page to learn more about these streamlined hills.) Farther south, **Goodland** (33), and **Babcock** (34) **County Parks** on Lake Waubesa and **Fish Camp** (35) and **La Follette** (36) **County Parks** on Lake Kegonsa also lie on these sediments. The upland of **Lake Kegonsa State Park** (37) stood as an island in the lake. Note the flat, poorly drained areas to the north, east, and west; these areas were the former lake bottom.

# Footprints of the glacier

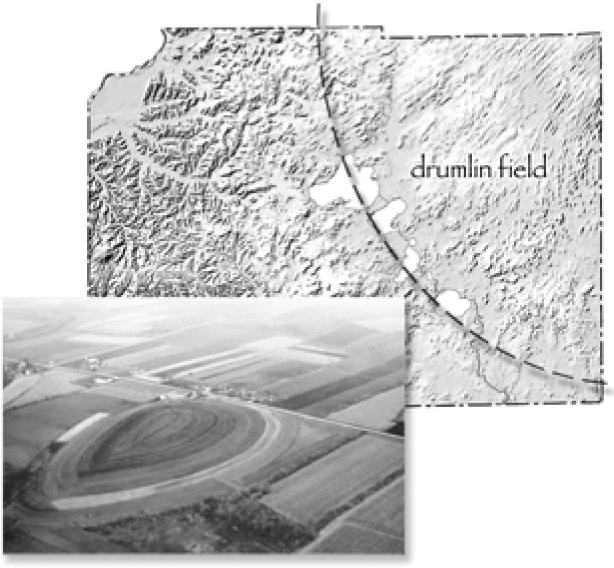
*Drumlins and eskers*

While the Green Bay Lobe stood at its maximum extent into Dane County, the landscape beneath thick ice in the central and eastern parts of the county was being streamlined, much like a layer of peanut butter being scraped with a serrated knife. The most distinctive results of this glacial sculpting are elongate hills called *drumlins,* which parallel the flow direction of the ice. These hills are commonly about 1 mile long and up to a few hundred feet high. They are composed of glacial deposits, stream-deposited sand and gravel, and bedrock of the preglacial landscape. Erosion and deposition contributed to the shaping of these hills. More than 5,000 drumlins are present in the area that was covered by the Green Bay Lobe. Interstate 94 between Madison and Milwaukee crosses many drumlins; Highway 151 from Madison to Beaver Dam parallels many of these elongate hills.

Why did drumlins form where they did? Perhaps they represent areas of the still-frozen, erosion-resistant glacier bed, shaped into streamlined forms by surrounding wet-bed, sliding ice. Drumlins are not apparent in the terminal moraine zone, suggesting that the ice had to be several hundred feet thick for them to form. A few small, discontinuous recessional moraines in eastern Dane County formed later than the drumlins and were draped over them as the ice margin wasted back across the subglacially sculpted landscape.

During the time when the edge of the ice was at the Johnstown and Milton moraines, drumlins were forming and tunnel channels were draining water and sediment from beneath the ice. By the time the ice edge had receded from the Milton moraine, the huge tunnel channels had ceased to carry water; the smaller tunnels in and beneath the ice drained water to the ice margin in thousands of places. Most of these subglacial streams dumped their sediment at the ice margin, leaving outwash and lake sediment in the lowlands of the central and eastern part of the county, and little trace of the tunnels.

A few ice tunnels, however, were filled with sand and gravel; when the glaciers had melted away, these deposits remained as winding ridges called *eskers*. Many of the larger eskers in Dane County were excavated long ago because they were excellent sources of sand and gravel.




Drumlins corrugate a large part of eastern Dane County. The tip of the teardrop-shaped drumlin in the photograph points in the direction of ice flow.

Stops 38–41

# Exploring the Drumlin Zone

East of the Yahara lowland, Ordovician dolomite of the Sinnipee Group caps the high hilltops. Low hills are topped with dolomite of the Oneota Formation; valleys are mostly underlain by sandstone. As you drive eastward of the Yahara lowland on Highway 30, note the rise of the dolomite upland between Highway 51 and Interstate 90–94. Conversely, note the broad Yahara valley and how low the Capitol is as you drive into Madison on Highway 30 from Interstate 90–94. You can see the same transition from the Yahara lowland to the dolomite upland on Cottage Grove Road just east of where it crosses the interstate.

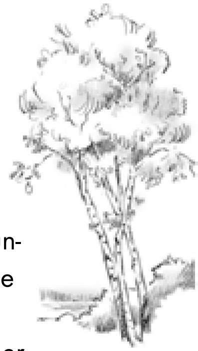
The streamlining action of the glacier created much of the landscape of the eastern third of Dane County. Drumlins abound, and a good place to see them is along the **Glacial Drumlin Trail** (see map). East of Cottage Grove, the trail winds around hills (all of them drumlins) oriented south–southwest, a direction that was parallel to ice flow. Most low areas are underlain by outwash sand that has a thin cover of peat; all have been partly drained for agriculture. Imagine the miles of wet, marshy ground surrounding the drumlins that existed before this land was drained. East of Deerfield, the floor of Mud Creek is underlain by sediment of a lake that developed in the Koshkonong Creek basin as the glacier receded. Farther south in this valley, **Cam-Rock County Park** (38) occupies outwash and lake sediment in a valley that probably was a tunnel channel when it was beneath ice. Hills surrounding the valley were streamlined somewhat by the ice and have dolomite bedrock close to the land surface.

Some of the upland is slightly streamlined without actually having drumlins. **Token Creek County Park** (39) is underlain by sandy outwash in low areas and in the south by till-covered bedrock. Edges of **McCarthy County Park** (40) are underlain by till, but lake sediment lies beneath all the low, flat areas.

Drumlins extend into the Yahara lowland as well, and most were islands in ancient Lake Yahara. The Capitol building sits on a drumlin. Another lies at the head of Wisconsin Avenue. **Bascom** and **Observatory Hills** (41) on the University of Wisconsin–Madison campus, although not very elongate, are also drumlins. On Observatory Hill, note Chamberlin Rock, a large erratic composed of gneiss, a metamorphic rock. From this vantage point, you can see Picnic Point, a former stream divide between the main preglacial Yahara River and a tributary that flowed beneath what is now University Bay. The Class of 1918 Marsh and surrounding athletic fields, parking lots, and buildings rest on clay and silt of the bed of glacial Lake Yahara.

Chamberlin Rock, on the University of Wisconsin–Madison campus, commemorates Thomas Crowder Chamberlin (1843–1928), an eminent scientist of varied interests, a prolific writer and mapmaker, and a pioneer in glacial geology.

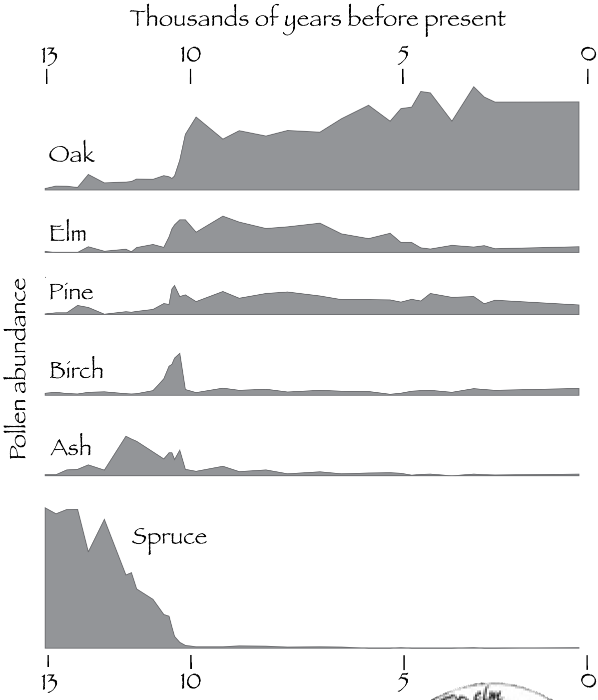
## The climate warms

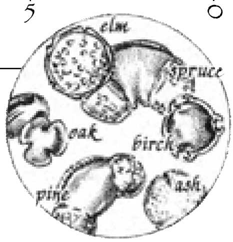


By 13,000 years ago, average annual temperatures had increased significantly, and glaciers were shrinking rapidly. In their wake, the tundra landscape was invaded by spruce trees, which first formed a savannah, then a dense forest of spruce and other conifers. Mammoths migrated northward with the tundra, and mastodons wandered the spruce-covered landscape to the south. Low areas between the drumlins were flooded with shallow lakes that were slowly invaded by peat bogs of *Sphagnum.* Giant beavers more than 6 feet long lodged in these wet areas. So did other mammals and invertebrates; some of the same species still inhabit the spruce forests of southern and central Canada.

As the ice was melting back from Dane County, the glacier continued to grind up the rocks at its base into mineral grains smaller than sand, but larger than clay. The resulting silt grains accumulated on the newly exposed floodplain and were later picked up by the wind. Major sources of this windblown loess in southern Wisconsin were the Mississippi, Rock, and Wisconsin River floodplains. At that time the air was full of dust on dry days, much like it is today in the spring when farmers prepare their fields. The loess fell with roughly equal thickness across all the landscape, but has since been concentrated by surface water at the base of slopes and in low areas between the drumlins. In many places it is several feet thick, especially in the Driftless Area. Throughout Dane County the loess forms a cover that provides great moisture-holding ability to our soils.

As shallow lakes filled in, *Sphagnum* gave way to the sedges and grasses of our present wetlands, and deciduous forests replaced spruce. Climate fluctuations during the past 10,000 years have resulted in alternations of deciduous forest, oak savannah, and prairie. Pollen grains preserved in basins like Hook Lake, near Oregon, and Lakes Waubesa, Wingra, and Mendota record the change in vegetation that was taking place as the landscape evolved.




Analysis of pollen material found in core samples from Hook Lake in Dane County reveals a shift from spruce to deciduous trees over time.

## Change marches on

As the ice margin receded, Paleo–Indians trekked across the landscape, harvesting fish and the wildlife of their time: mammoths, mastodons, giant beavers, and musk oxen. By approximately 4,000 years ago, these animals had become extinct or migrated northward with the tundra, and more permanent bands of village-dwelling Woodland Indians replaced the nomadic groups. The villagers hunted species that still exist today.

It was not until the arrival of European settlers in the 1830s that another major impact was made on our landscape. These settlers wanted land that was suitable for agriculture, so they cleared it of trees, drained many of the wetlands, and plowed the land into farm fields.

Much of this development has been enabled by the effects of glaciation. Silt-sized grains of diverse minerals—fragments abraded by the glacier and deposited on the land surface directly by the glacier, by meltwater streams, or by wind—resulted in naturally fertile, easily tillable soils. Coarser-grained glacial deposits contain abundant supplies of water for domestic wells and, perhaps more important, supply springs that feed the numerous streams and lakes in Dane County. The coarsest-grained sediments have also provided millions of tons of aggregate for asphalt and concrete, vital components for the development of Madison and surrounding towns.

Ice Age deposits are also used as repositories for the waste produced by our ever-expanding population. Fine-grained sediment, if properly used and engineered, can help to limit the migration of contaminants and provide relatively safe sites for waste disposal.

The further drainage of wetlands, modification of the landscape, and suburban development will play a major role in determining what future generations will see as the Dane County landscape.

Will the glaciers return to Dane County? It is likely that they will, if the geologic record of the past 2 million years is an indication. But humans may be modifying climate through deforestation and the burning of fossil fuels, thereby increasing emissions of carbon dioxide and other gases to our atmosphere, so the past may not be an accurate predictor of the future. Only time will tell.

# Sources of information

Clayton, Lee, and Attig, J.W., 1997, Pleistocene geology of Dane County, Wisconsin: Wisconsin Geological and Natural History Survey Bulletin 95, 64 p.

Clayton, Lee, Attig, J.W., and Mickelson, D.M., Johnson, M.D., and Syverson, K.M., 2006 [third edition], Glaciation of Wisconsin: Wisconsin Geological and Natural History Survey, Educational Series 36, 4 p.

Dott, R.H., Jr., and Attig, J.W., 2004, *Roadside Geology of Wisconsin:* Mountain Press Publishing Company, 346 p.

Mickelson, D.M., 1983, A Guide to Glacial Landscapes of Dane County, Wisconsin: Wisconsin Geological and Natural History Survey Field Trip Guide Book 6, 53 p.

Niemann, B.J., 1973, The environmental effects of urbanization upon the Yahara River Basin landscape: Environmental Awareness Center, University of Wisconsin–Madison, 16 p.

Reuss, H.S., Tanner, Gilbert, Dinsmoor, Philip, and Hellman, Robert, 1976, On the trail of the Ice Age: Milwaukee Public Museum, 77 p.

# Acknowledgments

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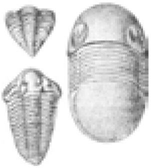
# Figure credits

Page 3: Shaded relief map of Wisconsin modified from Woodward, D.A., 1971, Landforms of Wisconsin: Wisconsin Geological and Natural History Survey Page Size Map 12, scale 1:2,730,000.



Page 4–5: Brachiopods from figure 30, crinoid from figure 48, and trilobites from figure 57 of Chamberlin, T.C., 1883, *Geology of Wisconsin, 1873-1879,* Volume I: Chief Geologist/Commissioners of Public Printing, p. 155, 189, and 195, respectively.

Page 6–7: Stratigraphic column modified from figure 8 of Clayton, Lee, and Attig, J.W., 1990, Geology of Sauk County, Wisconsin: Wisconsin Geological and Natural History Survey Information Circular 67, p. 14, and figure 39 of Clayton, Lee, and Attig, J.W., 1990, Pleistocene geology of Dane County, Wisconsin: Wisconsin Geological and Natural History Survey Bulletin 95, p. 35.

Page 10: Topographic detail modified from figure 3A of Clayton, Lee, and Attig, J.W., 1990, Pleistocene geology of Dane County, Wisconsin: Wisconsin Geological and Natural History Survey Bulletin 95, p. 4.

Page 11: Photograph of Donald Rock by D.M. Mickelson.

Page 14: Photograph of striations by T.S. Hooyer.

Page 20–21: Cross-section information courtesy of Lee Clayton.

Page 24: Marsh photograph by D.M. Mickelson.

Page 27: Aerial photograph by Donna Harris; drumlin map modified from figure 24 of Clayton, Lee, and Attig, J.W., 1990, Pleistocene geology of Dane County, Wisconsin: Wisconsin Geological and Natural History Survey Bulletin 95, p. 21.

Page 31: Pollen diagram modified from information provided by L.J. Maher; pollen close-up modified from Attig, J.W., Clayton, Lee, Lange, K.I., and Maher, L.J., 1990, The Ice Age geology of Devils Lake State Park: Wisconsin Geological and Natural History Survey Educational Series 35, p. 24.

# Notes

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Cover: Photograph of Prairie Moraine Park by D.M. Mickelson.