Department of Geography
University of Wisconsin-Madison
383 Science Hall
550 North Park Street
Madison, Wisconsin 53706
(608) 262-2138

October 15, 1992

James A. Hunt, Coordinator
Wine and Beer Branch
Bureau of Alcohol, Tobacco and Firearms
Ariel Rios Federal Building
1200 Pennsylvania Avenue NW
Washington, DC 20226

Reference: C:R:W:JAH 5120

Dear Mr. Hunt:

Based on the suggestions of your letter postmarked July 20, 1992, and our several phone conversations before and since that date, I wish to revise the last petition submitted to you, dated February 12, 1992, proposing an American Viticultural Area in Wisconsin. In that version of the petition, the place-name "Lake Wisconsin" was suggested as the Appellation of Origin for wines grown and produced within the Viticultural Area, hereafter referred to as the Lake Wisconsin Viticultural Area, or LWVA. This revised petition also supersedes the first version sent to you, dated June 17, 1991. I am re-submitting the petition on behalf of Robert P. Wollersheim and JoAnn I. Wollersheim, proprietors of the Wollersheim Winery, Prairie-du-Sac, Wisconsin, who wish to establish the Lake Wisconsin Viticultural Area in accordance with Treasury Decision ATF-53 (1978) and Treasury Decision ATF-60 (1979) regarding Title 27, *Code of Federal Regulations*, Part 4, Sections 4.25a(e)(1) and 4.25a(e)(2), and Part 9, all pertaining to the creation of American Viticultural Areas. The following information is offered in support of this petition and is presented according to BATF Industry Circular Number 80-15 (1980) and examples found in the *Federal Register*.

General Description of the LWVA and Winery

The LWVA is located in the state of Wisconsin, about thirty miles northwest of the capital of Madison, in the northwest corner of Dane County and the southwest corner of Columbia County, directly east across the Wisconsin River from Sauk City and Prairie-du-Sac, Sauk County. It includes all or part of Roxbury and Dane Townships in Dane County, and West Point and Lodi Townships in Columbia County. The LWVA is largely a region of pitted outwash plains and ground moraines interspersed with hills of limestone bedrock and glacial till (Martin, 1974; Hole, 1980). There are currently twenty-three acres of *vinifera* and French hybrid grape varieties being grown within the approximately 28,000 acre LWVA.

The vineyards and winery buildings are all located in Roxbury Township, Dane County. The Wollersheim family purchased the winery property in 1972 and began to restore the adjacent vineyards, which had been idle since the turn of the century. In 1976 they produced their first vintage from newly-bearing vines. After two decades of experimentation with appropriate grape varieties and cold-climate viticultural techniques, the Wollersheims now grow, produce, and bottle wine made from Marechel Foch, Leon Millot, and Seyval Blanc French hybrids, and from Chardonnay and Pinot Noir *vinifera* varieties. Viticultural adaptations to the northern, interior continental climate of the area include high-density vineyard planting, laying down and covering *vinifera* grapevines during winter, and low-training of hybrid varieties on double trellis and top cordon systems (Winkler, 1974; Weaver, 1976; Morton, 1985).

Established Use of the LWVA Name and Historical Significance of the LWVA

The place-name "Lake Wisconsin" was first used ca. 1917 to describe a widened section of the Wisconsin River that was submerged as a result of the construction of the Baraboo hydro-electric dam one mile upriver from Prairie-du-Sac. The travel brochure and map produced by the Lake Wisconsin Chamber of Commerce, entitled *Lake Wisconsin Chamber Recreation Area Vacationland* (1989) and showing various recreational and tourist facilities in the LWVA, provides evidence that the name is currently in use and is known and recognized locally. A copy of this brochure was sent to you with the February 12, 1992 version of this petition.

The LWVA has a long history of viticultural activity. Agoston Haraszthy, an immigrant from Hungary and a colorful figure of some renown in the wine industry, first planted grapevines on the winery property in 1847. Cold winter temperatures frustrated his winegrowing experiments, and two years later Haraszthy resettled to California. Around the same time the property was bought by a German immigrant, Peter Kehl, who replanted the vineyards with Isabella and Catawba native grape varieties (Pinney, 1989). According to the winery account books kept intermittently between 1858 and 1904, Kehl was producing both red and white wine by 1868. After his death in 1870, his son Jacob continued grape-growing and wine-making until the century's end. At least three other German-American families in Roxbury Township were engaged in viticulture during this period (*History of Dane County, Wisconsin*, 1880). The Kehl vineyards were destroyed by severe cold during the winter of 1898-99. Jacob Kehl died that same winter, and shortly thereafter the family stopped growing grapes and making wine.

In 1976 the winery and homestead were listed on the National Register of Historic Places as a property that is significant in the history of Wisconsin (see enclosed NRHP form). Landmark status is based on the architectural qualities of the winery buildings, and the winery's importance as a pioneer industry that contributed to the economic and social development of rural Wisconsin. Landmark status is also based on the winery's historic association with Agoston Haraszthy (mentioned above), who briefly experimented with wine-quality grapes on the site before moving to California, where he embarked on a new series of viticultural endeavors. Haraszthy is known today as the "father of California viticulture," and as a tireless promoter of the Zinfandel grape variety so important to the present-day California wine industry (Schoenman, 1979; Adams, 1990).

General Description of the LWVA Boundary

The LWVA is bounded by the shoreline of Lake Wisconsin and the Wisconsin River on the north and west. The south boundary is defined by several highways and roads, and the east boundary by Spring Creek.

The Wisconsin River (of which Lake Wisconsin is a part) is a major natural feature on a state and regional scale. It is the largest river in the state, a tributary of the Mississippi River, and a historic route of exploration, navigation, settlement, and trade (Martin, 1974). The section of the river that borders the LWVA (including the Lake Wisconsin shoreline) marks a significant change in soils between the former para-glacial environment within the LWVA, and the unglaciated regions north and west of the LWVA.

U.S. Highway 12, State Highways 188, Y, 60, 113, and Mack Road all define the southern boundary of the LWVA. The landscape north of this boundary, within the LWVA, is comprised of discontinuous end moraines interspersed with ground moraines and occasional outwash plains. By contrast, the landscape south of the boundary and outside the LWVA is of locally higher elevation and relief, and is comprised of rolling, hummocky upland with some outwash material.

The east boundary of the LWVA, defined by Spring Creek, identifies an area of low relief, continuous and intermittent stream drainage, and marsh. To the east of Spring Creek, and outside the LWVA, is a glaciated upland plain between Lodi and Interstate Highway 90/94, an area of generally higher elevations of ground and end moraines with little or no outwash material.

The natural features of the proposed boundary are described in directories of historical Wisconsin place-names (Cassidy, 1968; Gard, 1988), and can be located on maps of Dane and Columbia Counties that date back to 1861. They are correctly shown on recent USGS topographical maps of the general region (1975), and on a multitude of plat maps and county atlases published between 1861 and 1947. They are documented in USGS aerial photographs and are easily visible on the ground from a car or on foot.

Description of Growing Conditions Within the LWVA

Several environmental and geographic features set the LWVA apart from the surrounding region and produce unique grape-growing conditions that are not found outside the LWVA's boundaries. The LWVA has a mean annual precipitation of twenty-nine inches, two inches less than the state average and three inches less than the surrounding region. In effect it is an "island" of locally below-average rainfall and drier soils that grapevines respond to by concentrating vigor in the ripening fruit. In addition, the LWVA has a growing season of 160-180 days, ten to twenty days longer than the region west and north. The additional frost-free period allows the grapes to ripen adequately before the onset of winter cold (Palm, 1983; Weaver, 1976; Winkler, 1974).

The LWVA benefits from the microclimatic effects of the lower Wisconsin River Valley. The river is about 2,500 feet from the main vineyards and facilitates cold-climate viticulture in several ways (Geiger, 1966). It moderates winter temperatures in the vineyards, which can be several degrees warmer than areas further downwind from the river or on the river's windward side. Air circulation within the river valley prevents cold air accumulation and frost pockets from forming in the vineyards. In summer, the river valley and limestone bluffs along the river's edge serve to channel air currents and increase localized air circulation, protecting the vineyards from mildew and rot in hot, humid weather.

The Wisconsin River also forms an approximate dividing line between the glaciated and unglaciated regions of southcentral Wisconsin (Martin, 1974). Primarily glacial soils of depositional till and outwash material are found east of the river valley, in State Soil Region B, and characterize the soils of the LWVA (Hole, 1980). The unglaciated "driftless" soils west of the valley result from significant differences in soil parent materials, microrelief, and drainage.

The soils that support viticulture within the proposed area are Typic Hapludalfs of mixed mineral material and silty or loamy texture. All are underlain by gravelly or sandy loam glacial till or by dolomitic bedrock (Hole, 1976). Grouped by catena and county, the Dodge-St. Charles-McHenry association (Dane) and the St. Charles-Ossian-Dodge association (Columbia) are well-drained soils about 36-60 inches deep on slopes and rolling areas of 2-45 percent gradient. The other dominant soils, locally less well-drained, are Mollic Hapludalfs and Haplaquolls of the Batavia-Houghton-Dresden association (Dane) and the Mt. Carroll-Seaton-Dresden association (Columbia) (*County Soil Surveys*, 1977, 1978). These are underlain by outwash silt, sand, and gravel of glacial origin. The soils outside the area to the north and west are predominantly unglaciated, and so are not underlain by glacial till. They contain less outwash material and greater amounts of wind-blown silt (loess) in their upper horizons. The soils outside the area to the south and east, although glacially derived, are found on topography of rolling upland with fewer limestone outcrops and no outwash plains. The soils there have formed on slightly higher elevations over discontinuous end and ground moraines.

The vineyards are located at an elevation of 800-900 feet along south and southwest-facing slopes of 5-35 percent gradient. This combination of elevation, relief, and aspect contributes to the well-drained quality of the vineyard soils, the free circulation of air in summer and winter, and the locally longer growing season. Outside the proposed area, higher elevations of 900-1,200 feet increase the risk of wind damage to grapevines, or the soils become too shallow for successful grape cultivation where bedrock is nearer the surface or exposed. Elevations between 720 feet (Wisconsin River level) and 800 feet are generally less well-drained or are saturated during periods of rainfall and snow-melt.

Narrative Description of the LWVA Boundary

The following narrative refers to the "Lodi, Wis." and "Sauk City, Wis." 7.5 minute series USGS quadrangle maps sent to you with the first version of this petition dated June 17, 1991:

> The point of beginning is on the "Lodi, Wis." USGS map in the northeast quarter-section of Section 17, Lodi Township, Columbia County, where Spring Creek enters Lake Wisconsin,
>
> Then follow the southern shoreline of Lake Wisconsin northwest to where Lake Wisconsin narrows and becomes the Wisconsin River on the map, in the vicinity of the town of Merrimac, Sauk County,
>
> Then continue along the southern shoreline of the Wisconsin River, west and south past Goose Egg Hill, Columbia County, on the "Sauk City, Wis." quadrangle map, and then west to a southwest bend in the shoreline opposite Wiegands Bay, Sauk County, where the Wisconsin River becomes Lake Wisconsin again on the map,
>
> Then southwest and south along the eastern shoreline of Lake Wisconsin, to the hydroelectric dam and powerplant that defines where Lake Wisconsin ends and the Wisconsin River begins again,
>
> Then continuing south along the Wisconsin River shoreline to where it intersects with U.S. Highway 12 opposite Sauk City, Sauk County,
>
> Then south and southeast on U.S. Highway 12 to the intersection at State Highway 188, just over one-half a mile,
>
> Then east about 1,000 feet on State Highway 188, to the intersection of Mack Road,
>
> Then east on Mack Road to the intersection of State Highway Y, about three miles,
>
> Then follow State Highway Y northeast, southeast, and east onto the "Lodi, Wis." quadrangle map to the intersection with State Highway 60,

Then northeast on State Highway 60 to the intersection with State Highway 113 in the town of Lodi,

Then north on State Highway 113 to where it crosses Spring Creek the second time just before Chrislaw Road,

Then follow Spring Creek north to the point of beginning.

Per our phone conversation of October 14, 1992, I understand that you will revise the USGS quadrangle maps sent to you with the June 17, 1991 version of this petition, so that the maps depict the revised LWVA boundary described by this narrative.

Request for Pending Status, Information, and Updates

Please confirm in writing to me that this request for an Appellation of Origin for the Wollersheim Winery, to be known as "Lake Wisconsin," continues to be officially pending. Please also send the BATF quarterly bulletin that announces viticultural area hearings and designations.

If you have any questions or comments regarding this petition, please contact me at the above address, or telephone me at (608) 263-3992 (office) or [redacted] (home).

Sincerely,

Charles W. Dean

Charles W. Dean
Viticultural Area Consultant
cdean@geography.wisc.edu (INTERNET)

Attachments and enclosures:
Bibliography of sources;
National Register of Historic Places Nomination Form;
Topographic map detail showing vineyard locations relative to LWVA boundary;
Pages from the Kehl Winery account book (1868, 1891);
Wisconsin state maps showing the Lake Wisconsin Viticultural Area in relation to geographic and cultural features, annual precipitation levels, length of growing season, and Soil Region B.

copy: Robert Wollersheim

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Page from Account Book of Peter Kehl
showing place, date, and wine sold.

Roxbury February 1868

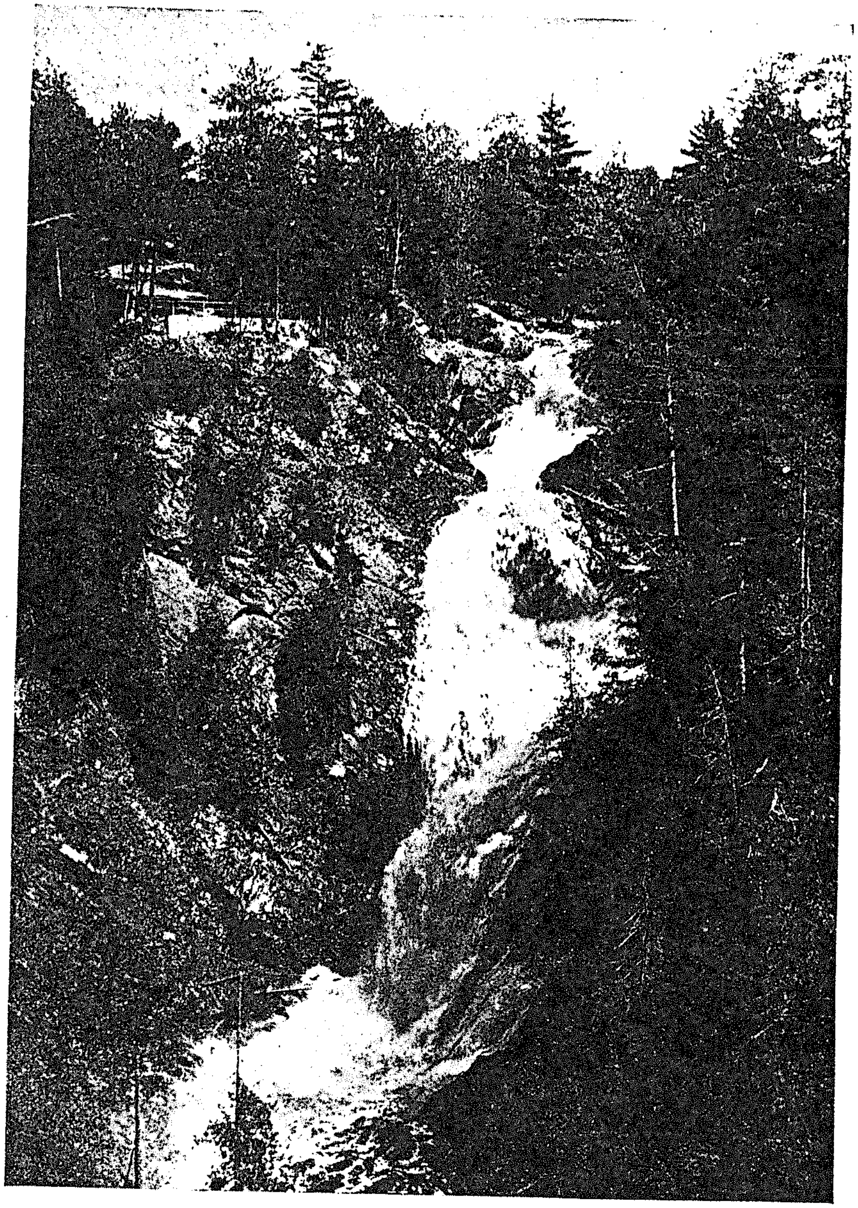
618,22	3	Alowis Becker Sauk City Dr. To 10 Gall. Catawba Wine	$ 12 50	
64	3	Augustus Ludwick Clifton Dr. To 6½ Gall. Catawba Wine	$ 8 12	
	5	Henry Hoesley New Glarus Dr. To 16 Gall. Wine @1/-	$ 20 00	
	5	Jacob Kipfer New Glarus Dr. To 16 Gall. Wine @1/-	$ 20 00	
	5	Jacob Hefty New Glarus Dr. To 16 Gall. Wine @1/-	$ 20 00	
	5	Peter Zweifel New Glarus Dr. To 16 Gall. Wine @1/-	$ 20 00	
	6	J. C. Ott Madison Dr. To 6 Gall. Wine @1/-	$ 7 50	
	3	A. Beaker Sauk City Cr. By 3 - 10 Gall. Kegs @1/-		$ 3 75
	3	Albrecht & Schlag Baraboo Cr. By 4 - 10 Gall. Kegs 1/-		5 00
		" 3 - 6 " do. 7/-		2 62
				$ 7 62
	3	F. Miller Baraboo Cr. By 6 - 10 Gall. Kegs @1/-		$ 7 50
		" 5 - 6 " do. 7/-		4 38
				$ 11 88

Page from Account Book of Jacob Kehl
showing place, date, and wine sold.

1891	Roxbury Wis		
May	C. Borgert Dr.		
2	To 6 gals. wine @ $1.00	6	00
June	M. Huth Dr.		
2	To 10 gal. wine @ $1.15	11	50
	Cr.		
"	By Cash	11	50
June	A. Borgesser Dr.		
17	To bills for wine.	26.	00
"	Cr.		
	By Cash	26	00
June	Chas. Borgert Jr. Dr.		
23	To 6 gals. wine @ $1.25	7	50
"	" 6 " " @ $1.00	6	
"	Wm. Kretschmar Dr.		
"	To 10 gals. wine @ $1.25	12	50
"	Wm. Eisenmenger Dr.		
"	To 10 gals. wine @ $1.25	12	50
"	Fred Hennes Dr.		
"	To 70 gals. wine @ $1.00	70.	00
"	" 53 " " @ $.75	39.	75
"	L. Miller Dr.		
"	To 10 gals. wine @ $1.25	12.	50
	Carl [illegible] Jr. Dr.		
"	To 10 gals. wine 1.25	12.	50
"	Alvin Frebel Dr.		
"	To 10½ gal. wine @ $1.25	13.	10
"	" 10 " " @ $1.00	10	00

	Roxbury Wis. June 1891		
June	C. Pannhausen Dr.		
23	To 10½ gals. wine @ $1.25	13	10
"	" 10 " " @ $1.00	10	00
"	A. Borgesser Jr. Dr.		
"	To 11½ gals. wine @ $1.25	14.	35
"	Aug. Weitemeier Dr.		
"	To 159 gals. wine @ $1.00	159.	00
"	John Wald Dr.		
"	To 24 gals. wine @ $1.25	30.	00
"	Henry Wald Dr.		
"	To 20 gals. wine @ $1.25	25	00
"	" 20 " " @ $1.00	20.	00
"	Chr. Lawrence Dr.		
"	To 11 gals. wine @ $1.25	13	75
"	" 1 keg.		75
~~June~~	~~A. Borgesser Sr. Dr.~~		
~~29~~	~~To bills for wine~~	~~46~~	~~80~~
June	Math. Huth Dr.		
30	To 10 gals. wine @ $1.15	11	50
"	Cr.		
"	By Cash	11	50
July	Caspar Meuer Cr.		
18	By Cash in full	13	75
July	Chr. Lawrence Cr.		
23	By Cash in full	14	50

129
70
[illegible]



MANITOU FALLS, THE HIGHEST WATERFALL IN WISCONSIN.

One-hundred-and-sixty-foot cascade on the Black River, a tributary of the Nemadji, south of the city of Superior.

LAWRENCE MARTIN

The Physical Geography of Wisconsin

THE UNIVERSITY OF WISCONSIN PRESS

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The University of Wisconsin Press
Box 1379, Madison, Wisconsin 53701
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70 Great Russell Street, London

THIRD EDITION

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FOREWORD

This volume is a reproduction of the second edition of Lawrence Martin's classical work on the physical geography of Wisconsin, published in 1932. It differs only slightly from the first edition, published in 1916. Why, it might be asked, is such a book being reprinted with virtually no changes after almost half a century? Have there been no changes in statistical data, no advances in scientific knowledge?

The answer is that the timeless quality of this work transcends statistics which, after all, are often outdated even before they are printed. Changes in scientific information have been remarkably few; for the most part they consist of a fuller knowledge of details rather than changes in basic concepts. It matters little whether the Lower Magnesian limestone is now called the Prairie du Chien Group, for names of individual rock units are always prone to change but the rocks themselves remain the same.

The most noteworthy scientific advances of the past thirty years have been in the field of glacial geology. New dating techniques show that many of the glacial events are younger than was previously thought. Studies of modern glaciers and ice sheets have led to a fuller knowledge of glacial processes, which may demand some major revisions of our concept of the Ice Age in Wisconsin; but speculation in this regard would be premature at present, since much work yet remains to be done.

The relief map originally included as Plate I in both previous editions has reluctantly been excluded because of technical difficulties. The printed version did not lend itself to further reproduction, and deterioration of the original three-dimensional model made rephotographing impossible. The omission is pointed out by footnotes at key points of reference in the pages following.

We particularly regret that newly established Menominee County (formerly the northeastern portion of Shawano County) does not appear in maps showing county areas. While some attempt was made in the second edition to revise the old city name of Kilbourn to the present name of Wisconsin Dells, this attempt was not wholly sucinto its present form by processes in every way comparable to those now in operation.

Topography

General Form. The general topographic form of Wisconsin is indicated in the relief map of the state (Plate I).* The larger part of the state lies between 700 or 800 feet in the southeast and 1600 or 1800 feet above sea level in the north (Fig. 7). The highest point, 1940 feet, is Rib Mountain, Marathon County, near Wausau. The lowest elevation, 581 feet, is the eastern coast at the level of Lake Michigan. The northern coast at the level of Lake Superior, 602 feet, is nearly as low, as is the western border along the Mississippi River, where the elevation ranges from 670 feet at Lake St. Croix, near Prescott and Hudson, to 600 feet at the extreme southwestern corner of the state in Grant County, opposite Dubuque, Iowa. The approximate mean altitude is 1050.

Hydrography

Relation to Topography, Geology and Climate. The hydrography, or description of the rivers and lakes and coast, is involved with the features previously discussed as follows. The topography controls the slopes down which water shall flow. This itself, however, is originally determined by the geology, for (a) the dip of the surface of the sedimentary rocks provides original slopes for drainage, (b) the resistance or weakness of rock textures determines where uplands shall be left and lowlands sculptured by stream erosion, (c) the ice invasion, by its erosion and deposition, modifies preglacial drainage, causes waterfalls and rapids, and provides basins for lakes. The humid climate, also, is of importance, determining the steady water supply of the streams and the maintenance of the lakes.

Rivers. The drainage of Wisconsin is treated in detail in the chapters on the several uplands and lowlands. It may be briefly summarized as follows. The state is divided by a major watershed (Fig. 8), which determines (a) that some of the streams shall flow east into the Atlantic Ocean by way of Lake Superior or Lake Michigan, and (b) that the remaining streams—the larger number—shall flow south into the Gulf of Mexico by way of the Mississippi River.

The largest river of the state is the Mississippi, on the western border. Its chief affluents are the St. Croix, Chippewa, Black, and

*Excluded from the reprinting.

Wisconsin rivers, which unite with it in Wisconsin, and the Rock River and several smaller streams which flow through Illinois to the Mississippi. In the St. Lawrence drainage are the Fox-Wolf-Lake Winnebago system, the Menominee on the northeastern boundary between Wisconsin and Michigan and many smaller streams which flow directly into Green Bay, Lake Michigan and Lake Superior.

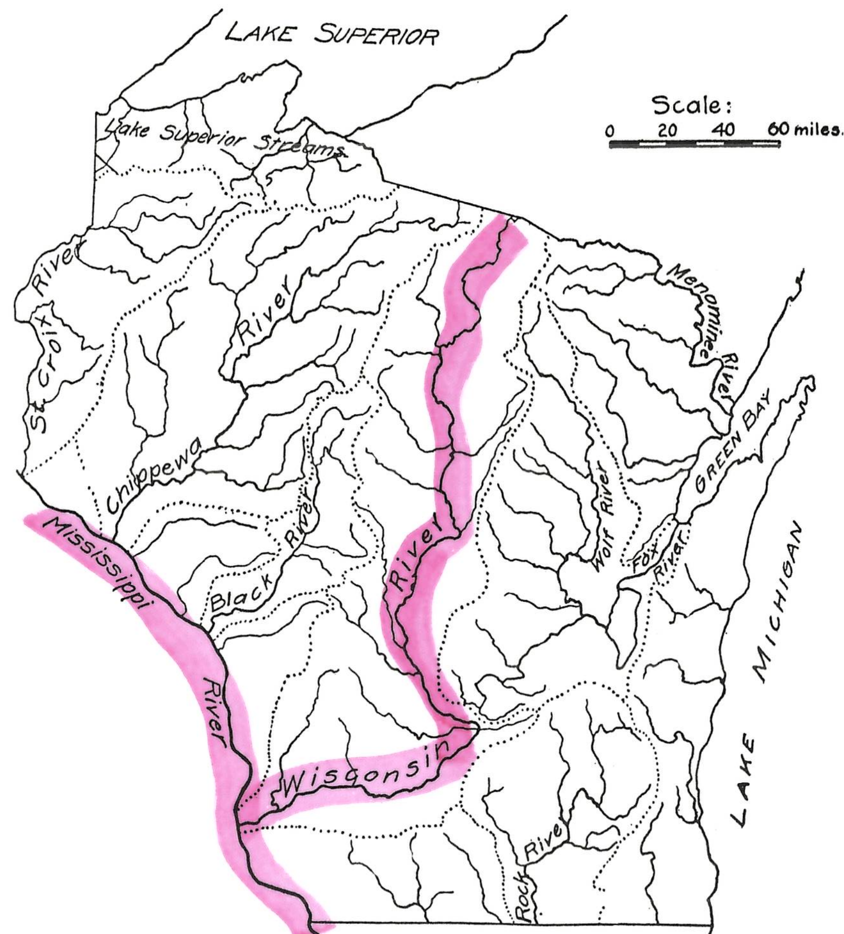


Fig. 8. The main drainage basins in Wisconsin.

The Lake Michigan streams include the Manitowoc, Sheboygan, and Milwaukee rivers. The chief streams that enter into Lake Superior are the St. Louis, Nemadji, Bois Brule, Bad, and Montreal.

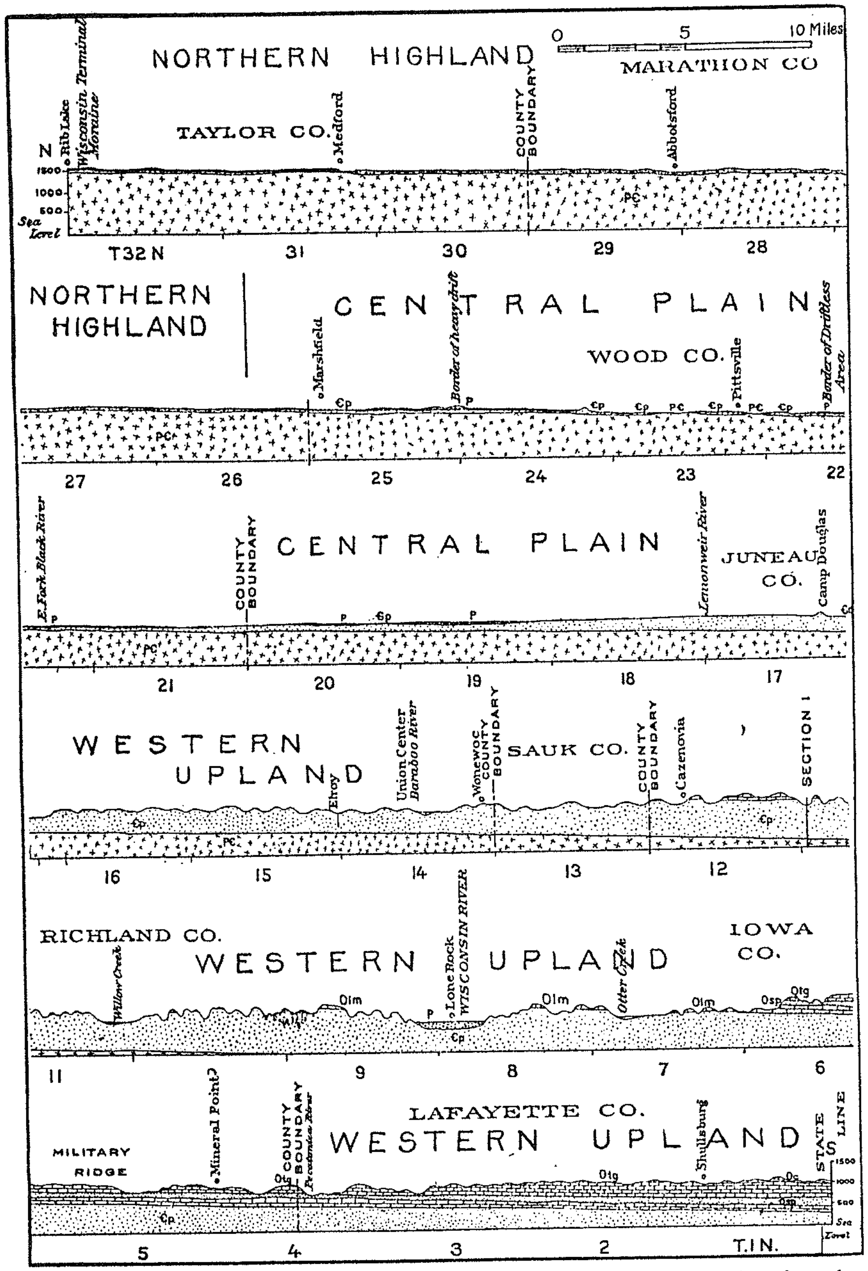


Fig. 9. A north-south section showing the relationships of the Western Upland to the underlying rock. PC—igneous and metamorphic rock of pre-Cambrian age; Cp—Cambrian sandstone; Olm—Lower Magnesian limestone of Ordovician age; Osp, Otg, and Oc—St. Peter sandstone, Black River-Galena limestone, and Richmond shale, all of Ordovician age; P—glacial deposits and river deposits of Pleistocene age.

CHAPTER II

THE GEOGRAPHICAL PROVINCES OF WISCONSIN

THE NATURE OF THE PROVINCES

Driftless Area and Glaciated Region. One simple way to describe the state of Wisconsin is to divide it into two parts,—(a) the Driftless Area and (b) the Glaciated Region. The Glaciated Area is mostly a plain. A large part of the Driftless Area is hilly. The Driftless Area and the Glaciated Region are natural regions, or, as we shall say in this book, geographical provinces.

Plains, Plateaus, and Mountains. From another point of view the state may be said to consist of three natural regions. These are (a) a large area of plains, (b) a smaller area of low plateaus, and (c) a large area of worn-down mountains. The plains are not all of the same level. The plateaus are so cut up by streams as to retain no flat-topped uplands. The former mountains are now worn down so low as to constitute a rather simple plain, although it includes the highest land in the state.

Physiographic Provinces. Another writer, formally resident in our state, in describing the whole United States, has divided Wisconsin into four physical divisions. His "Superior Upland" corresponds essentially with the *Northern Highland* and *Lake Superior Lowland,* described below; his other provinces are called "Eastern Lake Section", "Till Plains", and "Wisconsin Driftless Section." Both this writer and the author of this book agree that there are parts of Wisconsin and the Middle West where details of glacial geology have resulted in distinctions which are more continuous over large areas than bedrock geology is.

The Five Geographical Provinces. It seems best, however, to divide the state into five rather than two or three or four natural regions. These are related in certain ways to the driftless and glaciated areas, and to the plains, plateaus, and worn-down mountains. Three of these geographical provinces are uplands and two are lowlands.

The northernmost of the five geographical provinces is the *Lake Superior Lowland* (Chapter XVII), a part of the Lake Superior basin. The central province, called the *Northern Highland* (Chapter XV), is an upland,—part of the Lake Superior highland. A third division of the state is the large belted plain with curved strips of alternating lowland and upland. This plain is subdivided into three geographical provinces, (a) the *Central Plain* (Chapter XIII), (b) the *Eastern Ridges* and *Lowlands* (Chapter IX), and (c) the *Western Upland* (Chapter III). These geographical regions are not merely physiographic provinces or areas whose surface features have origins of a common nature. The geographical provinces of Wisconsin are also related to the use of the land by plants, by animals, and by man. Each differs from the others in roughness or smoothness of topography, in fertility or sterility of soil, in climate, in adaptation to occupation by wild plants, including forests, by cultivated plants, including crops and orchards, by animals, and by man, as well as in the extent to which white men have developed such resources during the march of Wisconsin history. The Northern Highland partakes of the characteristics of the frontier because it is remote, climatically inferior through altitude and short period between killing frosts, and off the main paths of trans-Wisconsin transportation. The Lake Superior Lowland is a dissected plain with good soil. The Western Upland is rough. The Central Plain, except where glaciated, is smooth but infertile. The Eastern Ridges and Lowlands are smooth, low, fertile, and convenient to through transportation, and hence this is the most densely populated and the richest of the geographical provinces of the state. With time, however, all parts of the state will become more and more alike in use of the land by man.

Boundaries of the Geographical Provinces

The boundaries of all five of these geographical provinces are determined largely by the variations of texture and structure in the underlying rocks. The fundamental differences of topography in the five divisions are due to this, and the minor topography in each area shows this relationship clearly. The boundaries of these provinces are shown in Figure 10. They do not follow contours on the topographic map (Fig. 7), they are not determined by climate (Figs. 4, 5), or by vegetation (Fig. 6), or any other single geographical feature. They resemble, but do not exactly correspond

to the boundaries on the geological map (Fig. 3). This shows that neither the relative weakness and resistance involved in rock texture, nor the control involved in rock structure, is entirely responsible for the difference in conditions between provinces. Nor is it only the process of wearing down that has determined the con-

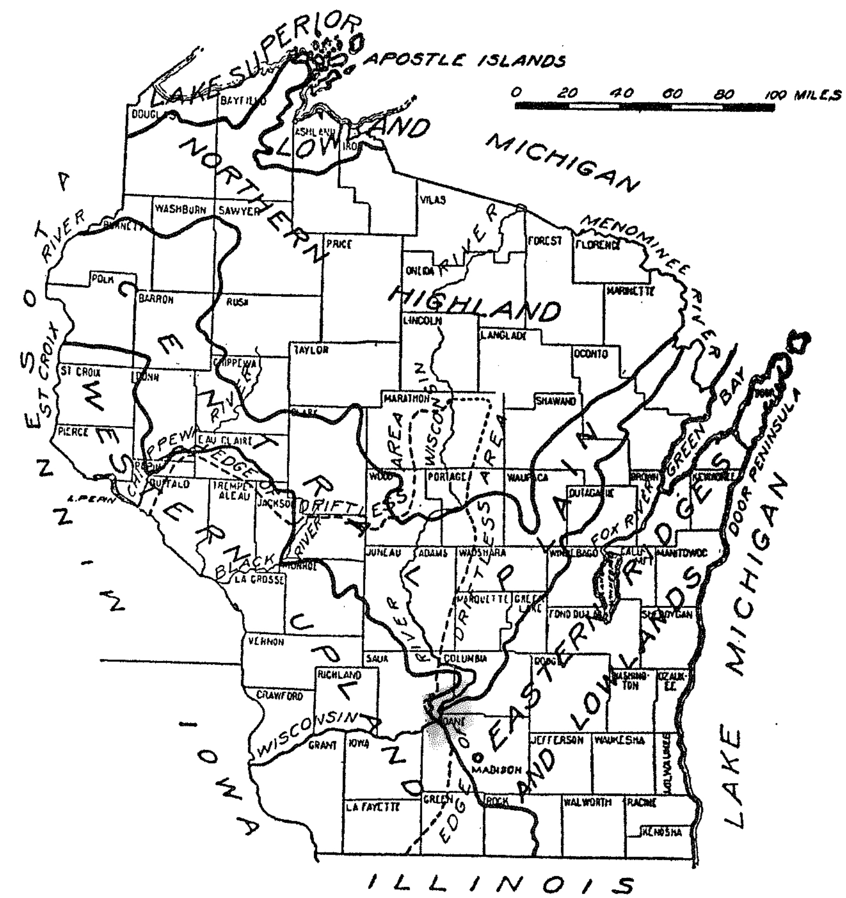


Fig. 10. The five geographical provinces of Wisconsin.

trasting topographies of the provinces. It is true that Wisconsin might be divided into two provinces on the basis of process alone,—weathering and stream erosion in one, the Driftless Area, having produced markedly different forms from the glacial erosion and

Himalayas, New Zealand, and Patagonia. In Greenland peaks which rise up like islands through a sea of ice are called *nunataks.* They are free from glaciation because of their height. The Driftless Area of Wisconsin is not a nunatak area.

The Driftless Area Is Neither an Island Nor a Lake Bed. About the middle of the last century, when the drift deposits were thought of as laid down in the ocean, the Driftless Area was considered to have been an island. Its lack of height above the surrounding areas, and our modern knowledge of drift deposits as glacial and not marine, render this explanation untenable.

It was also once thought to represent a lake bed. The deposits of fine silt or loess in Wisconsin, then thought to be lacustrine, are now known to be chiefly wind-laid (p. 135).

The Elements of Topography and Time. Instead, it is driftless because of three factors:

(a) The highland to the north furnished temporary protection from ice invasion;

(b) The more rapid movement of glacial lobes in the lowland to the east and the region to the west resulted in the final joining of these ice lobes south of the Driftless Area, so that it was completely surrounded by the continental glacier;

(c) The termination of the forward movement and the beginning of retreat came before there was time for the ice from the north, east, and west to cover the driftless remnant.

Such was the relation of the Driftless Area to (a) the topography of the adjacent region and (b) the element of time. It is assumed that the advances of the glacial lobes east, north, and west of the Driftless Area took place at the same time. There is no direct evidence of this, but no facts are known that disprove it.

Topographic Influences Outside. The upland which lent temporary protection to the Driftless Area was the Northern Highland. The lowland which rapidly led the eastern lobe southward past the Driftless Area was the river valley now occupied by Lake Michigan. The similar feature to the west was not so low, being the valley of the Red and Minnesota rivers in Minnesota and the valley of the Des Moines River in central Iowa.

Glacial Lobes. The ice which covered nearly all of northeastern and eastern Wisconsin during the Glacial Period is thought to have come chiefly from the Labrador ice sheet, east of Hudson Bay (Fig. 27). At least three advances in northwestern Wisconsin came from the north or northwest, as a part of either the Keewatin, or the Patrician, ice sheets west of Hudson Bay. The ice which covered northwestern Wisconsin and Minnesota and Iowa came chiefly from the Keewatin center (Fig. 27).

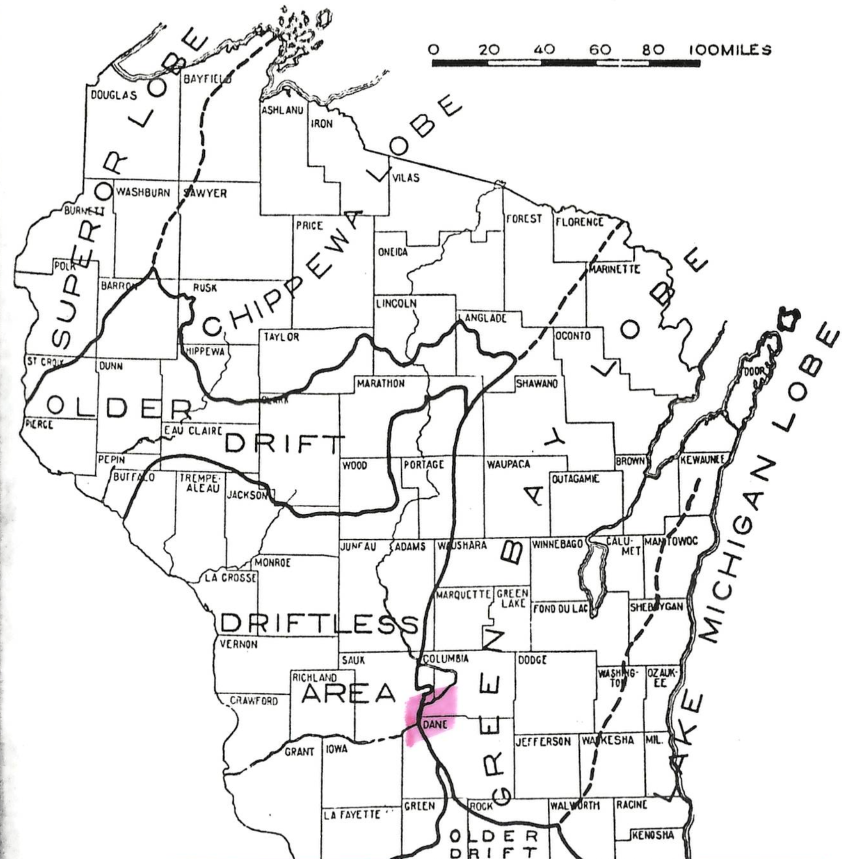


Fig. 28. The glacial lobes in Wisconsin and their relation to the Driftless Area.

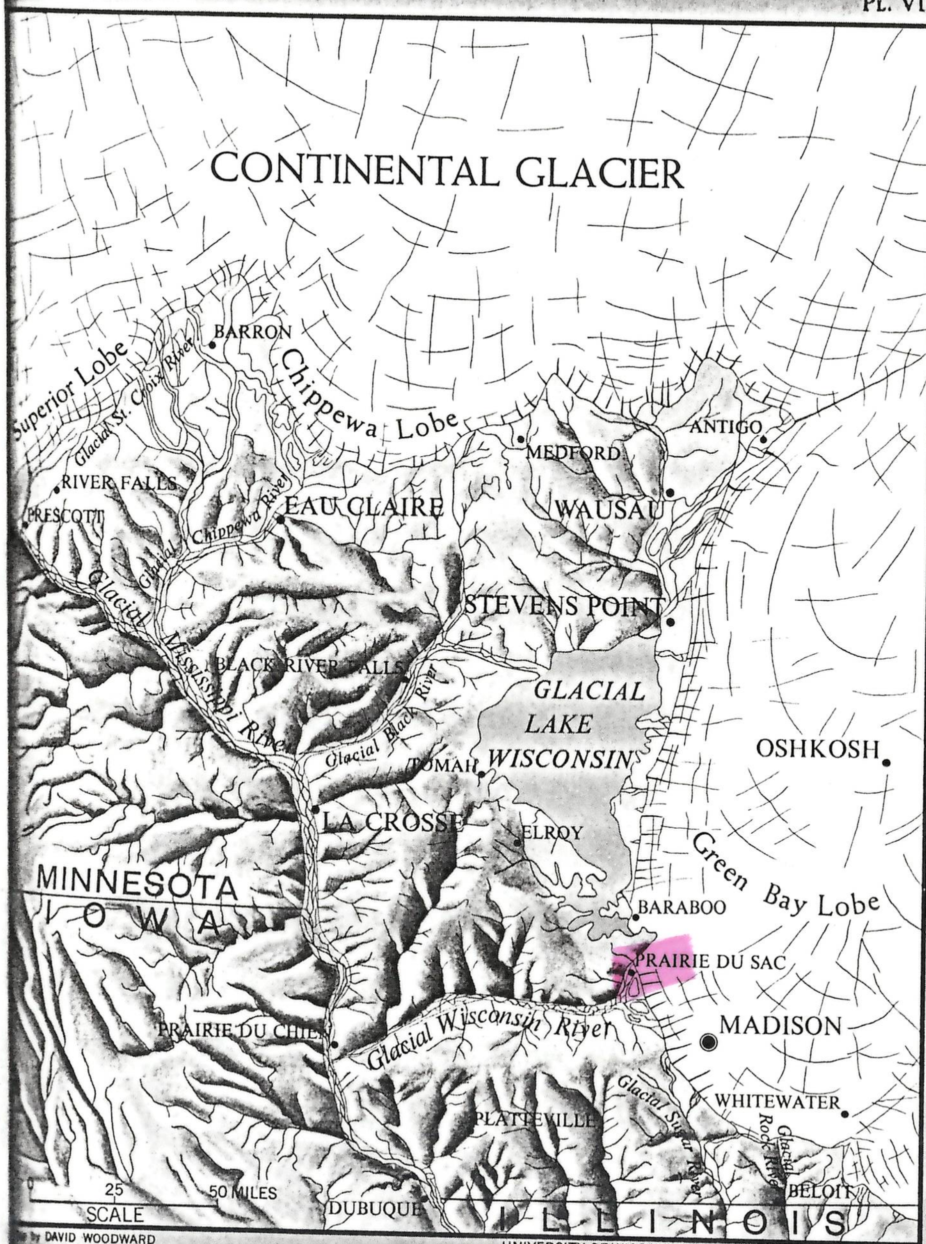
In advancing over Wisconsin the ice sheet or continental glacier, was divided into several lobes (Fig. 28), determined in position by the preglacial configuration of the land. These were the Lake

Michigan and Green Bay lobes on the east and the Lake Superior and Minnesota lobes on the west. On the north two minor branches of the Lake Superior lobe, one from the bay at Ashland, the other from the bay east of Keweenaw Point in upper Michigan united to form the Chippewa lobe. The movement of these ice lobes is known by the glacial scratches, or striae, upon the rock ledges and by the transported rocks, or erratics, which have been traced to their sources, often in Michigan, Minnesota, or Canada. These lobes advanced until they completely coalesced.

There were several stages of glacial advance, the latest being called the Wisconsin stage of glaciation. The earlier ones are known as the Iowan, Illinoian, Kansan, and pre-Kansan or Nebraskan. Their deposits are spoken of collectively as older drift. It is not yet decisively established that we do not now live in an interglacial period or that the ice may not advance again. The most recent glacial deposits in the United States are called Wisconsin drift, whether found in the state of Wisconsin or elsewhere.

The Ice East of the Driftless Area. To the east of the Driftless Area, the lobe from the Labrador center advanced down the preglacial river valleys now occupied by Lake Michigan, Green Bay, and Lake Winnebago. By the time it had advanced farthest in southern Illinois, about 300 miles south of Wisconsin, it had spread westward in this state nearly as far as Wausau and Madison. It covered the rather-low southeastern part of the Northern Highland, the eastern part of the Central Plain, and the low eastern region of Galena-Black River limestone. Thus it had expanded where ice movement was relatively easy. No doubt its later rate of broadening and westward expansion over those parts of the Driftless Area which are higher would have been slower. We know that such was the case with the expansion across the high eastern part of the Baraboo Range (p. 121).

The Ice North of the Driftless Area. In the meantime the lobe of the Labrador glacier in the lowland now occupied by Lake Superior, was advancing more slowly. It was retarded on the highland between western Lake Superior and the northern portion of the Driftless Area. Therefore the time necessary for the rapid southward movement of the Lake Michigan ice past practically the whole length of Wisconsin and Illinois, was only long enough for the Lake Superior ice to ascend to the crest of the Northern High-



THE DRIFTLESS AREA AT THE WISCONSIN STAGE OF GLACIATION

The relations of the border of the continental glacier to topography; the extent of Glacial Lake Wisconsin; the positions of some of the glacial streams which laid down deposits of gravel and sand outwash plains and valley trains many of which are now dissected into terraces.

Most of these outwash gravel deposits were probably built by glacial streams during the latest advance of the ice sheet. Thus they are of Wisconsin age.

Older Outwash in the Wisconsin Valley. Glacial waters also flowed down the Mississippi, Wisconsin, Black, and other stream

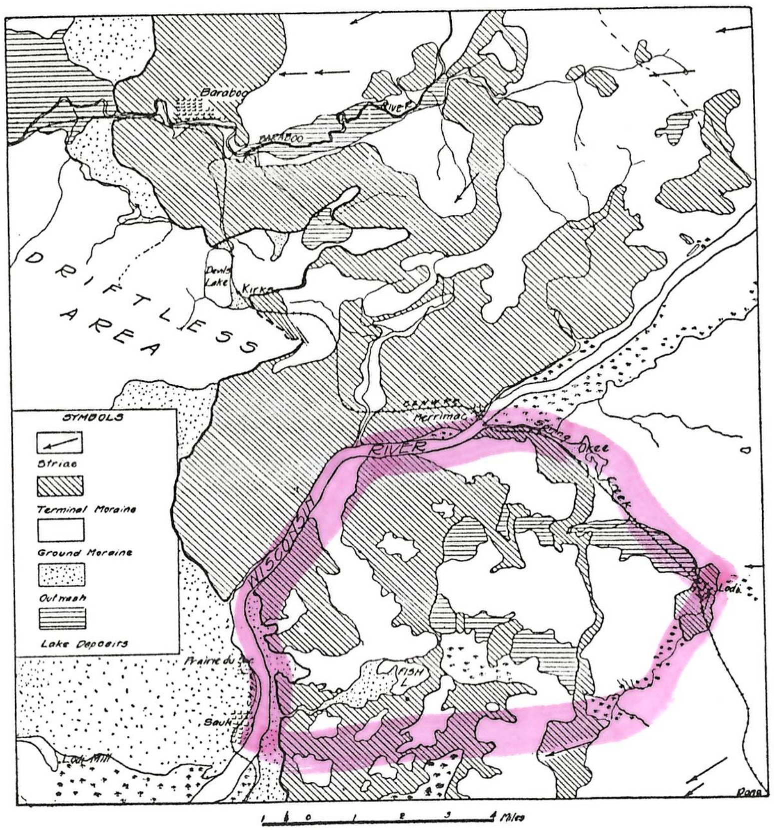


Fig. 37. The glacial deposits near the Baraboo Range, the terminal moraine near Prairie du Sac and the head of the valley train of outwash gravels which extend down the Wisconsin River. (Alden).

valleys of the Western Upland, during the earlier periods of glaciation. They undoubtedly deposited outwash gravels. Most of these accumulations of older outwash were subsequently buried or eroded away.

There are thin, scattered deposits of thoroughly-weathered drift east and west of Wauzeka and on the rock terrace at Bridgeport, near the mouth of the Wisconsin River. These are reddish, insoluble clays with rounded pebbles of quartzite, quartz, chert, and resistant igneous rocks. The clay is leached of all its soluble material, but there are rare limestone pebbles in the deposit. The nature of this drift seems to indicate that it represents outwash rather than till. Its relationships favor the view that it is not western drift from Iowa, but an ancient outwash deposit from an ice front somewhere east of Prairie du Sac.

There are also weathered gravels near Sauk City. The lime is entirely leached from the upper layers, though limestone pebbles are abundant below. As the same thing occurs in some deposits of undoubted Wisconsin age, as in Waushara County, it does not appear necessary that the outwash near Sauk City is of Illinoian age. It seems more probable that this is Wisconsin outwash.

Valley Fill in the Driftless Area. The most recent outwash deposits of the Western Upland are discussed more fully in the following chapters (pp. 156, 188, 202). There are valley train gravels of glacial origin, now represented by terraces. Many stream valleys are deeply filled with deposits of glacial time but not of glacial material. In general the valleys of the Driftless Area in the Western Upland are flat-floored. Hardly any of these streams are now cutting in rock.

Deposits of Driftless Area Streams

Within the Driftless Area the deposits of glacial time which do not contain any glacial material are found in the Kickapoo, Grant, Pecatonica, La Crosse, and many other rivers. Nearly all streams of any size, built up, or aggraded their courses so that they kept pace with the glacier-fed streams which crossed the Driftless Area. Certain smaller streams failed to keep up and were dammed at the mouth, where temporary lakes (p. 172) or small swamps were formed. Extensive alluvial fans were built.

One reason for up-building or aggradation by these non-glacial streams during glacial time was that the precipitation over the whole Driftless Area was undoubtedly increased by the presence of the surrounding continental glacier and the cold that it brought. The preglacial vegetation of the Driftless Area may have all been killed, for botanists tell us that the plant forms there now are not

FIELD TRIP GUIDE BOOK 6
1983

Charles Dean
October 5, 1990

A guide to the GLACIAL LANDSCAPES OF DANE COUNTY, WISCONSIN

by

David M. Mickelson

Department of Geology and Geophysics
University of Wisconsin-Madison

University of Wisconsin-Extension
GEOLOGICAL AND NATURAL HISTORY SURVEY
Meredith E. Ostrom, Director and State Geologist

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To Jean, Amy, Rebecca, and John
for their patience with a field geologist.

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Cover: False color infrared Landsat Satellite image of Dane County, Wisconsin, May 9, 1976. Courtesy of U. S. Geological Survey, Wisconsin Water Resources District.

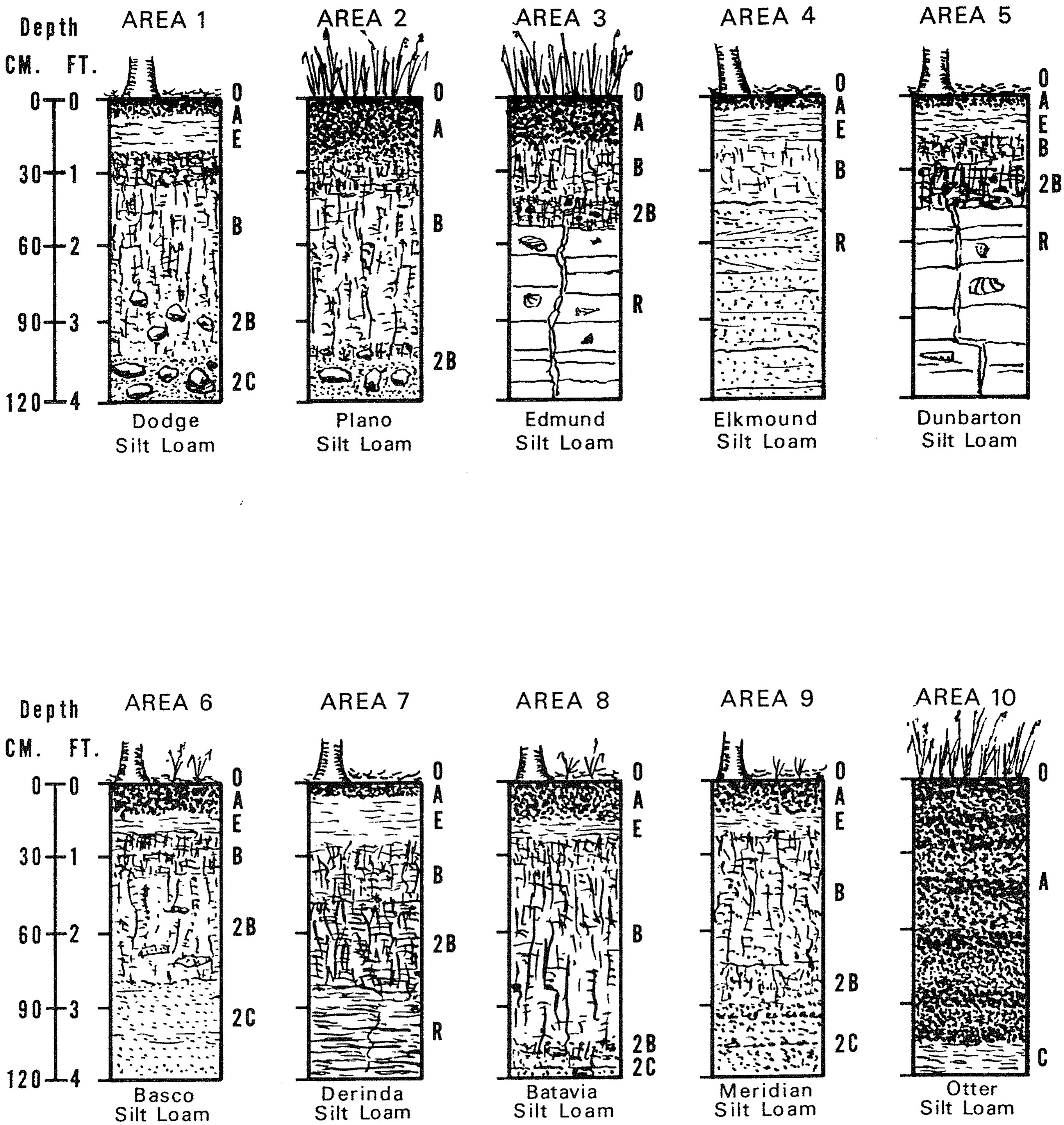


Figure 17: Representative soil profiles from Dane County Area shown at top of each profile corresponds to areas mapped in Figure 18. Diagrams by Francis Hole.

Names of dominant soils developed on various parent materials under deciduous forest or prairie vegetation.

	Loess over Till	Loess over Sand or Gravel	Loess over Dolomite	Loess over Sandstone or Shale
Deciduous Forest	<u>Area 1</u> Dodge St. Charles McHenry	<u>Area 9</u> Meridian Granby Dickinson	<u>Area 5</u> Dunbarton New Glarus Seaton	<u>Area 4 (Sandstone)</u> Elkmound Dunbarton <u>Area 7 (Shale)</u> Derinda Dunbarton
Prairie	<u>Area 2</u> Plano Ringwood Griswold	<u>Area 8</u> Batavia Houghton Dresden	<u>Area 3</u> Edmund Sogn Port Byron	<u>Area 6</u> Basco Elkmound Gale
Poorly Drained	Otter, Orion, and Troxel soils often formed on stream or lake sediment.			

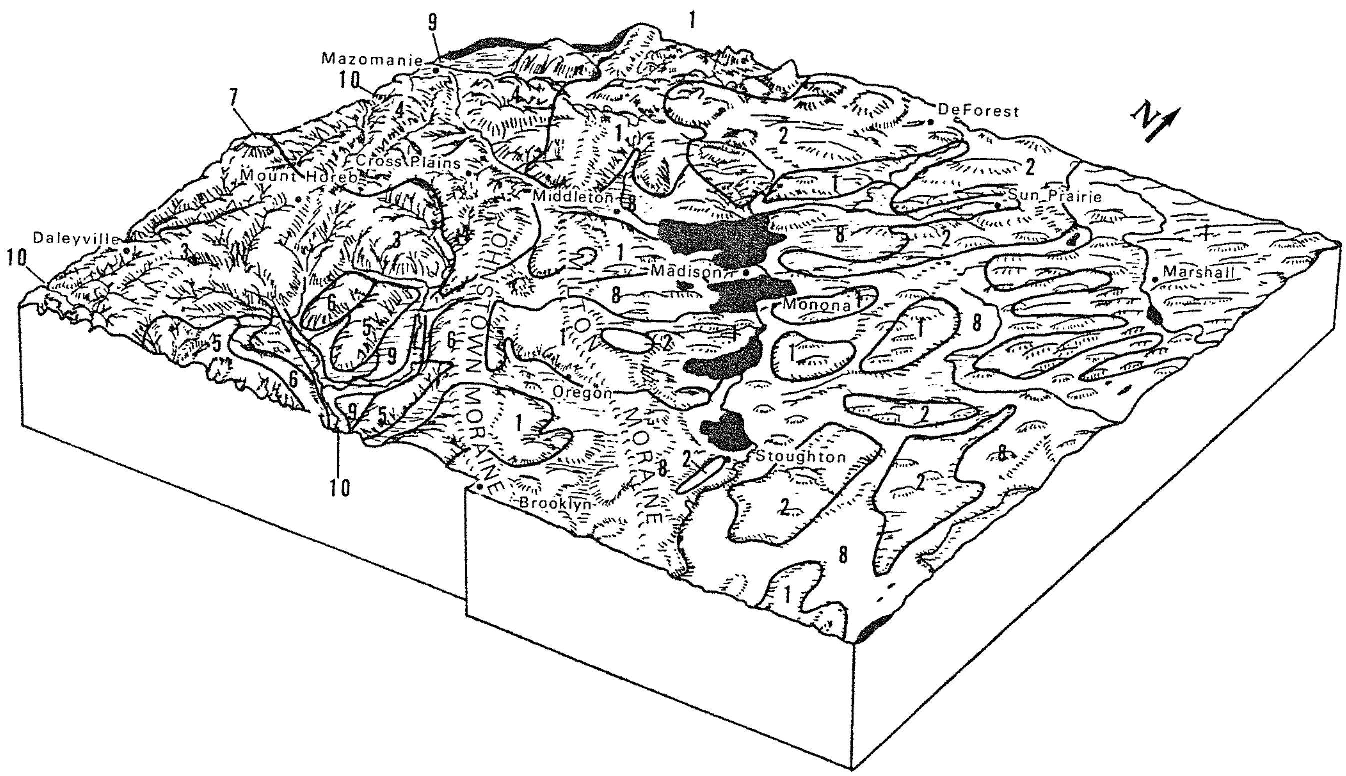
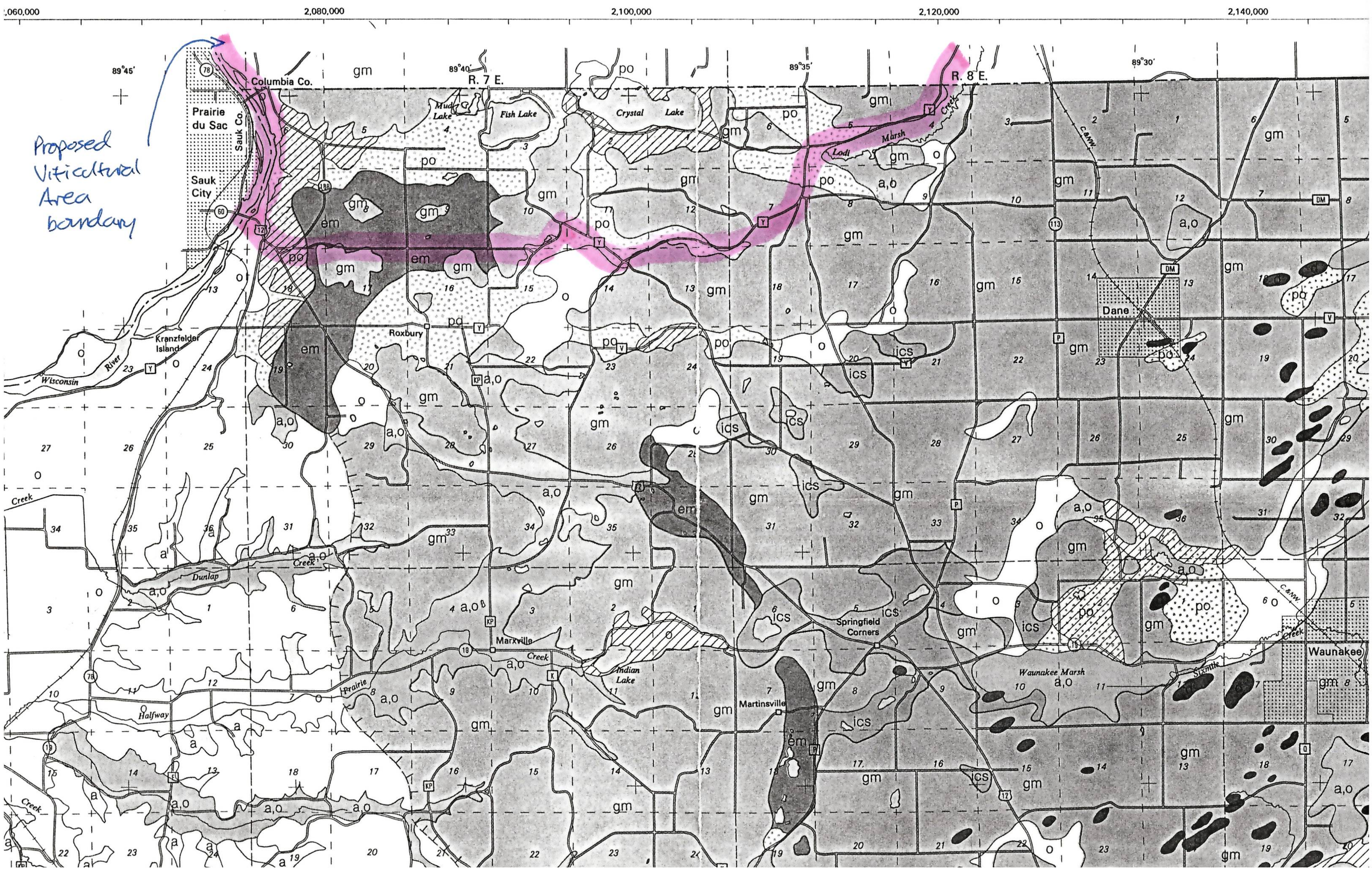


Figure 18: Map of generalized distribution of soil types in Dane County. Figure 17 illustrates the type of soil found in each of these areas. Diagrams by Francis Hole.

by D.M. MICKELSO



GLACIAL GEOLOGY OF DANE COUNTY, WISCONSIN

by

D.M. MICKELSON and M.C. McCARTNEY

UNIVERSITY OF WISCONSIN- EXTENSION
GEOLOGICAL AND NATURAL HISTORY SURVEY
Meredith E. Ostrom, Director and State Geologist

1979

EXPLANATION

HOLOCENE (approximately 10,000 years B.P. to present)

a

ALLUVIUM, COLLUVIUM IN DRIFTLESS AREA

Materials deposited by rivers or streams (alluvium) and materials moved downslope by gravity (colluvium) mixed and probably interbedded. Alluvial deposits are water-worked and are, therefore, usually well sorted and stratified. Colluvial deposits are a mixture of grain sizes, though in this area usually high in silt removed from the uplands.

a,o

ALLUVIUM, COLLUVIUM, ORGANIC DEPOSITS OFTEN OVER OUTWASH

Organic deposits such as peat and muck in combination with alluvium and colluvium (see above) often over sand and gravel which was deposited by glacial meltwater. Includes deposits of small, short-lived glacial lakes.

PLEISTOCENE

WISCONSINAN

MID-WOODFORDIAN (approx. 17,000 years B.P. to 13,000 years B.P.)

em

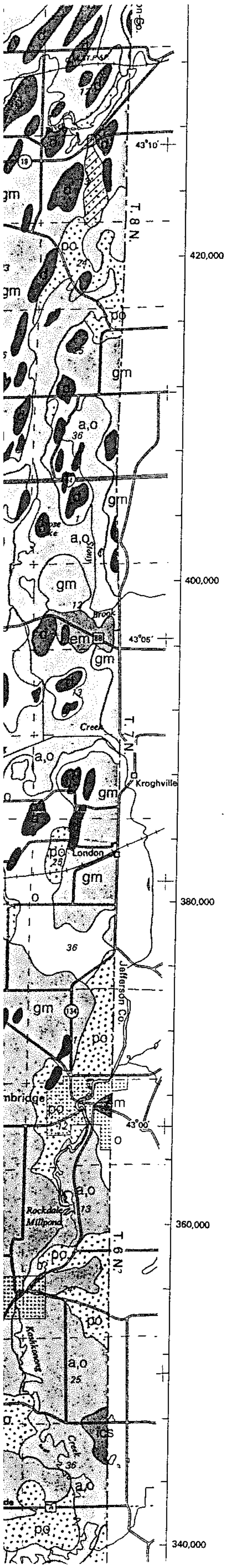
END MORAINE

Ridge (100 feet to 1 mile wide) marking the terminal zone of a glacier. Usually is composed of till (material deposited directly by ice) but often includes poorly sorted stratified material in places. Surface generally hummocky, containing kettles in places, and often littered with boulders.

gm

GROUND MORAINE

A relatively flat or rolling till surface which was created along the base of the glacier.



Organic deposits such as peat and muck in combination with alluvium and colluvium (see above) often over sand and gravel which was deposited by glacial meltwater. Includes deposits of small, short-lived glacial lakes.

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MID-WOODFORDIAN (approx. 17,000 years B.P. to 13,000 years B.P.)

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Ridge (100 feet to 1 mile wide) marking the terminal zone of a glacier. Usually is composed of till (material deposited directly by ice) but often includes poorly sorted stratified material in places. Surface generally hummocky, containing kettles in places, and often littered with boulders.

GROUND MORAINE

A relatively flat or rolling till surface which was created along the base of the glacier.

DRUMLIN

An elongate hill approximately oval in outline. This streamlined form can be made of till, till over stratified drift, till over a bedrock core, stratified drift or bedrock. The drumlins are really a type of ground moraine in that the forms are created beneath the glacier by erosion or deposition by ice.

ICE-CONTACT STRATIFIED DEPOSITS

Sand and gravel deposited in contact with ice. Includes such forms as kames and kettles, crevasse fillings and eskers. These have very variable characteristics but generally are more poorly sorted than outwash. They have good potential for aggregate, especially for asphalt aggregate.

OUTWASH PLAIN OR VALLEY TRAIN

Sand and gravel deposited by meltwater in an apron in front of the ice margin or in valleys leading away from the margin. Generally coarse aggregate near moraines and finer away. Better sorted and more predictable than ice-contact deposits but often have high watertable. Generally better for concrete aggregate.

PITTED OUTWASH PLAIN

Outwash plain with kettle holes which formed by melting buried ice blocks. Materials similar to outwash but deposited on ice which later melted, creating kettle holes or depressions.

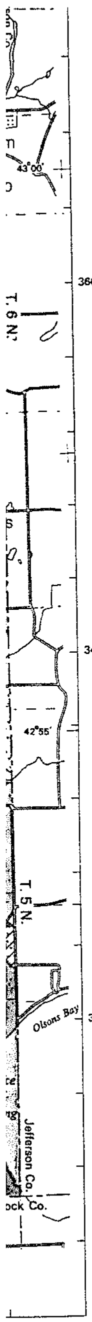
LACUSTRINE PLAIN

Glacial lake bottom. Materials generally fine-grained silt and clay although sand is present near former shorelines and near stream inlets. Often flat, poorly drained areas with peat accumulation.

EARLY WOODFORDIAN (approx. 22,000 years B.P. to 17,000 years B.P.)

END MORAINE

Subdued ridge which marks the terminal position of an earlier advance. Composed mostly of till of slightly different character than of Mid-Woodfordian moraine.



RATORY, 1973

finer away. Better sorted and more predictable than ice-contact deposits but often have high watertable. Generally better for concrete aggregate.

po

PITTED OUTWASH PLAIN

Outwash plain with kettle holes which formed by melting buried ice blocks. Materials similar to outwash but deposited on ice which later melted, creating kettle holes or depressions.

lp

LACUSTRINE PLAIN

Glacial lake bottom. Materials generally fine-grained silt and clay although sand is present near former shorelines and near stream inlets. Often flat, poorly drained areas with peat accumulation.

EARLY WOODFORDIAN (approx. 22,000 years B.P. to 17,000 years B.P.)

eem

END MORAINE

Subdued ridge which marks the terminal position of an earlier advance. Composed mostly of till of slightly different character than of Mid-Woodfordian moraine.

egm

GROUND MORAINE

Similar to above but much more bedrock control of topography. Drift generally thin and many bedrock exposures present.

PRE-WOODFORDIAN (more than 22,000 years old)

GROUND MORAINE

Similar to above but much more bedrock control of topography. Drift generally thin and many bedrock exposures present.

BEDROCK, WIND-BLOWN SILT AND RESIDUUM IN DRIFTLESS AREA

No evidence of glacial deposits.

Other Symbols

COARSE AGGREGATE POTENTIAL

Areas with high potential for sand and gravel production. Outwash and pitted outwash are less variable than ice contact stratified drift. Site examination must be done to determine economic feasibility (e.g. thickness and quality of deposit and depth to water table).

MAXIMUM EXTENT OF ICE WHERE NO MORAINE WAS FORMED

In places ice was nearly free of debris and no ridges were formed at the margin.

CONTACT

INFERRED CONTACT

BOUNDARY BETWEEN GLACIAL LAKES MIDDLETON AND YAHARA

WATER

This map shows the distribution of glacial and some post-glacial landforms and associated materials. All of the county was covered by wind-blown silt after glacier ice retreated, but we have ignored this deposit which is often several feet thick at the surface. Since boundaries of underlying materials are often covered, all contacts are approximate and many are based on interpretation of landform.

p.

eport

studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Columbia County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitablé for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in plannning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The 11 soil associations in Columbia County are described on the following pages.

1. Plano-Griswold-Saybrook Association

Well drained and moderately well drained silty soils that have a silty or loamy subsoil; underlain by sandy loam glacial till

This association is on glaciated uplands where the soils formed in loess and the underlying glacial till. The landscape is one of long low drumlins and ground moraines characterized by long slopes, swells, swales, and some broad depressions. Moderately steep, glaciated limestone ridges of higher topography parallel the larger drainageways.

This association makes up about 16 percent of the county. It is about 50 percent Plano soils, 14 percent Griswold soils, 10 percent Saybrook soils, and 26 percent soils of minor extent.

Plano soils, on swells, are mostly gently sloping and are well drained or moderately well drained. Typically the surface layer is silt loam, and the subsoil is mostly heavy silt loam. Calcareous sandy loam till is at a depth of more than 60 inches.

Griswold soils, on the crests of drumlins, are mostly gently sloping and sloping and are well drained. Typically the surface layer is silt loam, and the subsoil is mostly sandy clay loam. Calcareous sandy loam till is at a depth of about 38 inches.

Saybrook soils, on small rises and drumlins, are mostly gently sloping and sloping and are well drained. Typically, the surface layer is silt loam, and the subsoil is silty clay loam and loam. Calcareous sandy loam till is at a depth of 38 inches.

Less extensive in this association are Channahon, Joy, Ringwood, Ripon, and Troxel soils. Channahon and Ripon soils are along limestone ridges. Joy soils are on terraces along drainageways and in depressions. Ringwood soils are on drumlins. Troxel soils are in areas that receive sediments from adjoining soils.

This association is well suited to crops. The soils have a thick surface layer high in content of organic matter, and most have high fertility and available water capacity. The main concern in management is controlling water erosion. Improving drainage is a concern in some low-lying areas.

This association is used intensively for crops, mainly corn. Steeper areas are in permanent pasture. The main enterprises are dairying, feeding beef cattle, raising hogs, and growing cash crops. The trend is toward fewer dairy farms and more cash grain and vegetable farms. An increasing acreage is used for sweet corn, peas, and beans. The limestone ridges are a source of crushed limestone for roadbuilding.

2. St. Charles-Ossian-Dodge Association

Well drained, moderately well drained, and poorly drained silty soils that have a silty subsoil; underlain by sandy loam glacial till or silty sediment

This association is mostly a repeating pattern of silt-capped glaciated uplands, mainly drumlins, and wet valleys. This pattern is most distinct near the town of Columbus. The drumlins, several miles long, are northeast-southwest oriented. The landscape ranges from sharply crested drumlins and broad or narrow valleys to broad, low drumlins separated by ground moraines of swells and low-lying areas. Glaciated limestone ridges occupy elevation breaks to low-lying areas. Near the town of Lodi, islands of bedrock covered with silty-capped glacial till rise several hundred feet above the valley floor.

This association makes up about 15 percent of the county. It is about 25 percent St. Charles soils, 16 percent Ossian soils, 12 percent Dodge soils, and 47 percent soils of minor extent.

St. Charles soils, on the sides of drumlins and swells of ground moraines, are mostly gently sloping and sloping and are well drained or moderately well drained. Typically the surface layer is silt loam, and the subsoil is mostly silty clay loam. Calcareous sandy loam till is at a depth of about 58 inches.

Ossian soils, on valley floors along drainageways, are mostly nearly level and are poorly drained. Typically the surface layer is silt loam, and the subsoil is mostly light silty clay loam. Silt loam is at a depth of about 33 inches.

Dodge soils, on the sides of drumlins and swells of ground moraines, are mostly gently sloping and sloping and are well drained. Typically the surface layer is silt loam, and the subsoil is mostly silty clay loam. Calcareous sandy loam till is at a depth of about 39 inches.

Less extensive in this association are Atterberry, Channahon, Knowles, Lapeer, McHenry, and Wacousta soils. Atterberry soils are on valley terraces. Channahon and Knowles soils are along limestone ridges.

Lapeer and McHenry soils are on drumlins. Wacousta soils are in swales where water ponds for long periods.

This association is well suited to crops. Most of the major soils have high fertility and available water capacity. The main concerns in management are controlling water erosion and improving drainage. Water is likely to pond in the lowlands in spring and after a heavy rainfall.

This association is used intensively for crops, mainly corn and forage plants. Steeper areas are in permanent pasture or woodland. Small woodlots are common. The limestone ridges are a source of crushed limestone for roadbuilding. The main enterprises are dairying, feeding beef cattle, and growing cash crops. The trend is toward fewer dairy farms and more cash grain and vegetable farms. An increasing acreage is used for sweet corn, peas, and beans.

3. Mt. Carroll-Seaton-Dresden Association

Well drained and moderately well drained silty and loamy soils that have a silty or loamy subsoil; underlain by stratified silt and sand, silty sediment, or stratified sand and gravel

This association is on outwash plains and on high terraces and benches adjacent to the Wisconsin River (fig. 2). Most of the terrain has a capping of silt. Till-capped islands of sandstone bedrock adjacent to the southern edge of the Baraboo Bluffs rise several hundred feet above the valley floor. The topography is complex. It is mostly convex mounds and ridges of sand and gravel outwash interspaced with lower areas of silt-capped, stratified silt and sand. In a few broad areas the terrain is gently sloping. Deep silty soils are dominant in the lower areas and along valley sides. Coarser textured outwash soils are dominant north of Lake Wisconsin along the Sauk-Columbia County line.

This association makes up about 5 percent of the county. It is about 20 percent Mt. Carroll soils, 20 percent Seaton soils, 10 percent Dresden soils, and 50 percent soils of minor extent.

Mt. Carroll soils, in valleys and other lower areas, are mostly gently sloping and sloping and are moderately well drained. Typically the surface layer and the upper part of the substratum are silt loam. Stratified silt and sand are at a depth of about 56 inches.

Seaton soils, on valley sides and sides of rises, are mostly undulating and rolling and are well drained. Typically they are silt loam to a depth of more than 60 inches.

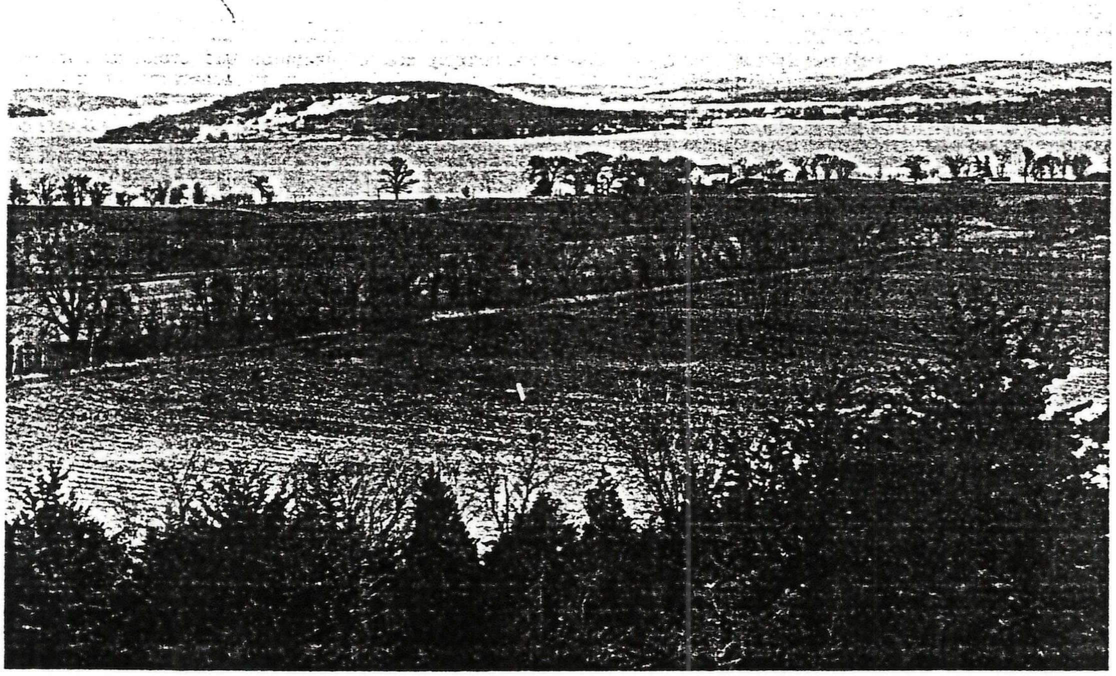


Figure 2.—Mt. Carroll and Seaton soils on high terraces along the Wisconsin River.

Dresden soils, on convex mounds and ridges, are mostly rolling and hilly and are well drained. Typically the surface layer is loam, and the subsoil is mostly sandy clay loam. Calcareous stratified sand and gravel are at a depth of about 26 inches.

Less extensive in this association are Lapeer, Military, St. Charles, and Sisson soils. Lapeer soils are mainly on the tops and Military soils are on the sides of the till-capped islands of sandstone bedrock. St. Charles soils are on the sides of rises. Sisson soils are on high terraces and valley sides.

The major soils in this association are well suited to crops. They have medium or high available water capacity and fertility. The main concern in management is controlling water erosion.

The major soils in this association are used intensively for crops. The sandstone ridges, steeper slopes, and areas of highly complex topography are in permanent pasture or woodland. Corn, alfalfa, and oats are the major crops. The main enterprises are dairying, growing cash crops of grain, and raising beef cattle. Dresden soils provide a good source of sand and gravel for roadbuilding. In many areas the soils are seriously limited for onsite sewage disposal.

4. McHenry-Baraboo-St. Charles Association

Well drained and moderately well drained silty soils that have a dominantly silty subsoil; underlain by sandy loam glacial till or quartzite bedrock

This association is on silt-capped glaciated uplands that are underlain by quartzite bedrock. The area is known locally as the Baraboo Bluffs. The bluffs are two bold ridges that run east and west at elevations between 400 and 800 feet higher than the surrounding terrain. The quartzite is exposed in many places, particularly in the sides of gorges. The rough-shaped area between the ridges is undulating to hilly silt-capped glacial till.

This association makes up about 2 percent of the county. It is about 30 percent McHenry soils, 24 percent Baraboo soils, 22 percent St. Charles soils, and 24 percent soils of minor extent.

McHenry soils, on the ridges and in the trough-shaped area, are rolling and hilly and well drained. The surface layer is silt loam. The subsoil is silty clay loam in the upper part and sandy clay loam in the lower part. Calcareous sandy loam till is at a depth of about 45 inches.

Baraboo soils, on the crests and sides of the ridges, are rolling to steep and well drained and moderately well drained. Typically the surface layer is silt loam, and the subsoil is mostly heavy silt loam. Quartzite bedrock is at a depth of about 36 inches.

St. Charles soils, in the trough-shaped area, are undulating and rolling and well drained and moderately well drained. Typically the surface layer is silt loam, and the subsoil is mostly silty clay loam. Calcareous sandy loam till is at a depth of about 58 inches.

Less extensive in this association are Lapeer soils and Rock land. The steep and very steep Lapeer soils are mostly on the ridges. Rock land is on the steeper sides of the ridges.

The major soils in this association have medium or high fertility and available water capacity. They are well suited to crops. The main concern in management is controlling water erosion. Many areas are too steep for cultivation.

The steeper ridges, mainly woodland, provide wildlife habitat. Most of the trough-shaped area is cropped to corn or alfalfa. The hilly soils are in pasture or woodland. The main enterprise is dairying. This association is a good source of quartzite for use as abrasive material. The quartzite bedrock, close to the surface, and the steep, complex topography restrict many uses of this association. Obtaining a good supply of well water out of the underlying quartzite bedrock is difficult.

5. Plainfield-Okee Association

Excessively drained and well-drained sandy soils that have a sandy or loamy subsoil; underlain by sandy sediment or sandy loam glacial till

This association is on gently undulating and rolling till and outwash plains. The landscape is one of sand-capped drumlins separated by lower areas of sandy outwash. In places the sand is actively shifting, and small blowouts are common. Steep sandstone ridges are in some areas.

This association makes up about 8 percent of the county. It is about 50 percent Plainfield soils, 10 percent Okee soils, and 40 percent soils of minor extent.

Plainfield soils, on outwash plains, are mostly gently undulating and rolling and are excessively drained. Typically they are sandy throughout, but about 25 percent of the acreage of Plainfield soils is loamy at a depth of 40 to 60 inches.

Okee soils, on drumlins, are gently undulating and rolling and well drained. Typically the surface layer is loamy fine sand. The subsoil is loamy fine sand in the upper part and mostly sandy clay loam in the lower part. Calcareous sandy loam till is at a depth of about 34 inches.

Less extensive in this association are Boone, Boyer, Lapeer, Oshtemo, and Wyocena soils. Boone soils are on sandstone ridges. Boyer and Oshtemo soils are on the outwash plain. Lapeer and Wyocena soils are on drumlins.

This association is poorly suited to farm crops. The major soils are droughty and subject to blowing. Plainfield soils have low fertility and available water capacity.

A large part of this association is wooded and provides wildlife habitat. Dairying and producing forage are the main enterprises. Pine tree plantations are common, and many Christmas trees are produced in these areas. The trend is towards more reforesting and to feeding beef cattle and hogs. An increasing number of homes are built on this association, probably because the association is of low value for farming and is near population centers.

6. Boyer-Oshtemo-Dresden Association

Well-drained sandy and loamy soils that have a loamy subsoil; underlain by sand or stratified sand and gravel

Representative profile of Colwood fine sandy loam, 0 to 3 percent slopes, in a clover field 45 feet north and 75 feet east of the southwest corner of NW¼SW¼ sec. 35, T. 11 N., R. 11 E.

Ap—0 to 10 inches, black (10YR 2/1) fine sandy loam; moderate, fine, granular structure; very friable; many fine roots; slightly acid; abrupt, smooth boundary.

A12—10 to 19 inches, black (10YR 2/1) heavy silt loam; common, fine, prominent, yellowish-red (5YR 4/6) mottles; weak, coarse, subangular blocky structure; friable; common fine roots; slightly acid; clear, wavy boundary.

A13—19 to 21 inches, very dark gray (10YR 3/1) fine sandy loam; few, fine, prominent, strong-brown (7.5YR 5/6) mottles; weak, coarse, subangular blocky structure; very friable; common fine roots; slightly acid; abrupt, wavy boundary.

B21g—21 to 23 inches, dark-gray (10YR 4/1) silty clay loam; many, fine, prominent, strong-brown (7.5YR 5/6) mottles; weak, fine, subangular blocky structure; friable; common fine roots; neutral; abrupt, wavy boundary.

B22g—23 to 32 inches, grayish-brown (2.5Y 5/2) loam; many, fine, prominent, yellowish-brown (10YR 5/6) mottles; weak, coarse, subangular blocky structure; friable; few fine roots; neutral; clear, wavy boundary.

B3g—32 to 37 inches, olive-gray (5Y 5/2) loam; few, fine, prominent, yellowish-red (5YR 4/6) mottles and common, fine, prominent, yellowish-brown (10YR 5/6) mottles; weak, coarse, subangular blocky structure; very friable; few fine roots; neutral; abrupt, wavy boundary.

C1—37 to 39 inches, olive-gray (5Y 5/2) sand; single grained; loose; moderately alkaline; slight effervescence; abrupt, wavy boundary.

C2—39 to 42 inches, olive-gray (5Y 5/2) light loam; few, medium, prominent, yellowish-red (5YR 4/8) mottles and common, fine, prominent, yellowish-brown (10YR 5/6) mottles; massive; very friable; neutral; abrupt, wavy boundary.

C3—42 to 60 inches, olive-gray (5Y 5/2) loamy sand; single grained; loose; neutral.

The solum typically ranges from 30 to 40 inches in thickness but in places ranges from 24 to 50 inches. It is dominantly slightly acid to neutral, but ranges to mildly alkaline. The A horizon ranges from 10 to 21 inches in thickness and from black (10YR 2/1) to very dark grayish brown (10YR 3/2) in color. The B horizon is 14 to 30 inches thick. The weighted textural class is heavy loam, sandy clay loam, or clay loam. Layers of silt loam, sandy loam, or light loam are in the B horizon in some places. A distinguishing feature of these soils is stratification of coarse textured and medium-textured sediment in the B horizon, the C horizon, or both, above a depth of 40 inches. The matrix of the B horizon has chroma of 1 or 2. The C horizon is generally stratified silt or loam and sand.

The Colwood soils in this survey area are generally more acid than is defined as the range for the series. In many places, carbonates do not occur above a depth of 40 inches.

Colwood soils occur with Gilford soils and form a drainage sequence with the well-drained Sisson soils and the somewhat poorly drained Kibbie soils. Colwood soils contain more clay between a depth of 10 and 40 inches than Gilford soils.

Colwood fine sandy loam, 0 to 3 percent slopes (CoA).—Large, irregularly shaped areas of this soil are on glacial lake plains and in depressions. Many long areas are in stream valleys and along drainageways.

Included with this soil in mapping are small areas where the surface is covered with a few inches of muck. In some small areas the substratum is mostly sand that has a few thin silt bands. Also included are small areas of Gilford fine sandy loam, stratified substratum, 0 to 3 percent slopes; some small areas where the surface layer is silt loam; and other small areas where the substratum is mostly silt.

Draining this Colwood soil is difficult because the silt and sand tend to flow easily if the soil is saturated. Runoff is very slow to ponded. The erosion hazard is slight.

If adequately drained, this soil is used for crops. Undrained areas are used as pasture or woodland. Controlling wetness is the major concern in management. Capability unit IIw-1; woodland group 1w5; wildlife group 5b.

Dodge Series

The Dodge series consists of well-drained silty soils that formed in 26 to 36 inches of silty sediment and the underlying calcareous sandy loam glacial till. These soils are on silt-covered till plains. Slopes range from 2 to 20 percent. The native vegetation was deciduous forest.

In a representative profile the surface layer is very dark grayish-brown silt loam about 8 inches thick. The subsoil is about 31 inches thick. The upper 3 inches is dark-brown, friable silt loam; the next 13 inches is dark yellowish-brown, friable heavy silt loam; the next 6 inches is dark yellowish-brown, friable silty clay loam; the next 4 inches is dark yellowish-brown, friable sandy clay loam; and the lower 5 inches is dark-brown friable sandy clay loam. The substratum is yellowish-brown, strongly effervescent sandy loam.

Permeability is moderate. Available water capacity and fertility are high.

Most of the acreage is cultivated.

Representative profile of Dodge silt loam, 6 to 12 percent slopes, eroded, in a cornfield 36 feet south and 171 feet west of the northeast corner of NE¼SE¼ sec. 31, T. 13 N., R. 12 E.

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) silt loam, light brownish gray (10YR 6/2) dry; weak, fine, subangular blocky structure; friable; many fine roots; neutral; abrupt, smooth boundary.

B1t—8 to 11 inches, dark-brown (10YR 4/3) silt loam; weak, fine and medium, subangular blocky structure; friable; common fine roots; common fine and few medium and coarse tubular pores; few thin clay films on faces of peds; neutral; clear, wavy boundary.

B21t—11 to 24 inches, dark yellowish-brown (10YR 4/4) heavy silt loam; moderate, fine, subangular blocky structure; friable; common fine roots; common fine tubular pores; common thin clay films on faces of peds; medium acid; gradual, wavy boundary.

B22t—24 to 30 inches, dark yellowish-brown (10YR 4/4) silty clay loam; moderate, medium, subangular blocky structure; friable; few fine roots; common fine and few medium tubular pores; common thin clay films on faces of peds; medium acid; clear, wavy boundary.

IIB23t—30 to 34 inches, dark yellowish-brown (10YR 3/4) sandy clay loam; moderate, medium, subangular blocky structure; friable; few fine roots; many fine and few medium tubular pores; about 2 percent gravel; common thin clay films on faces of peds, and many moderately thick clay bridges between mineral grains; slightly acid; clear, wavy boundary.

IIB24t—34 to 39 inches, dark-brown (7.5YR 3/4) sandy clay loam; weak, coarse, subangular blocky structure; friable; few fine roots; many fine, common medium, and few coarse tubular pores; about 2 percent gravel; few thin clay films on faces of peds, and many thin clay bridges between mineral grains; mildly alkaline; abrupt, wavy boundary.

IIC—39 to 60 inches, yellowish-brown (10YR 5/4) sandy loam; massive; very friable; about 13 percent gravel; strong effervescence.

The solum typically ranges from 35 to 40 inches in thickness but in places ranges from 30 to 40 inches. Depth to the till material ranges from 26 to 36 inches. The Ap horizon is very dark grayish brown (10YR 3/2), dark grayish brown (10YR 4/2), or dark brown (10YR 3/3 to 4/3) and ranges from 6 to 9 inches in thickness. The B horizon is dark-brown (10YR 4/3) to yellowish-brown (10YR 5/4) silt loam, heavy silt loam, and silty clay loam. The IIB horizon is commonly sandy clay loam, but in some places it is heavy sandy loam.

The Dodge soils in this survey area have more sand in the lower part of the B horizon and the C horizon than is defined as the range for the series.

Dodge soils occur with Knowles, McHenry, and St. Charles soils and are similar to Baraboo soils. In contrast with Knowles and Baraboo soils, they are not underlain by bedrock. They contain more silt and less sand in the upper 20 inches of the Bt horizon than McHenry soils. They have a thinner silt mantle and solum than the St. Charles soils.

Dodge silt loam, 2 to 6 percent slopes, eroded (DoB2).—This soil is in long, irregularly shaped areas on rises on the till plain near St. Charles and McHenry soils. Areas are commonly 30 to 60 acres in size. The silt mantle is commonly 32 to 36 inches thick, but otherwise, the profile is similar to the one described as representative of the series.

Included with this soil in mapping are small areas of McHenry silt loam, 2 to 6 percent slopes, eroded, and St. Charles silt loam, 2 to 6 percent slopes, eroded. In a few small areas the subsoil extends to a depth of 42 to 50 inches and in some bedrock is at a depth of 40 to 60 inches. Also included are areas where there is little or no erosion and areas where slopes are less than 2 percent.

In the more sloping areas, runoff is medium and the erosion hazard is moderate. Erosion is the major limitation.

Most of the acreage is cultivated, but some is forested. Capability unit IIe-1; woodland group 2o1; wildlife group 1.

Dodge silt loam, 6 to 12 percent slopes, eroded (DoC2). This soil is in long areas on rises and along ridges on the till plain near McHenry and St. Charles soils. Areas range up to 60 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of McHenry silt loam, 6 to 12 percent slopes, eroded, and St. Charles silt loam, 6 to 12 percent slopes, eroded. In a few small areas, the subsoil extends to a depth of more than 40 inches and in some bedrock is at a depth of 40 to 60 inches.

Runoff is medium. The erosion hazard is moderate. Erosion is the major limitation.

This soil is cropped to corn, small grain, and hay. A few areas are forested or pastured. Capability unit IIIe-1; woodland group 2o1; wildlife group 1.

Dodge silt loam, 12 to 20 percent slopes, eroded (DoD2).—This soil is in long, narrow areas along ridges and on rises on the till plain near McHenry, St. Charles, and Lapeer soils. Areas are commonly 10 to 20 acres in size. In wooded areas the surface layer is black to very dark grayish brown and is about 2 to 4 inches thick, and the subsurface layer is brown and is about 3 to 8 inches thick.

Included with this soil in mapping are small areas of McHenry silt loam, 12 to 20 percent slopes, eroded, and St. Charles silt loam, 12 to 20 percent slopes, eroded. Also included are a few steeper areas, some areas where the subsoil extends to a depth of more than 40 inches, and some where bedrock is at a depth of 40 to 60 inches.

Runoff is rapid. The erosion hazard is severe. Erosion is the major limitation.

This soil is generally not suited to intensive cropping. Most of the acreage is cropped to legumes. Some is cropped to corn or used as pasture or woodland. Capability unit IVe-1; woodland group 2r2; wildlife group 1.

Dresden Series

The Dresden series consists of well-drained loamy soils underlain at a depth of 24 to 40 inches by calcareous stratified sand and gravel outwash. Some gravel pits are indicated by spot symbols on the soil map. Slopes are commonly 1 to 12 percent but range to 20 percent. The native vegetation was mixed grasses and deciduous trees.

In a representative profile the surface layer is very dark brown loam about 8 inches thick. The subsoil is about 18 inches thick. The upper 5 inches is dark yellowish-brown, friable heavy loam; the next 9 inches is dark-brown, friable sandy clay loam; and the lower 4 inches is dark-brown, very friable gravelly light sandy clay loam. The substratum is light yellowish-brown, mildly alkaline stratified sand and gravel.

Permeability is moderate in the subsoil and rapid or very rapid in the substratum. Available water capacity is low, and fertility is medium. Roots are restricted by the sand and gravel substratum.

These soils are an important source of sand and gravel. Most of the acreage is cultivated.

Representative profile of Dresden loam, 1 to 6 percent slopes, in a cornfield 660 feet west and 450 feet north of the southeast corner of NE¼NE¼ sec. 4, T. 12 N., R. 10 E.

Ap—0 to 8 inches, very dark brown (10YR 2/2) loam; weak, medium, subangular blocky structure; friable; common fine roots; neutral; abrupt, smooth boundary.

B21t—8 to 13 inches, dark yellowish-brown (10YR 4/4) heavy loam; weak, medium, subangular blocky structure; friable; common fine roots; about 2 percent gravel; continuous thin clay bridges between mineral grains; neutral; clear, wavy boundary.

B22t—13 to 22 inches, dark-brown (7.5YR 4/4) sandy clay loam; moderate, medium, subangular blocky structure; friable; common fine roots; about 8 percent gravel; many thin clay films on faces of peds; neutral; abrupt, wavy boundary.

IIB3t—22 to 26 inches, dark-brown (7.5YR 3/2) gravelly light sandy clay loam; weak, medium, subangular blocky structure; very friable; common fine roots; about 45 percent gravel; continuous, moderately thick clay bridges between mineral grains; neutral; abrupt, wavy boundary.

IIC—26 to 60 inches, light yellowish-brown (10YR 6/4) stratified sand and gravel; single grained; loose; mildly alkaline; slight effervescence.

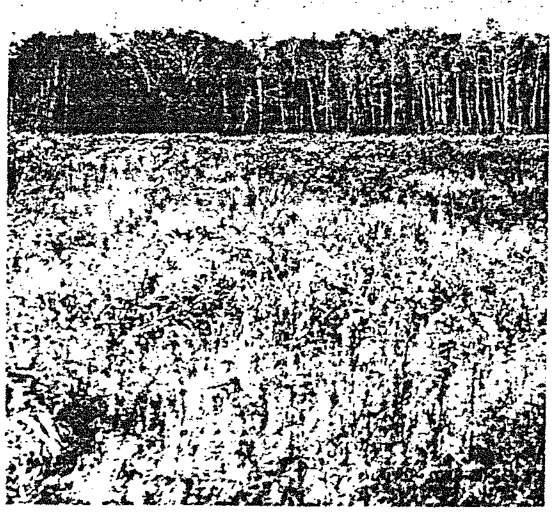


Figure 15.—Native vegetation of willows, sedges, and water-tolerant grasses on Marshan loam.

lying sandy sediment. Available water capacity and fertility are medium. Ground water is at or near the surface throughout most of the year.

Undrained areas of Marshan soils are used for pasture or woodland. Drained areas are planted to corn, soybeans, and small grain.

Representative profile of Marshan loam (0 to 2 percent slopes), 455 feet east and 212 feet north of the southwest corner of NE¼ sec. 28, T. 13 N., R. 7 E.

Ap—0 to 10 inches, black (10YR 2/1) loam; few, fine and medium, distinct and prominent, dark-gray (10YR 4/1) and dark-brown (7.5YR 4/4) mottles; moderate, fine, subangular blocky structure; friable, slightly sticky, slightly plastic; common fine roots; slightly acid; abrupt, smooth boundary.

B1g—10 to 14 inches, olive-gray (5Y 4/2) light sandy clay loam; few black (5Y 1/1) bands, 2 to 5 millimeters in diameter; many, fine, prominent, strong-brown (7.5YR 5/6) mottles and few, medium, distinct, gray (N 5/0) mottles; weak, medium and coarse, subangular blocky structure; friable, slightly sticky, plastic; common fine roots; slightly acid; clear, wavy boundary.

B2g—14 to 24 inches, black (5Y 2/1) sandy clay loam; few, medium, distinct, dark-gray (N 4/0) mottles and common, medium, prominent, yellowish-red (5YR 4/8) and strong-brown (7.5YR 5/6) mottles; weak, coarse, subangular blocky structure; friable, slightly sticky, plastic; common fine roots; slightly acid, abrupt, wavy boundary.

IIC—24 to 60 inches, grayish-brown (10YR 5/2) sand; single grained; loose; few fine roots in upper 3 inches; common, medium, distinct, brown (7.5YR 4/4) concretions in upper 6 inches; small pockets of moderate, fine, angular blocky clay loam just below concretions; neutral.

The solum is typically 24 to 30 inches thick, but ranges to 38 inches. It is medium acid to neutral in reaction. The A horizon ranges from 10 to 18 inches in thickness and is black (N 2/0 or 10YR 2/1 to 5Y 2/1). The B horizon has hues of 5Y or 2.5Y and chroma of 1 or 2. It is loam, heavy loam, light sandy clay loam, sandy clay loam, or clay loam. The IIC horizon typically is medium or coarse sand, but in some places it is fine sand or very coarse sand.

The Marshan soils in this survey area have a higher content of sand in the B horizon than is defined as the range for the series.

Marshan soils occur with Granby soils and with Alluvial land, loamy, wet. They contain more clay and less sand than Granby soils. In contrast with Alluvial land, loamy, wet, they have well defined horizons and do not have the variable stratification of textures typical of Alluvial land.

Marshan loam (0 to 2 percent slopes) (Mc).—This soil is on broad flood plains and terraces. Large areas, ranging up to several hundred acres, are long and broad and oriented to the flow of the river.

Included with this soil in mapping are small areas of Colwood fine sandy loam, 0 to 3 percent slopes. Also included are a few small areas where the surface layer is muck, sandy loam, or silt loam; small areas where the subsoil is sandy loam or silty clay loam; and a few spots of Marsh, which are indicated by spot symbols on the soil map. In few places this soil is buried by as much as 15 inches of recent alluvial sediment.

Dugout ponds and deep drainage ditches are difficult to establish in this soil because the sandy substratum tends to flow easily if saturated. Runoff is very slow to ponded. There is little or no erosion hazard. Wetness, occasional flooding, and ponding are the major limitations.

If adequately drained, this soil is well suited to the crops commonly grown in the survey area. Undrained areas are suited to pasture or woodland. Capability unit IIw-1; woodland group 4w5; wildlife group 5b.

McHenry Series

The McHenry series consists of well-drained silty soils that formed in 15 to 30 inches of silty sediment and the underlying calcareous sandy loam till. These soils are on silt-covered till plains. Slopes range from 2 to 20 percent. The native vegetation was mixed deciduous forest.

In a representative profile the surface layer is dark grayish-brown silt loam about 8 inches thick. The subsoil is about 29 inches thick. The upper 11 inches is dark yellowish-brown, friable light silty clay loam; the next 10 inches is dark-brown, friable sandy clay loam, and the lower 8 inches is dark-brown, very friable heavy sandy loam. The substratum is yellowish-brown, slightly effervescent gravelly light sandy loam.

Permeability is moderate. Available water capacity is medium. Fertility is high.

Most areas of these soils are cultivated.

Representative profile of McHenry silt loam, 2 to 6 percent slopes, eroded, 80 feet east and 396 feet north of the southwest corner of SE¼NE¼ sec. 9, T. 11 N., R. 8 E.

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak, very fine, subangular blocky structure; friable; many fine roots; neutral; abrupt, smooth boundary.

B21t—8 to 19 inches, dark yellowish-brown (10YR 4/4) light silty clay loam; moderate, fine, angular and subangular blocky structure; friable; common fine roots; continuous thin clay films on faces of peds; slightly acid; clear, wavy boundary.

IIB22t—19 to 29 inches, dark-brown (7.5YR 4/4) sandy clay loam; moderate, medium, subangular blocky structure; friable; few fine roots; many thin clay films on faces of peds; about 5 percent gravel; slightly acid; gradual, wavy boundary.

IIB3t—29 to 37 inches, dark-brown (7.5YR 4/4) heavy sandy loam; weak, medium, subangular blocky structure; very friable; few fine roots; common thin clay bridges between mineral grains; about 6 percent gravel; neutral; clear, wavy boundary.

IIC—37 to 60 inches, yellowish-brown (10YR 5/4) gravelly light sandy loam; massive; very friable; about 20 percent gravel; slightly effervescent.

The solum is commonly 30 to 40 inches thick, but ranges from 24 to about 50 inches. Depth to the till material is commonly 15 to 22 inches but ranges to 30 inches. The Ap horizon is very dark grayish brown (10YR 3/2), dark grayish brown (10YR 4/2), or dark brown (10YR 3/3–4/3). The B horizon is dark-brown (10YR 4/3) to yellowish-brown (10YR 5/4) light silty clay loam, heavy silt loam, or silty clay loam. The IIB horizon is dark brown (7.5YR 4/4) or dark yellowish brown (10YR 4/4). The lower part is dominantly sandy loam. The upper 20 inches of the Bt horizon is 18 to 30 percent clay and is 15 percent or more by weight fine sand or coarser particles. Reaction in the B horizon is commonly medium or slightly acid but ranges to mildly alkaline in the lower part. The C horizon is sandy loam or light sandy loam glacial till and is commonly gravelly.

McHenry soils occur with Dodge, St. Charles and Lapeer soils. They contain more sand and less silt in the upper 20 inches of the Bt horizon than Dodge and St. Charles soils. They have more silt and clay and less sand in the upper part of the B horizon than Lapeer soils.

McHenry silt loam, 2 to 6 percent slopes, eroded (MeB2).—This soil is in irregularly shaped or long areas on slight rises on the till plain near Dodge, Lapeer, and St. Charles soils. Areas are commonly 20 to 50 acres in size. This soil has the profile described as representative of the series. In the western part of the survey area, however, it has a thicker surface layer and subsoil than is typical.

Included with this soil in mapping are small areas of Dodge silt loam, 2 to 6 percent slopes, eroded, and Lapeer fine sandy loam, 2 to 6 percent slopes. Also included are a few areas where bedrock is at a depth of 40 to 60 inches, the soil is nearly level, or the substratum is loamy sand till; and areas where the soil is uneroded or only slightly eroded.

Runoff is medium. Erosion is the major limitation. The hazard is moderate in the more sloping areas.

This soil is well suited to the crops commonly grown in the survey area. Most of the acreage is cultivated. Capability unit IIe–1; woodland group 2o1; wildlife group 1.

McHenry silt loam, 6 to 12 percent slopes, eroded (MeC2).—This soil is in broad and long areas along ridges and rises on the till plain. Most areas range from 10 to 40 acres in size. The profile of this soil is similar to the one described as representative of the series, but west of the Wisconsin River, the surface layer and subsoil are thicker.

Included with this soil in mapping are a few small areas of Dodge silt loam, 6 to 12 percent slopes, eroded, and Lapeer fine sandy loam, 6 to 12 percent slopes, eroded. Also included are a few areas where the substratum is loamy sand till, the soil is uneroded or only slightly eroded, or bedrock is at a depth of 40 to 60 inches.

Runoff is medium. The erosion hazard is moderate.

Most of the acreage is cropped to corn, small grain, or hay. Some is in woodland or used as pasture. Capability unit IIIe–1; woodland group 2o1; wildlife group 1.

McHenry silt loam, 12 to 20 percent slopes, eroded (MeD2).—This soil is commonly in long, narrow areas along ridges and on the sides of drumlins and other rises on the till plain. Most areas are less than 20 acres in size. In many places this soil has a profile similar to the one described as representative of the series, but the surface layer and subsoil combined is 26 to 34 inches thick. In forested areas the surface layer is 2 to 5 inches thick, and the subsurface layer is brown and 3 to 8 inches thick.

Included with this soil in mapping are few small areas of Dodge silt loam, 12 to 20 percent slopes, eroded, and Lapeer fine sandy loam, 12 to 20 percent slopes, eroded. Also included are a few areas where the substratum is loamy sand till, areas where slopes range from 20 to 30 percent, areas where most of the surface layer has been lost through erosion, and a few gullies, which are indicated by spot symbols on the soil map.

Runoff is rapid. The erosion hazard is severe. Moderately steep slopes and erosion are the major limitations.

This soil is generally not suited to intensive cultivation. Most of the acreage is cropped to hay or is pastured or forested. Capability unit IVe–1; woodland group 2r2; wildlife group 1.

Military Series

The Military series consists of gently sloping to moderately steep, well-drained loamy soils underlain at a depth of 20 to 40 inches by sandstone. These soils formed in loamy glacial till. They are on the sides and crests of upland ridges. The native vegetation was mixed hardwoods.

In a representative profile the surface layer is black fine sandy loam about 2 inches thick. The subsurface layer is dark grayish-brown fine sandy loam about 1 inch thick. The subsoil is about 22 inches thick. The upper 8 inches is brown, very friable fine sandy loam; the next 5 inches is dark-brown, very friable sandy loam; the next 4 inches is dark-brown, friable light sandy clay loam; and the lower 5 inches is dark-brown, friable sandy clay loam. Sandstone is at a depth of about 25 inches.

Permeability is moderate. Available water capacity is low, and fertility is medium. Roots are limited by bedrock.

Most of the acreage is woodland or pasture. Some of the less sloping areas are in corn or hay.

Representative profile of Military fine sandy loam, 2 to 6 percent slopes, 200 feet north and 820 feet east of the corner of NE¼ sec. 25, T. 13 N., R. 9 E.

A1—0 to 2 inches, black (10YR 2/1) fine sandy loam; weak, fine, subangular blocky structure; very friable; many roots; neutral; abrupt, wavy boundary.

A2—2 to 3 inches, dark grayish-brown (10YR 4/2) fine sandy loam; weak, fine, subangular blocky structure; very friable; many roots; few fine and medium tubular pores; slightly acid; abrupt, wavy boundary.

B2—9 to 14 inches, yellowish-brown (10YR 5/6) fine and medium sand; few, medium, prominent, light-gray (2.5Y 7/2) mottles and common, medium, faint, strong-brown (7.5YR 5/6) mottles; weak, medium, subangular blocky structure; very friable; few fine roots; medium acid; clear, smooth boundary.

B3—14 to 24 inches, yellowish-brown (10YR 5/6) fine and medium sand; common, medium, prominent, light brownish-gray (2.5Y 6/2) mottles and few, medium, faint, strong-brown (7.5YR 5/8) mottles; single grained; loose; few fine roots; medium acid; gradual, wavy boundary.

C—24 to 60 inches, pale-brown (10YR 6/3) fine and medium sand; many, coarse, faint, light-gray (2.5Y 7/2) mottles and few, fine, prominent, brownish-yellow (10YR 6/8) mottles; single grained; loose; medium acid.

The solum typically ranges from 24 to 35 inches in thickness. It is typically medium acid, but in some places it is strongly acid. The Ap horizon is very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2). The B horizon is highly mottled and is brown (10YR 5/3) or yellowish-brown (10YR 5/4–5/6–5/8) fine and medium sand. The upper part has mottles with chroma of 2 or less. The C horizon is fine and medium sand and is slightly acid or medium acid.

The somewhat poorly drained Morocco soils occur in a drainage sequence with the excessively drained Plainfield soils and the poorly drained Granby soils. The A horizon is thinner and contains less organic matter than that of Granby soils.

Morocco loamy sand, 0 to 3 percent slopes (MoA).—This soil is in glacial lake basins, on slightly convex flood plains, in swales and along drainageways on outwash plains, and on terraces in depressions. Areas are irregularly shaped or long and broad, and many are several hundred acres in size. The larger areas are in lake basins and on flood plains near Granby soils.

Included with this soil in mapping are small areas of Granby loamy sand and Plainfield loamy fine sand, 0 to 2 percent slopes. Also included are areas where a silty or loamy substratum is at a depth of 40 to 60 inches; some areas where thin bands of silt are in the subsoil and substratum; a few areas where the subsoil is loamy sand or loamy fine sand; and some areas on flood plains where the sand, at a depth of about 20 to 30 inches, is weakly cemented by concentrations of what appears to be iron, since the layer is reddish in color.

Runoff is very slow. There is little or no hazard of water erosion. Wetness and low fertility are the major limitations.

This soil is poorly suited to crops. If adequately drained, however, it is cropped to soybeans, hay, small grain, and some corn, Many areas are pastured or wooded. Capability unit IVw-5; woodland group 3w4; wildlife group 5a.

Mt. Carroll Series

The Mt. Carroll series consists of moderately well drained silty soils. These soils formed in silty deposits, which are underlain at a depth of about 45 to 60 inches by stratified deposits of silt and sand. They occur in valleys and basins adjacent to the Wisconsin River. Slopes are typically 0 to 8 percent but range to 20 percent. The native vegetation was grasses and some deciduous trees.

In a representative profile the surface layer is very dark grayish-brown silt loam about 9 inches thick. The subsurface layer is brown silt loam about 3 inches thick. The subsoil is about 36 inches thick. The upper 5 inches is dark yellowish-brown, friable silt loam; the next 18 inches is dark yellowish-brown, friable heavy silt loam; and the lower 13 inches is yellowish-brown, friable silt loam. The upper 8 inches of the substratum is brown, medium acid silt loam. This is underlain by brown, slightly acid, stratified silt and sand.

These soils are saturated at a depth of about 3 to 5 feet for significant periods during wet seasons. Permeability is moderate. Available water capacity and fertility are high.

Most of the acreage is cultivated.

Representative profile of Mt. Carroll silt loam, benches, 2 to 6 percent slopes, in a cornfield 300 feet north and 185 feet west of the southeast corner of SW¼SW¼ sec. 3, T. 11 N., R. 8 E.

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, medium, subangular blocky structure; friable; many fine roots; few very fine tubular pores; neutral; abrupt, smooth boundary.

A2—9 to 12 inches, brown (10YR 5/3) silt loam; weak, medium, platy structure parting to moderate, very fine, subangular blocky; friable; many fine roots; common very fine tubular pores; neutral; clear, wavy boundary.

B21t—12 to 17 inches, dark yellowish-brown (10YR 4/4) silt loam; moderate, fine, subangular blocky structure; friable; common fine roots; common very fine tubular pores; common thin clay films; neutral; clear, wavy boundary.

B22t—17 to 27 inches, dark yellowish-brown (10YR 4/4) heavy silt loam; moderate, fine, subangular blocky structure; friable; common fine roots; common very fine tubular pores; common thin clay films; neutral; gradual, wavy boundary.

B31t—27 to 35 inches, dark yellowish-brown (10YR 4/4) heavy silt loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; friable; common fine roots; common very fine tubular pores; few thin clay films; slightly acid; clear, wavy boundary.

B32—35 to 48 inches, yellowish-brown (10YR 5/4) silt loam; few, fine and medium, distinct and faint, strong-brown (7.5YR 5/6) and brown (10YR 5/3) mottles; weak, coarse, subangular blocky structure; friable; few fine roots; few very fine tubular pores; very few thin clay films; slightly acid; clear, wavy boundary.

C1—48 to 56 inches, brown (10YR 5/3) silt loam; common, coarse, faint and prominent, light brownish-gray (2.5Y 6/2) and strong-brown (7.5YR 5/6) mottles; massive; friable; few fine roots; few very fine tubular pores; medium acid; abrupt, wavy boundary.

IIC2—56 to 60 inches, brown (10YR 5/3) stratified silt and sand; common, fine and medium, faint and prominent, grayish-brown (10YR 5/2) and yellowish-brown (10YR 5/6) mottles; massive; very friable; slightly acid.

The solum typically ranges from 42 to 60 inches in thickness. A distinguishing feature of these soils is a stratified silt and sand IIC horizon at a depth of 45 to 60 inches. The Ap or A1 horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2) and is 6 to 9 inches thick. The A2 horizon ranges from dark grayish brown (10YR 4/2) to brown (10YR 5/3). The B horizon ranges from dark brown (10YR 4/3) to yellowish brown (10YR 5/4). The clay content ranges from about 18 to 24 percent. The B horizon ranges from medium acid to neutral in reaction.

The Mt. Carroll soils in this survey area are more mottled in the lower part of the B horizon and in the C horizon than is defined as the range for the series.

Mt. Carroll soils occur with Seaton soils, but typically occupy a lower position on the landscape. Their A horizon is slightly thicker and contains more organic matter than that of Seaton soils. Unlike those soils, they are mottled in the lower part of the B horizon and have a IIC horizon of stratified silt and sand at a depth of about 45 to 60 inches.

Mt. Carroll silt loam, 12 to 20 percent slopes, eroded (MrD2).—This soil is in long and narrow areas along valley sides. Areas are less than 40 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is 5 to 8 inches thick. In many places, the subsurface layer and part of the subsoil have been incorporated into the plow layer.

Included with this soil in mapping are small areas of Seaton silt loam, 12 to 20 percent slopes, eroded; areas where the entire surface layer has been lost through erosion; and a few gullies, which are indicated by spot symbols on the soil map. Also included are small areas where stratified silt and sand is at a depth of less than 45 inches and some areas where sandy loam glacial till is at a depth of less than 60 inches.

Runoff is rapid. The erosion hazard is severe.

This soil is too steep and erodible to be intensively cultivated. It is used mostly for forage plants and is suitable for pasture. Capability unit IVe–1; woodland group 2r2; wildlife group 1.

Mt. Carroll silt loam, benches, 0 to 2 percent slopes (MtA).—This soil is in irregularly shaped areas on low terraces on valley floors and in basins. Areas are commonly 40 to 80 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is black or very dark brown.

Included with this soil in mapping are a few areas of Plano silt loam, 0 to 2 percent slopes. Also included are areas where stratified silt and sand is not within a depth of 60 inches and the silty substratum is very massive or platy at a depth of 45 to 60 inches; and a few wet spots, which are indicated by spot symbols on the soil map.

Runoff is slow or very slow. The erosion hazard is slight. Water is likely to pond on the surface during wet seasons and after a heavy rainfall.

This soil is well suited to intensive cultivation. Most of the acreage is cropped to corn or vegetable crops. The soil is poorly suited as septic tank filter fields. Capability unit I; woodland group 2o1; wildlife group 1.

Mt. Carroll silt loam, benches, 2 to 6 percent slopes (MtB).—This soil is in irregularly shaped or long areas on terraces in valleys and basins. Areas range up to several hundred acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of Plano silt loam, 2 to 6 percent slopes; Seaton silt loam, 2 to 6 percent slopes, eroded; and Mt. Carroll silt loam, benches, 0 to 2 percent slopes. Also included are some areas of eroded soil and some areas where the silty deposits are more than 60 inches thick.

Runoff is slow. The erosion hazard is slight in most areas.

This soil is well suited to intensive cultivation. Most of the acreage is cultivated, and corn is the major crop. Use of this soil as septic tank filter fields is hazardous. Capability unit IIe–1; woodland group 2o1; wildlife group 1.

Mt. Carroll silt loam, benches, 6 to 12 percent slopes, eroded (MtC2).—This soil is commonly in long, narrow areas along valley sides. Areas are 20 to 40 acres in size. In most areas, the surface layer is only 7 or 8 inches thick and is a mixture of the subsurface layer and the original surface layer.

Included with this soil in mapping are a few areas of Seaton silt loam, 6 to 12 percent slopes, eroded, and Plano silt loam, 6 to 12 percent slopes, eroded. Also included are a few small areas where the surface layer is only 5 to 7 inches thick, areas where the silty deposits are less than 45 inches or more than 60 inches thick, and a few gullies, which are indicated by spot symbols on the soil map.

Runoff is medium. The erosion hazard is moderate. Erosion is the major limitation.

Most of the acreage is cultivated. Corn and legumes are commonly grown. Capability unit IIIe–1; woodland group 2o1; wildlife group 1.

Northfield Series

The Northfield series consists of well-drained loamy soils that are only 10 to 20 inches deep over sandstone. These soils formed in loamy glacial till. They occupy the crests and sides of sandstone ridges in the till plain. Slopes are typically 12 to 30 percent, but range from 2 to 30 percent. The native vegetation was a mixture of oaks, juniper, and grasses.

In a representative profile the surface layer is about 1 inch of black sandy loam. The subsurface layer is about 3 inches of dark grayish-brown sandy loam. The subsoil is about 14 inches thick. The upper 5 inches is dark yellowish-brown sandy loam, and the lower 9 inches is dark yellowish-brown sandy clay loam. Sandstone bedrock is at a depth of about 18 inches.

These soils are droughty during dry seasons. Permeability is moderate. Available water capacity is very low. Fertility is medium. The shallowness over sandstone restricts many uses of these soils.

Most of the acreage is forested.

Representative profile of Northfield sandy loam, 12 to 30 percent slopes, in a wooded area 330 feet east and 80 feet south of the northwest corner of SW¼ sec. 18, T. 10 N., R. 8 E.

A1—0 to 1 inch, black (10YR 2/1) sandy loam; weak, very fine, granular structure; very friable; many fine roots; strongly acid; abrupt, smooth boundary.

A2—1 to 4 inches, dark grayish-brown (10YR 4/2) sandy loam; weak, fine, subangular blocky structure; very friable; many fine roots; strongly acid; abrupt, wavy boundary.

B1t—4 to 9 inches, dark yellowish-brown (10YR 4/4) sandy loam; weak, medium, subangular blocky structure; very friable; few fine roots; common thin clay bridges between mineral grains; about 3 percent gravel; medium acid; abrupt, wavy boundary.

B21t—9 to 13 inches, dark yellowish-brown (10YR 4/4) light sandy clay loam; weak, fine and medium, subangular blocky structure; very friable; few fine roots; continuous thin clay bridges between mineral grains; about 5 percent gravel; medium acid; clear, wavy boundary.

B22t—13 to 18 inches, dark yellowish-brown (10YR 3/4) light sandy clay loam; moderate, fine, subangular

Oshtemo loamy sand, 0 to 2 percent slopes (OmA).—Large, irregularly shaped areas of this soil are on valley floors and on broad outwash plains near Boyer soils. The few gravel pits are indicated by symbols on the soil map. This soil has a profile similar to the one described as representative of the series, but the surface layer is about 9 inches thick and in some places it has a thin subsurface layer of brown loamy sand.

Included with this soil in mapping are small areas of Boyer loamy sand, 0 to 2 percent slopes; Oshtemo loamy sand, 2 to 6 percent slopes; and Plainfield loamy fine sand, 0 to 2 percent slopes. Also included are some areas where the surface layer is thicker and darker colored and areas where the lower part of the subsoil is saturated during wet seasons.

Runoff is very slow. The hazard of water erosion is slight.

This soil has excellent potential for growing special crops under irrigation and is a source of sand and gravel. Most of the acreage is cultivated or pastured. Some is wooded. Capability unit IIIs–4; woodland group 3o1; wildlife group 3.

Oshtemo loamy sand, 2 to 6 percent slopes (OmB).—Large, broad, irregularly shaped areas of this soil are on undulating outwash plains near Boyer soils. Some areas are hundreds of acres in size. The few gravel pits are indicated by symbols on the soil map. This soil has the profile described as representative of the series. Small areas are saturated at a depth of about 30 to 50 inches during wet seasons.

Included with this soil in mapping are small areas of Boyer loamy sand, 2 to 6 percent slopes; Oshtemo loamy sand, 0 to 2 percent slopes; and Plainfield loamy fine sand, 2 to 6 percent slopes. Also included are some small areas where the surface layer is darker colored and areas where part of the surface layer has been lost through soil blowing.

Runoff is slow. The hazard of water erosion is slight.

This soil has good potential for growing special crops under irrigation and is a source of sand and gravel. Most of the acreage is cropped or pastured. Growth of crops is limited by low available water capacity and low fertility. Capability unit IIIs–4; woodland group 3o1; wildlife group 3.

Oshtemo loamy sand, 6 to 12 percent slopes, eroded (OmC2).—Large, irregularly shaped or long areas of this soil are on rises on outwash plains, on moraines, or along valley sides. The surface layer is commonly dark grayish brown, very dark grayish brown, or dark brown and about 5 to 7 inches thick. In some wooded spots, the surface layer is very dark brown and less than 5 inches thick, and there is a subsurface layer of brown loamy sand about 4 inches thick. In the more eroded spots, material from the subsoil is exposed at the surface.

Included with this soil in mapping are small areas of Boyer loamy sand, 6 to 12 percent slopes, eroded; Plainfield loamy fine sand, 6 to 12 percent slopes; and Wyocena loamy sand, 6 to 12 percent slopes, eroded.

Runoff is medium. The hazard of water erosion is moderate. Low available water capacity and low fertility are the major limitations.

This soil is a source of sand and gravel. Most of the acreage is in hay or pasture. Capability unit IIIe–7; woodland group 3o1; wildlife group 3.

Oshtemo loamy sand, 12 to 20 percent slopes, eroded (OmD2).—Narrow, long areas of this soil are along short valley sides. The areas are commonly less than 15 acres in size. The surface layer is commonly very dark grayish brown or dark grayish brown and about 1 to 3 inches thick, and the subsurface layer is brown loamy sand about 4 to 6 inches thick.

Included with this soil in mapping are small areas of Boyer loamy sand, 12 to 30 percent slopes, eroded; Plainfield loamy fine sand, 12 to 25 percent slopes; and Wyocena loamy sand, 12 to 20 percent slopes, eroded. In a few places, glacial till or sandstone is at a depth of 40 to 60 inches.

Runoff is rapid. The hazard of water erosion is severe.

This soil is limited by low available water capacity and low fertility and is poorly suited to cultivated crops. Most of the acreage is in pasture or woodland. Capability unit IVe–7; woodland group 3r2; wildlife group 3.

Ossian Series

The Ossian series consists of poorly drained silty soils. These soils formed in deposits of silty sediment that is underlain at a depth of more than 50 inches by loamy glacial till, sand and gravel glacial outwash, or lacustrine silt and sand. They are in broad depressions, on valley floors along drainageways, and in low concave areas within areas of silty soils. Slopes range from 0 to 3 percent. The native vegetation was water-tolerant grasses.

In a representative profile the surface layer is about 15 inches thick. It is black silt loam in the upper part and black silty clay loam in the lower part. Just below the surface layer is a transitional layer of mixed black and very dark gray light silty clay loam about 3 inches thick. The subsoil is about 15 inches thick. The upper 12 inches is olive-gray, friable light silty clay loam, and the lower 3 inches is gray, friable silt loam. The substratum is gray, mildly alkaline silt loam.

These soils are saturated at or near the surface throughout most of the year. They are subject to ponding in spring and after a heavy rain (fig. 16). Permeability is moderate to moderately slow. Available water capacity and fertility are high.

Most of the acreage is cropped or pastured.

Representative profile of Ossian silt loam, 0 to 3 percent slopes, in a field of clover 522 feet north and 480 feet east of the southwest corner of SE¼SW¼ sec. 24, T. 10 N., R. 12 E.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure; friable; common fine roots; moderately alkaline; abrupt, smooth boundary.

A12—8 to 15 inches, black (10YR 2/1) light silty clay loam; weak, medium, subangular blocky structure; friable; few fine roots; few fine tubular pores; moderately alkaline; clear, wavy boundary.

AB—15 to 18 inches, mixed black (10YR 2/1) and very dark gray (10YR 3/1) light silty clay loam; many, fine, prominent, olive-gray (5Y 5/2) mottles; moderate, very fine, subangular blocky structure; friable;

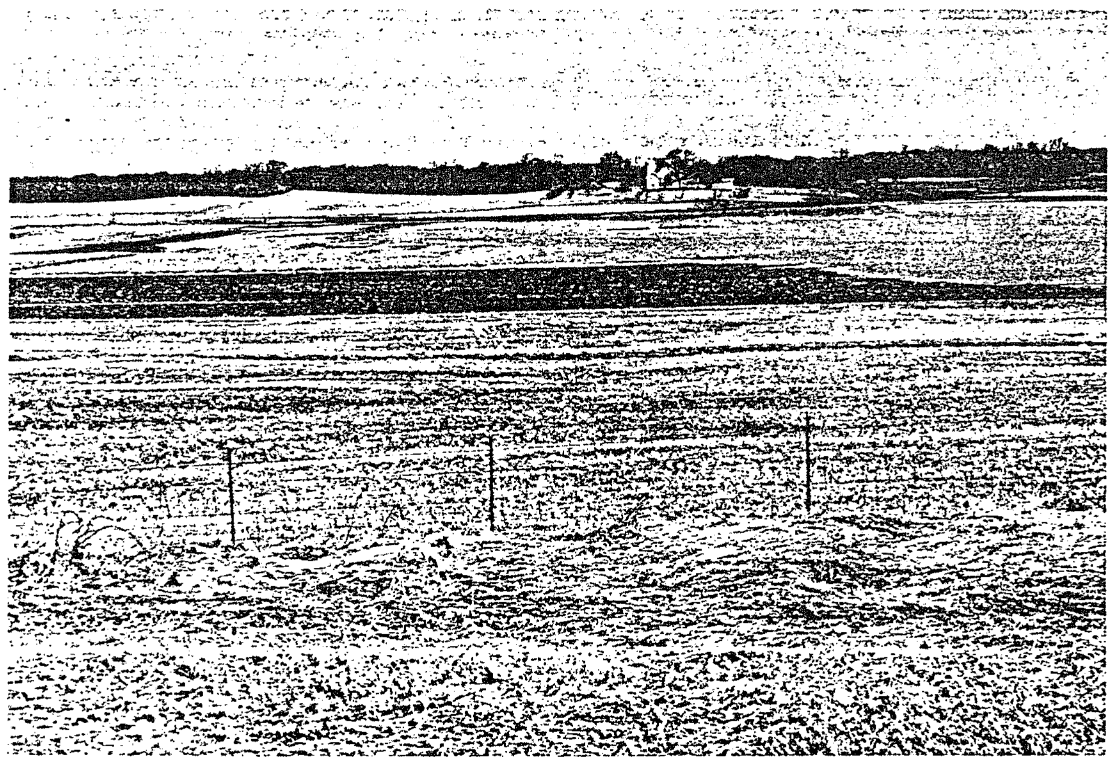


Figure 16.—**Water ponded on an Ossian soil.**

few fine roots; few fine and medium tubular pores; few thin clay films in pores; mildly alkaline; clear, wavy boundary.

B21g—18 to 21 inches, olive-gray (5Y 5/2) light silty clay loam; few, fine, faint and prominent, dark-gray (5Y 4/1) and strong-brown (7.5YR 5/8) mottles; moderate, fine, subangular blocky structure; friable; few fine roots; few fine and coarse tubular pores; few thin films in pores; mildly alkaline; clear, wavy boundary.

B22g—21 to 25 inches, olive-gray (5Y 5/2) light silty clay loam; common, fine, prominent, strong-brown (7.5YR 5/6) and yellowish-red (5YR 4/8) mottles; weak, medium, prismatic structure parting to weak, medium, subangular blocky; friable; few fine roots; few coarse tubular pores; few thin clay films in pores; mildly alkaline; clear, wavy boundary.

B23g—25 to 30 inches, olive-gray (5Y 5/2) light silty clay loam; many, prominent, strong-brown (7.5YR 5/6) and yellowish-red (5YR 4/8) mottles; weak, medium, prismatic structure parting to weak, coarse, subangular blocky; friable; few fine roots; few medium tubular pores; few thin clay films in pores; mildly alkaline; clear, wavy boundary.

B3g—30 to 33 inches, gray (5Y 5/1) silt loam; few, fine and medium, prominent, strong-brown (7.5YR 5/6) and dark reddish-brown (5YR 3/4) mottles; weak, coarse, prismatic structure; friable; few fine roots; few coarse tubular pores; very few thin clay films in pores; mildly alkaline; clear, wavy boundary.

Cg—33 to 60 inches, gray (5Y 5/1) silt loam; few, fine, prominent, dark yellowish-brown (10YR 4/4) mottles along pores; massive; friable; few fine roots; few medium tubular pores; mildly alkaline; slight effervescence.

The solum typically ranges from 30 to 40 inches in thickness, but in places ranges to 50 inches. Below the influence of agricultural lime it is typically neutral or mildly alkaline, but in some places it is slightly acid or moderately alkaline. It commonly formed in more than 50 inches of silty material underlain by outwash or till. Depth to carbonates is more than 40 inches. The A horizon ranges from 10 to 24 inches in thickness. The A and B horizons are silt loam, heavy silt loam, or light silty clay loam. The C horizon is typically silt loam, but in some places it is loamy glacial till, sand, and gravel glacial outwash, or stratified lacustine silt and fine sand.

In many areas the Ossian soils in this survey area are more alkaline than is defined as the range for the series.

Ossian soils form a drainage sequence with the well drained and moderately well drained St. Charles soils and the somewhat poorly drained Atterberry soils. They also occur with Wacousta soils, which occupy slight depressions within areas of Ossian soils, but in contrast they are not mucky and they have a thicker solum. They have a thicker A horizon and are wetter than Atterberry and St. Charles soils.

Ossian silt loam, 0 to 3 percent slopes (OsA).—Larger areas of this soil are in broad depressions. Smaller areas are on valley floors along drainageways.

Included with this soil in mapping are small areas of Wacousta mucky silt loam and Otter silt loam and some small areas where glacial till is at a depth of 30 to 50 inches. Also included are a few small spots of Marsh, which are indicated by spot symbols on the soil map.

Runoff is very slow to ponded. There is little or no erosion hazard. Wetness, along with occasional overflow from runoff, is the major limitation.

Undrained areas of this soil are used as pasture. Drained areas are cropped to corn or other vegetables. Capability unit IIw-1; woodland group 3w5; wildlife group 5b.

Otter Series

The Otter series consists of nearly level poorly drained silty soils. These soils formed in recent silty alluvium washed mainly from soils formed in loess on adjoining uplands and deposited over a mineral soil. They are on valley floors along streams and in low areas that receive runoff from adjacent uplands. Uncultivated areas are in water-tolerant grasses and sedges.

In a representative profile the surface layer is black silt loam and silty clay loam about 28 inches thick. The substratum is just below the surface layer. The upper 6 inches is gray, mildly alkaline silt loam. This is underlain by dark-gray, moderately alkaline silty clay loam.

These soils are saturated at or near the surface throughout most of the year. They are subject to ponding in spring and after heavy rains and to frequent flooding or overflow from runoff from adjacent uplands. Permeability is moderate. Available water capacity is very high. Fertility is high.

If drained, these soils are used for corn and vegetable crops. Most of the acreage is in pasture.

Representative profile of Otter silt loam (0 to 2 percent slopes), in a field of clover 441 feet north and 354 feet east of the southwest corner of NE¼SW¼ sec. 18, T. 12 N., R. 8 E.

Ap—0 to 7 inches, black (10YR 2/1) silt loam; moderate, fine and medium, subangular blocky structure; very friable; common fine roots; mildly alkaline; abrupt, smooth boundary.

A12—7 to 21 inches, black (10YR 2/1) silt loam; few, fine, prominent, strong-brown (7.5YR 5/6) mottles; weak, fine and medium, subangular blocky structure; very friable; common fine roots; mildly alkaline; abrupt, smooth boundary.

A13—21 to 28 inches, black (10YR 2/1) silty clay loam; few, fine, prominent, strong-brown (7.5YR 5/6) mottles and few, medium, prominent, grayish-brown (10YR 5/2) mottles; moderate, very fine, subangular blocky structure; friable; few fine roots; mildly alkaline; clear, wavy boundary.

C1g—28 to 34 inches, gray (5Y 5/1) silt loam; common, fine, prominent, strong-brown (7.5YR 5/6) mottles; weak, fine and medium, subangular blocky structure; friable; few fine roots; mildly alkaline; clear, wavy boundary.

C2g—34 to 60 inches, dark-gray (5Y 4/1) silty clay loam; common, fine, prominent, yellowish-red (5YR 4/8) mottles; massive; friable; moderately alkaline; slight effervescence.

The A horizon ranges from 24 to 40 inches in thickness. It is black (10YR 2/1), very dark brown (10YR 2/2), or very dark gray (10YR 3/1) silt loam or silty clay loam, but in some places it has thin strata of loam or sandy loam. Reaction ranges from slightly acid to mildly alkaline. The C horizon is mostly silt loam or silty clay loam, but in some places it is stratified silt loam, loam, sandy loam, or silty clay loam. The C horizon ranges from neutral to moderately alkaline.

Otter soils are similar to Wallkill and Troxel soils. In contrast, they are underlain by mineral sediment, whereas Wallkill soils are underlain by organic deposits. They are poorly drained, whereas Troxel soils are well drained and moderately well drained.

Otter silt loam (0 to 2 percent slopes) (Ot).—This soil is in broad and long or fan-shaped areas on valley floors along streams and in low areas that receive runoff from adjoining uplands. Some large areas, ranging up to several hundred acres in size, are along major streams. Some long and narrow areas are on old bayous of meandering streams.

Included with this soil in mapping are some small areas that are slightly better drained; a few areas where an old, buried surface layer is at a depth of 30 to 60 inches; a few small spots of Marsh, which are indicated by spot symbols on the soil map; small areas where the alluvium is loamy rather than silty; and a few areas where thin strata of muck are within the silty sediment. Also included are a few small areas of Alluvial land, loamy, wet.

Runoff is very slow to ponded. There is little or no erosion hazard. Wetness, along with frequent flooding or overflow, is the major limitation.

Most of the acreage is pastured. A few drained areas are used for crops. Capability unit IIw-1; woodland group 1w5; wildlife group 5b.

Palms Series

The Palms series consists of nearly level, very poorly drained organic soils underlain by loamy mineral soil. The organic material is 16 to 50 inches of well-decomposed residue from water-tolerant plants. These soils are in broad glacial lakebeds, in depressions, and along drainageways. The native vegetation was mainly reeds and sedges.

In a representative profile the surface layer is dark reddish-brown muck about 13 inches thick. It is underlain by about 17 inches of dark-brown and black, medium acid muck. The lower 5 inches of this layer is about 60 percent mineral soil material. The substratum is dark-gray and greenish-gray silty clay loam.

Unless drained, these soils are saturated at or near the surface throughout most of the year. Permeability is moderately rapid in the organic material and moderately slow in the mineral substratum. Available water capacity is very high. Fertility is low.

In drained areas, Palms soils are cropped intensively to corn, truck crops, and mint. Some acreage is used for growing sod for lawns. Undrained areas are suited to permanent pasture or wildlife habitat.

Representative profile of Palms muck (0 to 2 percent slope), 380 feet east and 370 feet south of the northwest corner of SE¼NW¼ sec. 23, T. 13 N., R. 8 E.

Oap—0 to 13 inches, dark reddish-brown (5YR 2/2) sapric material, very dark brown (10YR 2/2) rubbed and pressed; about 70 percent fiber, 5 percent rubbed; weak, coarse, subangular blocky structure; very areas where the substratum is loamy sand till, and some more eroded spots where subsoil material is exposed at the surface.

Runoff is medium. The erosion hazard is moderate.

This soil is commonly cropped to hay and some corn. It is poorly suited to intensive cultivation. Most of the acreage is cultivated. Some is used as pasture or woodland. Capability unit IVe–4; woodland group not classified; wildlife group 4.

Rotamer loam, 12 to 20 percent slopes, eroded (RtD2).—This soil is in long, narrow areas along ridges and on the sides and crests of drumlins on the till plain. Areas range up to 30 acres in size.

Included with this soil in mapping are small areas of Lapeer fine sandy loam, 12 to 30 percent slopes, eroded; areas of soils that have a surface layer of fine sandy loam; and some areas where the substratum is loamy sand till. Also included are severely eroded spots, indicated by spot symbols on the soil map, where subsoil material is exposed at the surface.

Runoff is rapid. The erosion hazard is severe.

This soil is in pasture or hay. It is poorly suited to cultivated crops. Most of the acreage is cultivated or has been cultivated. Some is forested. Capability unit VIe–4; woodland group not classified; wildlife group 4.

Rotamer loam, 20 to 30 percent slopes, eroded (RtE2). This soil is in long, narrow areas along ridges on the till plain. Areas are less than 15 acres in size. The surface layer is 1 to 3 inches thick. In some convex areas, the original surface layer has been lost through erosion, and subsoil material is exposed at the surface.

Included with this soil in mapping are small areas of Lapeer fine sandy loam, 20 to 30 percent slopes, eroded. Also included are more eroded spots, where limy substratum material is exposed at the surface and a few places where the substratum is loamy sand till.

Runoff is very rapid. The erosion hazard is very severe.

This soil is poorly suited to cultivated crops. Most of the acreage is used as pasture. Capability unit VIIe–4; woodland group not classified; wildlife group 4.

St. Charles Series

The St. Charles series consists of well drained and moderately well drained silty soils. These soils formed in 40 to 60 inches of silty sediment and the underlying calcareous sandy loam glacial till. They occur on silt-covered till plains. Slopes are typically 0 to 12 percent but range up to 30 percent. The native vegetation was deciduous forest.

In a representative profile the surface layer is very dark grayish-brown silt loam about 9 inches thick. The subsoil is about 49 inches thick. The upper 2 inches is dark-brown, friable heavy silt loam; the next 24 inches is dark yellowish-brown, friable and firm silty clay loam; the next 12 inches is dark yellowish-brown, friable silt loam; and the lower 11 inches is dark-brown, friable sandy clay loam. The substratum is yellowish-brown, very friable, moderately alkaline sandy loam.

Permeability is moderate. Available water capacity and fertility are high. In many places, typically in the less sloping areas, these soils are saturated at a depth of about 3 to 5 feet for significant periods during wet seasons.

Most of the acreage is cultivated. Corn is the main crop, but some areas are cropped to peas, small grain, or hay. The more sloping areas are used as pasture or woodland. The less sloping areas are well suited to crops.

Representative profile of St. Charles silt loam, 2 to 6 percent slopes, eroded, 610 feet north and 240 feet west of the southeast corner of sec. 30, T. 10 N., R. 12 E.

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) silt loam, light brownish gray (10YR 6/2) dry; weak, very fine, subangular blocky structure; friable; common fine roots; neutral; abrupt, smooth boundary.

B1t—9 to 11 inches, dark-brown (10YR 4/3) heavy silt loam; weak, very fine, subangular blocky structure; friable; few fine roots; common fine and few medium and coarse tubular pores; very dark grayish-brown (10YR 3/2) material in coarse pores; few thin clay films on faces of peds; slightly acid; clear, wavy boundary.

B21t—11 to 26 inches, dark yellowish-brown (10YR 4/4) silty clay loam; strong, fine and very fine, subangular blocky structure; firm; few fine roots; many fine and few medium tubular pores; continuous thin clay films of faces of peds; slightly acid; clear, wavy boundary.

B22t—26 to 35 inches, dark yellowish-brown (10YR 4/4) silty clay loam; common, fine, faint, yellowish-brown (10YR 5/4) mottles and few, fine, distinct and prominent, brownish-yellow (10YR 6/6) and reddish-black (10R 2/1) mottles at a depth of 30 to 35 inches; moderate, fine, subangular blocky structure; friable; few fine roots; common fine and few medium tubular pores; continuous thin clay films on faces of peds; slightly acid; gradual, wavy boundary.

B31t—35 to 47 inches, dark yellowish-brown (10YR 4/4) silt loam; common, fine, prominent, strong-brown (7.5YR 5/8) mottles and few, fine, prominent, reddish-black (10R 2/1) and yellowish-red (5YR 4/8) mottles; weak, very fine, subangular blocky structure; friable; few fine roots; common fine tubular pores; common thin clay films on faces of peds; slightly acid; abrupt, wavy boundary.

IIB32—47 to 58 inches, dark-brown (7.5YR 4/4) sandy clay loam; few, fine, prominent, yellowish-red (5YR 4/8) mottles; weak, coarse, subangular blocky structure; friable; many thin clay bridges between mineral grains; about 4 percent gravel; neutral; clear, wavy boundary.

IIC—58 to 60 inches, yellowish-brown (10YR 5/4) sandy loam; massive; very friable; about 8 percent gravel; moderately alkaline; slight effervesence.

The solum ranges from 44 to more than 65 inches in thickness. Depth to the till ranges from 40 to 60 inches. The Ap horizon is dark grayish brown (10YR 4/2) or very dark grayish brown (10YR 3/2) and is 5 to 9 inches thick. The B horizon is dark brown (7.5YR 4/4) or dark brown (10YR 4/3) to yellowish brown (10YR 5/4) and ranges from 30 to 50 inches in thickness. The estimated clay content ranges from about 23 to 32 percent. The IIB3 horizon is sandy loam, sandy clay loam, or loam. Reaction in the B horizon is commonly medium acid or slightly acid but ranges to neutral in the lower part. In some places, mottles do not occur between depths of about 30 and 50 inches. The C horizon is sandy loam or heavy sandy loam glacial till.

The St. Charles soils in this survey area are less acid than is defined as the range for the series.

The well drained and moderately well drained St. Charles soils occur in a drainage sequence with the somewhat poorly drained Atterberry soils and the poorly drained Ossian soils. They also occur with Dodge and Knowles soils and are similar to Seaton soils. Their A horizon contains less organic matter than that of Atterberry and Ossian soils, and is not so thick. Unlike Atterberry and Ossian soils, the lower part of their B horizon formed in sandy loam till. They formed in thicker deposits of silt than Dodge soils. Unlike Knowles soils, they are not underlain by bedrock within a depth of 40 inches. They have more clay in the B horizon than Seaton soils, and unlike those soils, they have contrasting texture in the lower part of the B horizon.

St. Charles silt loam, 0 to 2 percent slopes (SaA).—Large, irregularly shaped areas of this soil are in slight depressions in the till plains. The profile of this soil is similar to the one described as representative of the series, but the silty sediment is typically 55 to 60 inches thick, and the subsoil extends to a depth of more than 60 inches.

Included with this soil in mapping are small areas of Atterberry silt loam, 0 to 2 percent slopes. Also included are many areas where the silty sediment is more than 60 inches thick, a few areas where the substratum is sand and gravel outwash, areas where the surface layer is 10 to 11 inches thick, areas where the subsoil contains less clay, areas where the surface layer is loamy, and areas where limestone is at a depth of 50 to 60 inches.

This soil is poorly suited as a septic tank filter field. Runoff is slow, and there is little or no erosion hazard. Water is likely to pond in spring and after rains.

This soil has few limitations and is suited to intensive cropping. Most of the acreage is cropped to corn or vegetable crops. Capability unit I; woodland group 1o1; wildlife group 1.

St. Charles silt loam, 2 to 6 percent slopes, eroded (SaB2).—This soil is on rises on the till plain near Dodge and Atterberry soils. The broad, irregularly shaped areas are large, ranging up to several hundred acres in size. This soil has the profile described as representative of the series. In the more sloping areas, 2 to 5 inches of the original surface layer has been lost through erosion and the subsoil generally is not mottled.

Included with this soil in mapping are small areas of St. Charles silt loam, 0 to 2 percent slopes, and Atterberry silt loam, 2 to 6 percent slopes. Also included are a few areas where the silty sediment extends to a depth of more than 60 inches, areas where the substratum is sand and gravel outwash, areas where the surface layer is darker colored or is loamy, areas where limestone is at a depth of about 40 to 60 inches, and areas, mainly where slopes are 2 to 4 percent, where there is little or no erosion.

Runoff is medium. The erosion hazard is moderate in the more sloping areas.

This soil is well suited to crops if properly managed to control erosion (fig. 20). It is also suited to pasture and woodland. Most of the acreage is cropped to corn or vegetable crops. Capability unit IIe–1; woodland group 1o1; wildlife group 1.

St. Charles silt loam, 6 to 12 percent slopes, eroded (SaC2).—This soil is generally in long areas on the sides of ridges and on rises on the till plain and in valleys adjacent to drainageways. Areas range from 20 to 60 acres in size. This soil is not mottled in the lower part of the subsoil; the thickness of the surface layer and subsoil combined is 44 to about 50 inches; and the surface layer is dark grayish brown and about 6 to 7 inches thick.

Included with this soil in mapping are small areas of Dodge silt loam, 6 to 12 percent slopes, eroded. Also included are a few areas where bedrock is at a depth of 40 to 60 inches and areas where the substratum is sand and gravel outwash.

Runoff is medium. The erosion hazard is moderate.

Most of the acreage is cropped to corn, small grain, or hay. Some is pastured or forested. Erosion is the major limitation. Capability unit IIIe–1; woodland group 1o1; wildlife group 1.

St. Charles silt loam, 12 to 20 percent slopes, eroded (SaD2).—This soil is in long and somewhat narrow areas along ridges or on valley sides on till plains. Areas range from 10 to 30 acres in size. In most areas the surface layer is black or very dark gray and 2 or 3 inches thick, and the subsurface layer is brown or pale brown and 5 to 9 inches thick. This soil is not mottled in the lower part of the subsoil; the thickness of the surface layer and subsoil combined is about 44 to 50 inches; and the silt sediment is 40 to 45 inches thick.

Included with this soil in mapping are small areas of Dodge silt loam, 12 to 20 percent slopes, eroded. Also included are a few severely eroded spots and gullies, which are indicated by spot symbols on the soil map.

Runoff is rapid. The erosion hazard is severe.

This soil is generally not well suited to cultivated crops. Most of the acreage is used as pasture or woodland. Capability unit IVe–1; woodland group 1r2; wildlife group 1.

St. Charles silt loam, 20 to 30 percent slopes (SaE).—This soil is along ridges on till plains. Some areas are irregularly shaped, but most are long and have short slopes. Areas are less than 40 acres in size. This soil is not mottled in the lower part of the subsoil; the thickness of the surface layer and subsoil combined is 44 to 50 inches; the silty sediment is 40 to 45 inches thick; the surface layer is black and is 1 to 3 inches thick; and the subsurface layer is brown or pale brown and is 5 to 9 inches thick.

Included with this soil in mapping are small areas of soils that have less than 40 inches of silty sediment, more than 60 inches of silty sediment, or steeper slopes. In some areas the subsoil formed entirely in silt, or it contains less clay and a high content of fine sand. Also included are a few small areas where the substratum is stratified silt and sand and the lower part of the subsoil is mottled. Some gullies have formed which are indicated by spot symbols on the soil map.

Runoff is very rapid. The erosion hazard is very severe.

This soil is poorly suited to cultivated crops. Most of the acreage is in deciduous trees. A few areas are pastured. Capability unit VIe–1; woodland group 1r2; wildlife group 1.

B21t—13 to 31 inches, dark yellowish-brown (10YR 4/4) silty clay loam; moderate, fine and medium, subangular blocky structure; firm; few fine roots; common thin clay films on faces of peds; slightly acid; clear, wavy boundary.

B22t—31 to 35 inches, dark-brown (7.5YR 4/4) heavy silt loam; weak, medium, subangular blocky structure; friable; few fine roots; common thin clay films on faces of peds; slightly acid; clear, wavy boundary.

IIB3t—35 to 38 inches, dark-brown (7.5YR 4/4) sandy loam; weak, medium, subangular blocky structure; friable; few fine roots; thin clay bridges between mineral grains; about 10 percent gravel; slightly acid; clear, wavy boundary.

IIC—38 to 60 inches, yellowish-brown (10YR 5/4) sandy loam; massive; very friable; about 14 percent gravel; slight effervescence.

The solum typically ranges from 35 to 40 inches in thickness but in places ranges from 30 to 42 inches. Depth to the till ranges from 26 to 36 inches. The A horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2) in color and from 10 to 18 inches in thickness. The B horizon is dark-brown (7.5YR 4/4 or 10YR 4/3) to yellowish-brown (10YR 5/4) heavy silt loam and silty clay loam. The IIB horizon is dark-brown (7.5YR 4/4) or dark yellowish-brown (10YR 3/4-4/4) sandy loam, heavy sandy loam, sandy clay loam, or clay loam. The upper 20 inches of the B horizon is less than 15 percent fine sand or coarser material. Reaction is commonly medium acid or slightly acid, but ranges to mildly alkaline in the lower part.

The Saybrook soils in this survey area have more sand and less silt in the C horizon than is defined as the range for the series.

Saybrook soils occur with Plano, Ringwood, and Ripon soils. They formed in a thinner mantle of silt and have a thinner solum than Plano soils. They contain more silt and less sand in the upper 20 inches of the Bt horizon than Ringwood soils. Unlike that of Ripon soils, their solum is not underlain by bedrock.

Saybrook silt loam, 2 to 6 percent slopes, eroded (SeB2).—This soil is in irregularly shaped or long areas on rises on the till plain. It occurs with Plano and Ringwood soils. Areas are commonly 30 to 60 acres in size. This soil has the profile described as representative of the series, but in most places part of the surface layer has been removed by erosion.

Included with this soil in mapping are small areas of Plano silt loam, 2 to 6 percent slopes, and Ringwood silt loam, 1 to 6 percent slopes, eroded. Also included are a few areas where the subsoil extends to a depth of more than 42 inches, areas where bedrock is at a depth of 40 to 60 inches, areas where slopes are less than 2 percent, areas where the substratum is sand and gravel outwash, and a few small areas where the lower part of the subsoil is mottled.

In the more sloping areas, runoff is medium and the erosion hazard is moderate.

This soil is well suited to crops. Most of the acreage is cultivated. Corn and vegetable crops are commonly grown. Capability unit IIe-1; woodland group not classified; wildlife group 4.

Saybrook silt loam, 6 to 12 percent slopes, eroded (SeC2).—This soil is in long areas on rises and along ridges on the till plain. It occurs with Plano and Ringwood soils. Areas range up to 30 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is 9 to 12 inches thick, and the mantle of silt is about 30 inches thick.

Included with this soil in mapping are small areas of Plano silt loam, 6 to 12 percent slopes, eroded; and Ringwood silt loam, 6 to 12 percent slopes, eroded. Also included are a few small areas where the subsoil extends to a depth of more than 42 inches, areas where bedrock is at a depth of 40 to 60 inches, and areas where the surface layer is only 7 to 9 inches thick.

Runoff is medium. The erosion hazard is moderate.

This soil is cropped to corn, small grain, or hay. A few areas are pastured. Erosion is the main limitation. Capability unit IIIe-1; woodland group not classified; wildlife group 4.

Saybrook silt loam, 12 to 20 percent slopes, eroded (SeD2).—This soil is along ridges and on knobs on the till plain. Areas are typically 5 to 10 acres in size. They are commonly long, but a few very small areas are roughly circular. The surface layer is commonly 8 to 10 inches thick, the mantle of silt ranges from 26 to 30 inches in thickness, and the substratum is at a depth of 30 to 35 inches.

Included with this soil in mapping are small areas of Griswold silt loam, 12 to 20 percent slopes, eroded. Also included are a few areas where the surface layer is 5 to 7 inches thick, areas where bedrock is at a depth of 40 to 60 inches, areas where the subsoil extends to a depth of more than 42 inches, and areas where depth to the underlying till is more than 36 inches.

Runoff is rapid. The erosion hazard is severe. Erosion is the main limitation.

This soil is poorly suited to cultivated crops. Most of the acreage is cropped to legumes or used for pasture. Small areas, within or contiguous to less sloping areas, are cropped to corn or small grain. Capability unit IVe-1; woodland group not classified; wildlife group 4.

Seaton Series

The Seaton series consists of well-drained silty soils. These soils formed in thick deposits of silt that have a high content of coarse silt. They occur in valleys and on bluffs adjacent to the Wisconsin River. Slopes range from 0 to 20 percent. The native vegetation was mixed deciduous forest.

In a representative profile the surface layer is very dark grayish-brown silt loam about 3 inches thick. The subsurface layer is brown silt loam about 8 inches thick. The subsoil extends to a depth of more than 60 inches. The upper 37 inches is yellowish-brown silt loam, and the lower 12 inches is brown silt loam.

Permeability is moderate. Available water capacity and fertility are high.

Most of the acreage is suited to crops.

Representative profile of Seaton silt loam, 6 to 12 percent slopes, eroded, in an uneroded area 60 feet east and 50 feet north of the southwest corner of NE¼ sec. 21, T. 12 N., R. 8 E.

A1—0 to 3 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine, granular structure; very friable; many fine roots; neutral; abrupt, smooth boundary.

A2—3 to 11 inches, brown (10YR 5/3) silt loam; weak, thin, platy structure; very friable; many fine roots; few very fine tubular pores; neutral; abrupt, smooth boundary.

B1—11 to 16 inches, yellowish-brown (10YR 5/4) silt loam; weak, fine, subangular blocky structure; very friable; common fine roots; few silt coatings on faces of peds; common very fine tubular pores; strongly acid; clear, wavy boundary.

B2t—16 to 36 inches, yellowish-brown (10YR 5/4) silt loam; moderate, fine, subangular blocky structure; friable; few fine roots; few silt coatings on faces of peds; common very fine tubular pores; few thin clay films on faces of peds common at a depth of 30 to 36 inches and many thin clay films in pores; strongly acid; clear, wavy boundary.

B31t—36 to 48 inches, yellowish-brown (10YR 5/4) silt loam; weak, medium and coarse, subangular blocky structure; friable; few fine roots; common silt coatings on faces of peds; few fine and many very fine tubular pores; few thin clay films on faces of peds and many thin clay films in pores; strongly acid; gradual, wavy boundary.

B32—48 to 60 inches or more, brown (10YR 5/3) silt loam; weak, coarse, subangular blocky structure; friable; few fine roots; common silt coatings on faces of peds; few fine and many very fine tubular pores; few thin clay films on faces of peds and in pores; medium acid.

The solum is typically more than 60 inches thick, but ranges from 42 to more than 72 inches. The A1 horizon ranges from very dark brown (10YR 2/2) to dark grayish brown (10YR 4/2) and is 2 to 5 inches thick. If it occurs, the Ap horizon is 6 to 9 inches thick and ranges from very dark grayish brown (10YR 3/2) to brown (10YR 5/3). The A2 horizon is dark grayish brown (10YR 4/2) to brown (10YR 5/3) and ranges from 2 to 10 inches in thickness. The B horizon ranges from brown (10YR 4/3) to yellowish brown (10YR 5/4) and is silt loam or heavy silt loam. It is high in content of coarse silt and very fine sand. Content of clay is 18 to 24 percent. Reaction is typically medium acid or strongly acid, but ranges to neutral in the lower part. The C horizon is silt loam.

Seaton soils are similar to St. Charles soils and occur with Mt. Carroll soils. Their A horizon is thinner and contains less organic matter than that of Mt. Carroll soils, and they do not have a C horizon of stratified silt and fine sand at a depth of 45 to 60 inches, which is typical of those soils. They formed in thick deposits of silt, whereas the lower part of the solum of St. Charles soils formed in sandy loam glacial till.

Seaton silt loam, 0 to 2 percent slopes (SfA).—This soil is in irregularly shaped areas on valley floors and in slight depressions in basins. Areas are commonly less than 40 acres in size. The surface layer is 8 or 9 inches thick, and the subsurface layer is 1 to 4 inches thick.

Included with this soil in mapping are a few areas of Mt. Carroll silt loam, benches, 0 to 2 percent slopes; and areas where the soil is saturated at a depth of about 3 to 5 feet during wet seasons. Also included are a few small areas where the surface layer is darker colored and areas where the subsoil is dominantly silty clay loam.

Runoff is slow. The erosion hazard is slight. Water is likely to pond on the surface during wet seasons and after heavy rains.

The soil has few limitations and is well suited to intensive cultivation. Most of the acreage is cropped to corn or vegetable crops. Capability unit I; woodland group 1o1; wildlife group 1.

Seaton silt loam, 2 to 6 percent slopes, eroded (SfB2).—This soil is in irregularly shaped or long areas on terraces in valleys and basins. Areas are commonly 40 to 80 acres in size. This soil has a profile similar to the one described as representative of the series, but in most areas tillage has mixed the subsurface layer with the original surface layer, and part of this has been lost through erosion. The present surface layer is only 7 to 9 inches thick.

Included with this soil in mapping are a few small areas of Seaton silt loam, 0 to 2 percent slopes; Mt. Carroll silt loam, benches, 2 to 6 percent slopes; St. Charles silt loam, 2 to 6 percent slopes, eroded; and some areas where this soil is saturated at a depth of about 3 to 5 feet during wet seasons. Also included are a few small areas where the surface layer is darker colored, areas where the subsoil is dominantly silty clay loam, and a few places where there is little or no erosion.

This soil is more susceptible to erosion where slopes are 4 to 6 percent. Runoff is medium. The erosion hazard is slight to moderate.

This soil is well suited to intensive cultivation if well managed. Most of the acreage is cultivated. Capability unit IIe-1; woodland group 1o1; wildlife group 1.

Seaton silt loam, 6 to 12 percent slopes, eroded (SfC2).—This soil is along valley walls and on rises and the crests of bluffs. It follows the slopes set by the drainage pattern. Areas are commonly 20 to 40 acres in size. This soil has the profile described as representative of the series, but the surface layer is thinner. In cultivated areas the present surface layer is a mixture of the remaining original material, the subsurface layer, and material from the upper part of the subsoil. The present surface layer is only 6 to 8 inches thick.

Included with this soil in mapping are small areas of Mt. Carroll silt loam, benches, 6 to 12 percent slopes, eroded, and St. Charles silt loam, 6 to 12 percent slopes, eroded. In many places, this soil is segmented by short drainageways. In a few small areas, the subsoil is dominantly silty clay loam. In some places, the silt loam substratum is underlain at a depth of about 50 to 60 inches by sandy loam till.

Runoff is rapid. The erosion hazard is moderate.

Most of the acreage is cultivated. Corn or legumes are commonly grown. Erosion is the major limitation. Some acreage is used as pasture or woodland. Capability unit IIIe-1; woodland group 1o1; wildlife group 1.

Seaton silt loam, 12 to 20 percent slopes, eroded (SfD2). This soil is in long and somewhat narrow areas along valley sides. It follows the slope set by the drainage pattern. Areas are commonly less than 40 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner. In cultivated areas the present surface layer is a mixture of the remaining original material the subsurface layer, and material from the upper part of the subsoil.

Included with this soil in mapping are a few small areas of St. Charles silt loam, 12 to 20 percent slopes, eroded. Also included are areas where the subsoil is silty clay loam, areas where slopes are segmented by short drainageways, and many gullies, which are indicated by spot symbols on the soil map.

Runoff is very rapid. The erosion hazard is severe.

This soil is too steep and erodible to be well suited to cultivated crops. It is better suited to woodland or limited pasture than to other uses. Capability unit IVe-1; woodland group 1r2; wildlife group 1.

Soils of Wisconsin

Francis D. Hole

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M. E. Ostrom, State Geologist
F. D. Hole, in charge, Soil Survey Division

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ORIGINAL COVER OF VEGETATION WITH ASSOCIATED ANIMALS

The major gross influences of the biota on the soil are (1) stabilization and protection against removal by water and wind erosion, and (2) development of characteristic layers (horizons) that are enriched in organic matter.

An S-shaped curve, delineated by the southern boundary of the northern mesic forest (Plate 6; Table 2-8; Figs. 1-9, 2-40), marks the transition between major areas of original northern mixed broadleaf-conifer forest, and southern broadleaf forest and prairie association (Curtis, 1959). Distribution of prairie on ridge tops (southwestern Wisconsin), on outwash plains (as in the vicinity of Janesville and Beloit in Rock County), and on irregular topography elsewhere has been explained as an effect of fires (Curtis, 1959) which burned over these areas often enough to suppress or eliminate forest growth. The presence of large areas of oak savanna in the south and the less extensive pine barrens and pine forest in the north is also attributed to the effects of major fires that either suppressed trees without eliminating them, as in oak savannas and pine barrens, or cleared the way for a succession of white and red pine on sandy loam soils. In northern counties fires created conditions locally favorable for bracken fern-sedge meadows. These are sometimes called stump prairies (Vogl, 1964), but are not true prairies. In places, the Rock and Crawfish rivers in Dodge and Jefferson counties in southeastern Wisconsin served as fire breaks that limited the spread of oak savanna into southern mesic forest (Zicker, 1955). This was important for soil formation because organic matter is abundantly incorporated into the soil under cover of prairie and savanna. Northern forests, especially hemlock stands, have favored the development of Spodosols (Podzols).

Animals associated with the plant communities have had their influence on soil directly or indirectly. Before European settlement, for example, beavers expanded the area of wet soils by constructing innumerable dams along drainageways throughout the state (Schorger, 1965; Hole et al., 1962). Recent build-up of the deer herd in Wisconsin, as a result of both the destruction of natural predators and particularly the increase in range following lumbering and burning, has damaged the forest reproduction in much of northern Wisconsin, with consequent interruption of the biocycling of nutrients by trees (Creed and Stearns, in Milfred, Olson, and Hole, 1967; Leopold, 1943). The vast numbers of smaller animals (rodents, worms, insects) have had a more direct and pervasive effect on soils of the state (Nielsen and Hole, 1964; Baxter and Hole, 1967; Salem and Hole, 1968). In general, fauna in Wisconsin have been more abundant and active in the soil of prairie and savanna lands than in forest lands, activity being proportionate to the intensity of solar illumination of the soil surface.

It is evident that the biotic overlay on soil and penetration into soil is dynamic. The soil responds to biologic events; sometimes rapidly, as in the case of biocycling of nutrients, and sometimes slowly. Long-term changes in prairie-border soil profiles, for example, have been very gradual, in response to the vegetative shift of the last few thousand years (Curtis, 1959) from grassland to encroaching forest. The fact that there must be a time lapse, called pedologic lag, between the conversion of vegetation and that of soil profile would lead us to expect the deep dark mineral soils to be more extensive in Wisconsin than the actual prairies that European settlers found here. It is possible that this is the real explanation for the fact that the soil map shows more of the state occupied by prairie soils (about 8% Hapludolls and Haplaquolls) than was occupied by prairie a century ago (5%; Table 2-8).

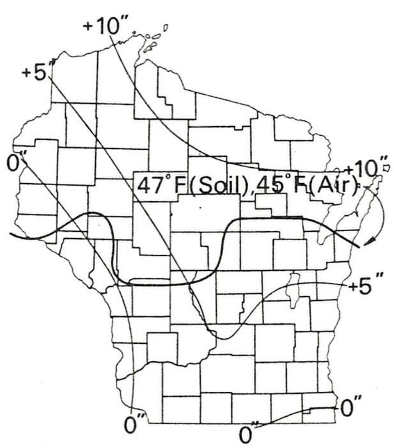


Figure 2-32. Transition boundary between mesic (to the south) and frigid (to the north) soils families; with isolines of precipitation minus potential evapotranspiration (after Bryson, 1957).

CLIMATE

Regional Climate

The air masses that pass over a region determine its climate. In Wisconsin the interaction is between continental arctic, continental polar, maritime tropical, and maritime pacific air masses. Wisconsin lies in a midlatitude (temperate) continental climatic zone (Dbf and Daf of Trewartha, in Finch et al., 1957) that also prevails over parts of eastern Europe and China. Borchert (1950) characterized the climate of northeastern Wisconsin as one that brings deep winter snows and reliable summer rains; that of southwestern Wisconsin as providing relatively dry winters and frequent severe summer droughts (Figs. 2-33 through 2-37). Fig. 2-32 shows the transition boundary between two soil-climatic regions of the state, one relatively cool (roughly corresponding to the Dbf zone) and the other warm (Daf). The new USDA soil classification designates these regions as frigid and mesic, respectively.[4] In terms of soils, these are the Spodosol (with widespread fragipans) and Alfisol-Mollisol (without fragipans) regions (Fig. 2-40). Precipitation is

4. These are defined as follows: Frigid soils are those with mean annual soil temperatures below 47° (8°C), at a depth of 20 inches (50 cm); mesic soils are those with mean annual temperatures between 47 and 59°F (8-15°C). Both groups of soils have a difference greater than 9°F (5°C) between mean summer and mean winter temperatures. The mean annual soil temperature at the depth indicated is about 2°F (1°C) warmer than the mean annual atmospheric temperature at the same site.

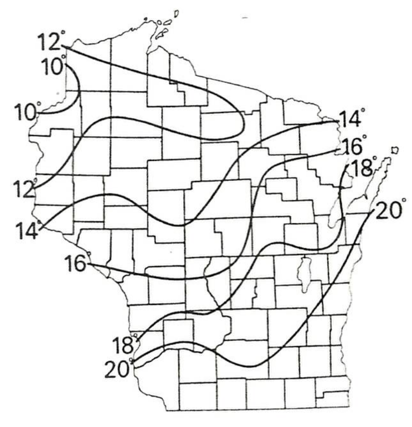


Figure 2-33. Mean air temperature (°F) for January (after Burley, 1964).

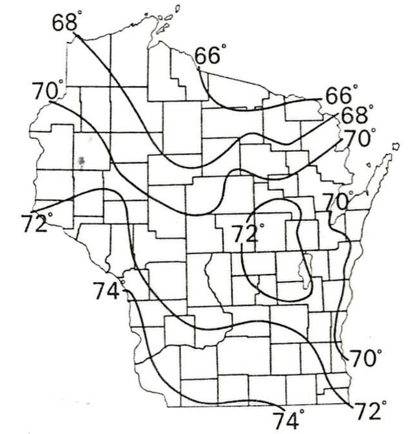


Figure 2-34. Mean air temperature (°F) for July (after Burley, 1964).

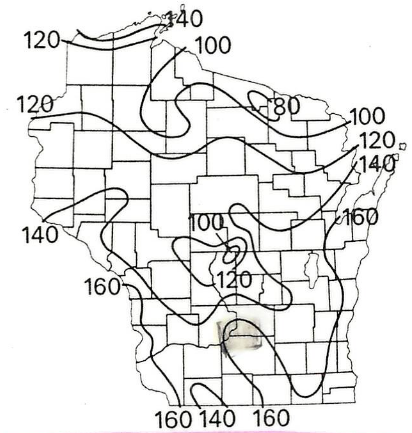


Figure 2-35. Average length (in days) of growing (frost-free) season (after Burley, 1964).

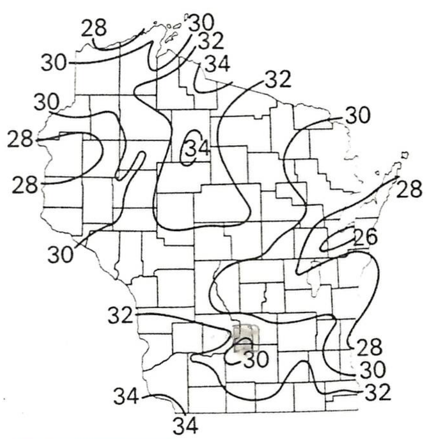


Figure 2-36. Mean annual precipitation (inches; after Holt, Young, and Cartwright, 1964).

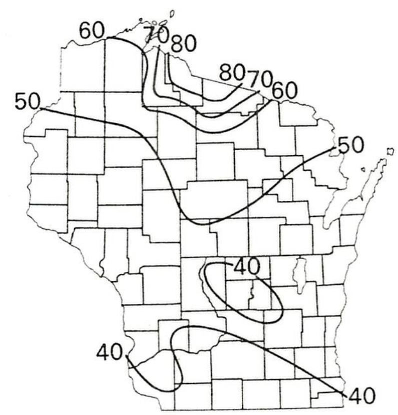


Figure 2-37. Average seasonal snowfall, 1930-1959 (inches) (after Burley, 1964).

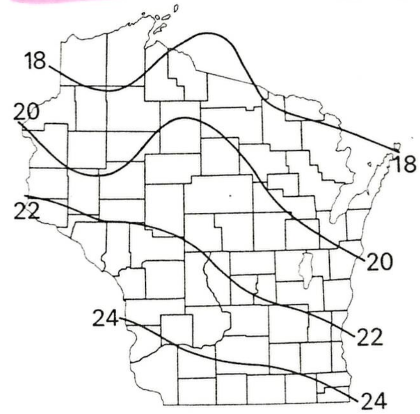


Figure 2-38. Estimated evapotranspiration in inches (annual precipitation, after Burley, 1964, minus annual total runoff, after Holt, Young, and Cartwright, 1964).

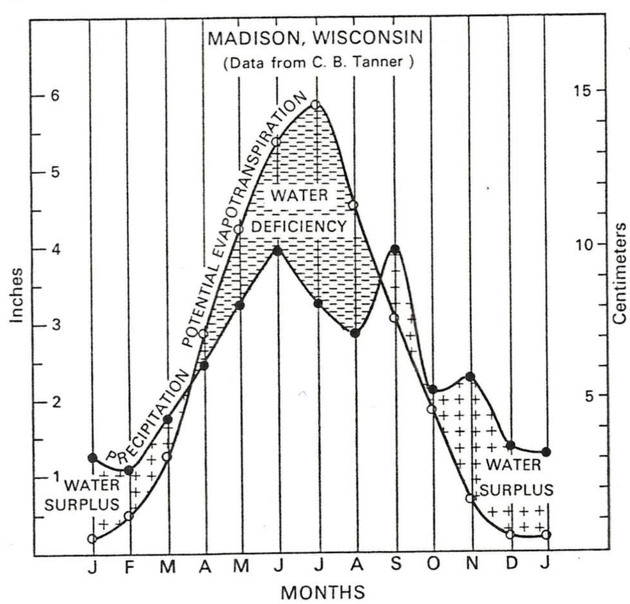
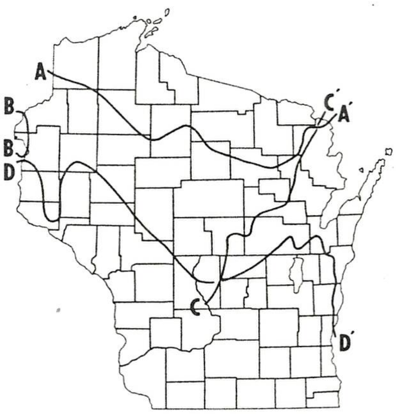


Figure 2-39. Water surplus and water deficiency periods at Madison, Wisconsin.

greatest in the growing season when it is needed for plant growth (Figs. 2-35 through 2-39); however, the moisture supply does not satisfy vegetation needs in most years. Hence, supplemental irrigation is beneficial on level areas (Figs. 2-53, 2-54), and is essential on sands in Adams and Juneau counties in the Central Plain. Three light lines in Fig. 2-32 indicate that Wisconsin might well be semiarid if evapotranspiration were to reach its theoretical potential.[5] Although the climate of the state is referred to as temperate compared with tropical and polar climates, it is actually rather severe (Figs. 2-33 through 2-37). During the year, changes in weather are rapid and marked. The northward march of the spring response of plant-

5. Out of the total solar radiation received in a year at Madison—that is, an amount sufficient to evaporate about 80 inches of water—about a 51-inch-equivalent is lost by reflection and long wave radiation. The remainder, the net radiation, could evaporate 29 inches, which is nearly equal to the 31-inch annual precipitation. But part of this net radiation is used in heating air and soil. Cattail plants in swamps transpire 40 inches a year. Upland conifers could transpire the same amount, if the moisture were available. Transpiration by corn is about 20 inches, and by alfalfa-brome is 23 inches (see Tanner, 1964).



AA′ The southern limit of most strongly developed fragipans in Wisconsin

BB′ The eastern limit of carbonate-rich glacial drift of the Grantsburg glacial lobe (Wright and Ruhe, 1965)

CC′ The western limit of carbonate-rich glacial drift of the Green Bay glacial lobe (Thwaites, 1943)

DD′ The southern limit of the zone of bisequal soils (in part after Carroll, 1959, and Beaver, 1963)

Figure 2-40. Distribution of soil fragipans in Wisconsin in relation to calcareous and acid glacial drifts.

soil units proceeds at a rate of about 15 miles per day for a period of about three weeks, judging by phenological data for May blooming of lilacs (Dana, Zimmerman, and Lettau, 1963). Farmers frequently have difficulty in harvesting air-dried hay because of periodic thunderstorms in summer.

Local Climate

The climate is cooler and more moist on north-facing slopes and in low places than on southern exposures or moderate elevations. The growing season is not only notably short in wetlands of central and northern counties, but is likely to be abbreviated in small depressions (frost pockets), even in uplands. Soils adjacent to Lakes Michigan and Superior are subject to an ameliorated local climate, as in the case of shorelands of soil associations I18 and I19. Degree of exposure of the soil to sunlight and to wind affects the soil temperature and moisture content. Dark plowed soil and burned-over grassland heat up more quickly in the sun than soil protected by vegetation and mulch. Pavements and buildings bring about complicated local climatic regimes in adjacent and subjacent soil. These sometimes include accentuated freeze-thaw cycles. Local climates in nonurban settings must leave their impress on soils, and special studies of these are needed.

Paleoclimate

Students of climatic succession in Wisconsin and adjacent areas report evidence for alternation of relatively cool and warm, dry and moist climatic periods that began and ended abruptly (Bryson and Wendland, 1966, 1967). Fig. 7-6 presents a diagram of a postulated soil succession, corresponding to major climatic episodes. Freezing action on soils was so severe near the glacier during its long stay in the state that polygonal networks of cracks formed several feet deep in soft materials, including Cambrian sandstone. These cracks were filled and enlarged by growing wedges of ice. With later climatic warming the ice disappeared and sand blew into the empty cracks. The resulting ice-wedge casts are still present in the B and C horizons of a variety of soils in the state, from Pierce and Outagamie counties in the north to Rock and Green counties in the south (Black, 1965b).

The fragipan, so widespread in soils of northern Wisconsin (Fig. 2-40), may have been produced in part under permafrost conditions before and after late glacial advances, or during the thawing of frozen subsoil in post-Valderan (Holocene) times. Fitzpatrick (1956) noted soil structure and color in fragipans of northern Wisconsin similar to those in lower active layers over permafrost in Spitsbergen (see summary by Hole et al., 1962).

TOPOGRAPHY AND SOME SOIL-WATER RELATIONSHIPS

Topography

Wisconsin is in the Central Lowlands geomorphic province of the United States (Thornbury, 1965). Specifically it lies in (1) the Great Lakes Section characterized by lakes and glacial lake plains, conspicuous end moraines, cuestaform topography partially exposed, and poorly integrated drainage; and (2) the Wisconsin "Driftless Section" (approximately the Western Upland of Fig. 2-1), characterized by maturely dissected cuestas in Paleozoic rocks and by valley trains deposits of glacial outwash.

The Great Lakes Section is further subdivided into four subsections: (1) the Northern Highland, with a general elevation of 1,400 to 1,650 feet (Tim's Hill in Price County is at 1,952.9 feet, the highest point in the state); (2) the Lake Superior Lowland, an undulating to rolling plain, with elevations of 600 to 900 feet above sea level; (3) the Central Plain, with elevations commonly between 750 and 850 feet; and (4) the Eastern Ridges and Lowlands, with prominent end moraines and the Kettle Moraine. The Wisconsin "Driftless Section" is dissected

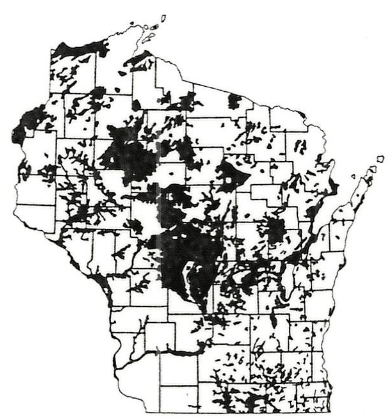


Figure 2-41. Soil association areas in which nearly level slopes (0 to 3% gradient) are common.

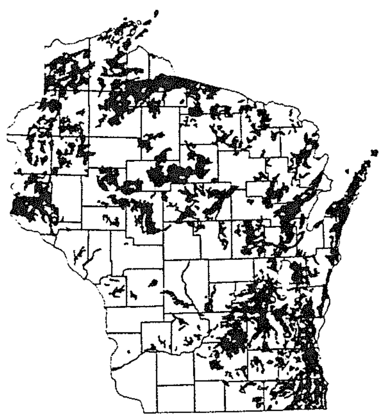


Figure 2-42. Soil association areas in which undulating to gently rolling topography (2 to 10% gradient) is extensive.

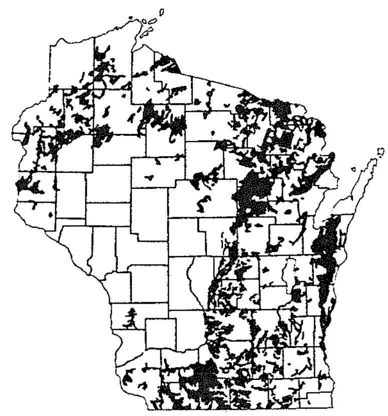


Figure 2-43. Soil association areas in which rolling topography (5 to 20% gradient) is extensive.

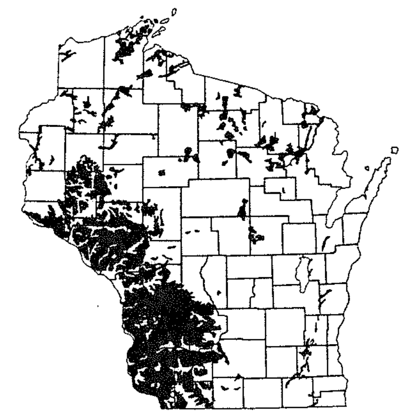


Figure 2-44. Soil association areas in which hilly and steep topography (slopes of 20% gradient or more) is common.

by valleys to a depth as great as 500 feet below the upland, whose surface stands at 1,000 to 1,450 feet above sea level.

The total range in elevation in the state is from 580 feet to 1,953 feet (Fig. 2-45). Local relief ranges from 600 feet at Wyalusing State Park at the confluence of the Wisconsin River with the Mississippi and about the same relief at Wausau where Rib Mountain stands boldly above the Wisconsin River, to less than a foot in a hundred feet of distance on old lake plains near Lake Winnebago. The relief in drumlin landscapes may be as much as 50 feet and in the Kettle Moraine reaches 300 feet in the vicinity of Lapham Peak in Waukesha County. The reader is referred to Martin (1932) for a full discussion of relationships between topography and geology.

The soil map shows that much of the land surface of Wisconsin is rolling, with slope gradients of 5 to 18%. In the eroded cuesta terrain (Thwaites, 1960) of southwestern counties and in scattered areas elsewhere many soils are hilly, with slope gradients of 18 to 30%. The remainder of the state is undulating to nearly level (0 to 5% gradient) (Figs. 2-41 through 2-44). The approximate distribution of slope (gradient) groups of soils of the state is as follows: 0 to 1% slopes, 6% of the area of the state; 1 to 3% slopes, 25%; 3 to 12% slopes, 48%; 12 to 30% slopes, 15%; and 30 to 45% slopes, 6%. Such generalizations do not do justice to the wide variety of soil slope patterns in Wisconsin landscapes.

Region A (see Plates 1 and 2) is characterized by mature topography. Valley fills, as much as 200 feet deep in the Mississippi and Wisconsin River valleys, have produced the broadest flats of the region. Here natural levees, oxbows, cutbanks, slip-off slopes, alluvial fans, and natural terraces are common features (Hole, Peterson, and Robinson, 1952; Hole, 1956a). Each has characteristic soils and soil patterns. Steep-sided tributary valleys, called coulees, are numerous, in accordance with the dendritic drainage pattern. Detached blocks of bedrock have moved down steep slopes by the process of creep. Soil patterns tend to follow the intricacies of knife-edge ridges, benches produced by resistant rock ledges, sinkholes, cliffs, natural bridges, rock "monuments" and crags, dissected cuestas, and escarpments (Martin, 1932). Even areas dotted by man-made pits and mounds in the lead-zinc district are given a soil name with a topographic term, "Fayette and Dubuque soils and Pits, eroded."

Region B can be subdivided first into three bands: (1) the Rock River-Lake Winnebago lowland characterized by many included bodies of wetlands (soils of Region J) and prairie soils; (2) the Silurian ("Niagara") upland to the east (see Plate 3), clearly delineated by soil association B1 just south of Lake Winnebago; and (3) the Prairie du Chien and Sinnipee cuestas (Fig. 1-2). These physiographic units are overlaid by glacial features, such as the Kettle Moraine (soil association B4) and end moraines diverging from it that trend northwest to the Baraboo Range and southeast to Lake Geneva (Plate 4). The Kettle Moraine is largely composed of gravel deposited in conical hills called kames, curvilinear ridges called eskers, straighter ridges called crevasse fillings, and deep pits called kettles. Glacial till is more abundant than outwash in the end moraines. Outwash plains (soil associations B32, B33, B34) are scattered throughout the region but are particularly notable at the borders of the major moraines. More than 1,400 oval, streamlined hills, called drumlins, are concentrated in a belt about 35 miles wide lying behind (up-ice from) and parallel to the prominent end moraines. The drumlins are largely composed of till (soil association B13) and they point in the direc-

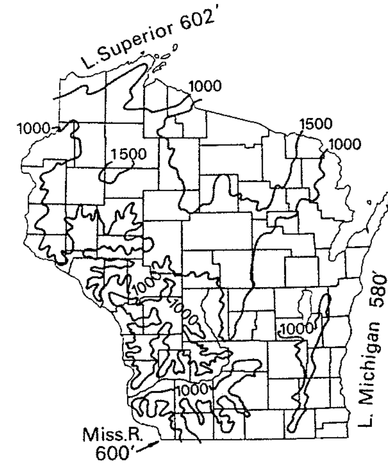
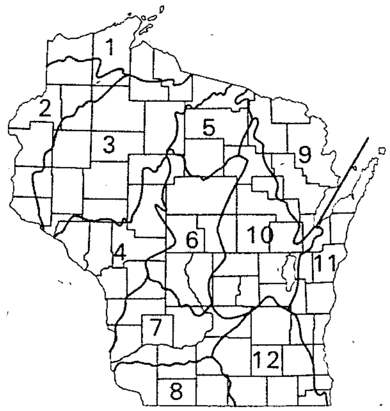


Figure 2-45. Generalized topographic map of Wisconsin (after Martin, 1932; elevations of contours are in feet above sea level).



1. Lake Superior Streams
2. St. Croix River
3. Chippewa River
4. Trempealeau and Black Rivers
5. Upper Wisconsin River
6. Middle Wisconsin River
7. Lower Wisconsin River
8. Platte and Pecatonica Rivers
9. Menominee and Oconto Rivers
10. Wolf and Fox Rivers
11. Lake Michigan Streams
12. Rock and Fox Rivers

Figure 2-46. Principal river basins of Wisconsin (after Holmstrom, 1972).

tion of ice movement, which was in a spreading pattern in each of the two major ice masses, the Green Bay and the Lake Michigan lobes. Ground moraine occupies the remainder of the areas, interrupted by glacial lake plains (Plate 4).

In Region C, outwash and lake plains, with organic soils in depressions, are interrupted or bordered by glacial landforms, outwash terraces and escarpments, and cuestas. Areas of stabilized and active sand dunes are extensive. In the western part, sandstone pinnacles and hills are scattered here and there "like a child's blocks on the bedroom floor" (Black, 1964).

Region D is largely rolling, with characteristic conical hills of Cambrian sandstone and shale and buttes of sandstone. Between the hills are coulees and outwash and lake plains, with some associated wetlands.

Landforms of Region E include those already mentioned for Region B. Areas of shallow soils on limestone bedrock are extensive on the Door Peninsula, and the escarpment of Silurian dolomite is prominent on the west side of the peninsula.

Region F, in addition to aforementioned glacial landforms, has fluted landscapes that are composed of parallel ridges less than 20 feet high, separated by elongated bodies of poorly drained soils (Hole and Schmude, 1959). Undulating, relatively featureless till plains are extensive (soil association F21).

Region G includes silt-cover-free glacial terrain of northern Wisconsin. There are spectacular end moraine zones, festoons of eskers and kames with associated kettles, and vast areas of rolling ground moraine and pitted outwash (Plate 4). The region is one that contains many lakes, and small lake plains and outwash plains. "Reversal" of landscape occurs locally in Washburn County where surfaces of small lacustrine plains stand as depositional features a few tens of feet above surrounding ground moraine. Original retaining walls of stagnant glacial ice melted away. Bedrock hills and ridges protrude through the drift at the Penokee Ranges, Barron Hills, McCaslin Mountain (Fig. 1-2), and some other areas.

The landscapes of Region H are associations of eskers, kames, kettles, outwash plains, and stabilized and active dunes. Lakes and bogs occupy many of the countless kettles.

"Red clay" landscapes of Region I include lake plains, nearly level and rolling moraines, some drumlins, shallow kettles, and a few crevasse fillings. The region includes the Lake Superior Lowland and the northern part of the three topographic units mentioned for Region B, namely, two cuestas and the intervening Winnebago-Green Bay lowland (Figs. 1-2, 2-1). Limestone outcrops and bodies of shallow soil are numerous in places along the cuestas.

Region J has already been referred to in connection with mineral soil regions. Alluvial soils are prominent in the setting of Region A. Bogs and mineral soil wetlands are numerous in Regions B, C, E, F, G, H, and I. Local small-scale topographic features include burned-out or excavated pits in peat and masses of organic soils occurring naturally on slopes with gradients as steep as 15%.

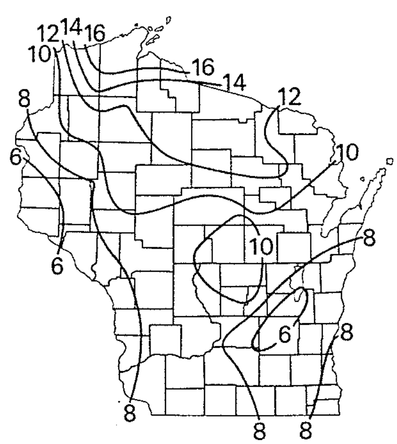


Figure 2-47. Average annual runoff (inches) (Holt, Young, and Cartwright, 1964).

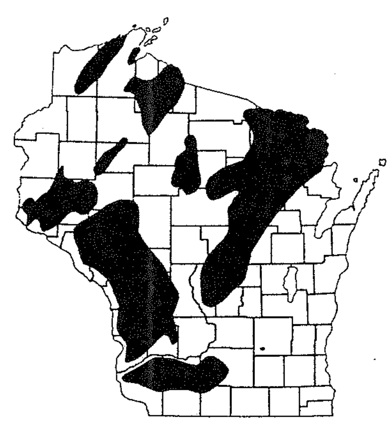


Figure 2-48. Trout stream regions (after Threinen and Poff, 1963).

CHAPTER 8

Soil Region B: Soils of the Southeastern Upland

Prominent topographic features of this region include the spectacular Kettle Moraine, the less bold End Moraine, the glacially smoothed east end of the Baraboo Range, the Silurian ("Niagara") Escarpment, and several lower cuestas. Even the ground moraine presents a rolling landscape that is in many places corrugated by "swarms" of drumlins and intervening depressions. In this setting lie hundreds of lakes, marshes, bogs, streams, ancient lake beds, and level outwash flats. The soil surveyors who walked these hills and lowlands were impressed with the extent of the wetlands, the variability of soil depth and character, and the high level of natural soil productivity.

This region includes the southern portions of the Eastern Ridges and Lowlands (Fig. 2-1), in which the glacial drift is yellowish brown to grayish brown in color (the Munsell color notations are 10YR 5/4-5/2 for moist material) (Fig. 2-18). Two patches of soil are separated from the main body of Soil Region B—a large one in Brown, Manitowoc, and Kewaunee counties (mostly B17), and a small one in southern Adams County (mostly B15) (Figs. 8-1, 8-2). The pattern of ridges and lowlands is irregular, because of glaciation (Figs. 8-3, 8-4), in contrast to the well-developed dendritic pattern of Soil Region A (Plate 2). Strip-cropping, so characteristic of Region A, is much less common in Region B (compare Figs. 7-3 and 8-3), except in drumlin country (Fig. 8-12). In most of Region B the bedrock is buried under tens of feet of glacial drift (Fig. 8-7) (Alden, 1904, 1918b) of Woodfordian and Altonian (Cary and pre-Cary) age (Fig. 8-1; Table 2-10). Poorly drained swales are far too numerous to show on the general soil map of the state. Nearly two thirds of the soils of the region are formed on glacial till (Fig. 8-6), about a fourth on glacial outwash, and the remainder on glacio-lacustrine deposits. Nearly all of these materials are calcareous at depth (Figs. 2-6, 2-8, 2-10, 2-15, 8-5). The local relief of the land surface is usually less than 100 feet, and in many areas less than 50 feet.

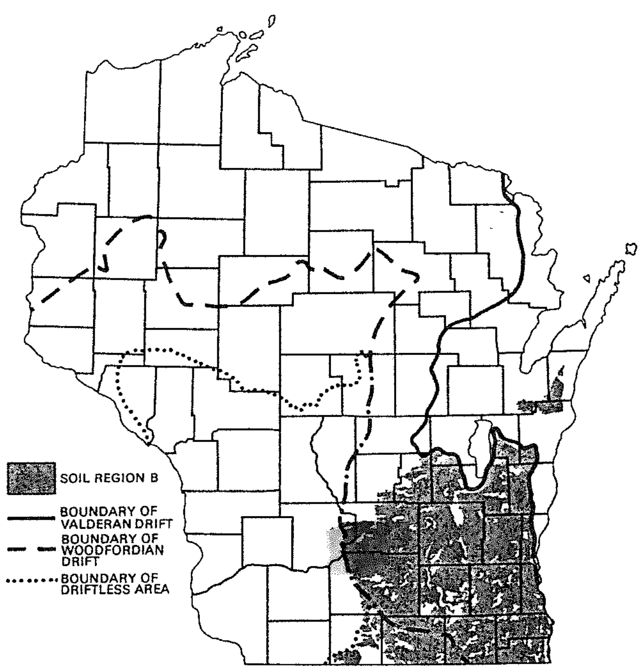


Figure 8-1. Index map showing the geographic relationship of Soil Region B to major glacial boundaries.

About three fourths of the landscape is occupied by soils without important impediments to natural downward drainage. More specifically, about a third of the area is in well-drained soils, another third is in excessively drained (droughty) soils, and about 12% of the landscape is in moderately well drained soils. Nearly 10% of the region is in peat and muck soils. The remaining 15% is wet mineral soil of the numerous lowlands.

The usual rectilinear pattern of fields and woods is modified or interrupted in places by several features already mentioned: (1) nearly parallel glacial flow traces where there is an abundance of drumlins (Figs. 8-12, 8-13) in central Dodge and Jefferson counties; (2) sinuous or curved bold ridges of the Kettle Moraine (Plate 4; Figs. 8-3, 8-4; see Black, 1969b) and other prominent moraines; (3) natural drainageways such as those of the Rock River system; and (4) bedrock escarpments, particularly where the drift covering is slight. Included in the fourth category are the Silurian ("Niagara") Escarpment of eastern Fond du Lac County and lesser escarpments to the west.

Because of urban expansion in the region, notably in southeastern counties, scarcely two thirds of the land is in farms and this proportion is steadily decreasing. The farmland consists mainly (62%) of cropland harvested, with about 17% in pasture and 10% in woodland. Some of the woodland is pastured.

The landscape surface is estimated (Bryson and Wendland, 1966) to be about 13,000 years old, except for a section in the southwest corner of the region where the age may be 20,000 years (Black et al., 1970). Large blocks of stagnant ice probably stood in depressions, some of which are now occupied by lakes and peat bogs. Soils of the uplands can be expected to be the oldest, wherever they have not been truncated by erosion or rejuvenated by surficial deposits of aeolian material. Soils of depressions have been cumulative, chiefly of organic materials where peat and muck have formed, or of mixed mineral and organic matter in the extensive loamy and clayey wetlands. Acceleration of erosion by land clearing and farming since about 1850 has resulted in siltation of lowlands and bog fringes. This process continues in the vicinity of paved surfaces along highways and in urbanizing areas. The area of "made land" delineations on soil maps is increasing and there is need for detailed mapping of these young soils.

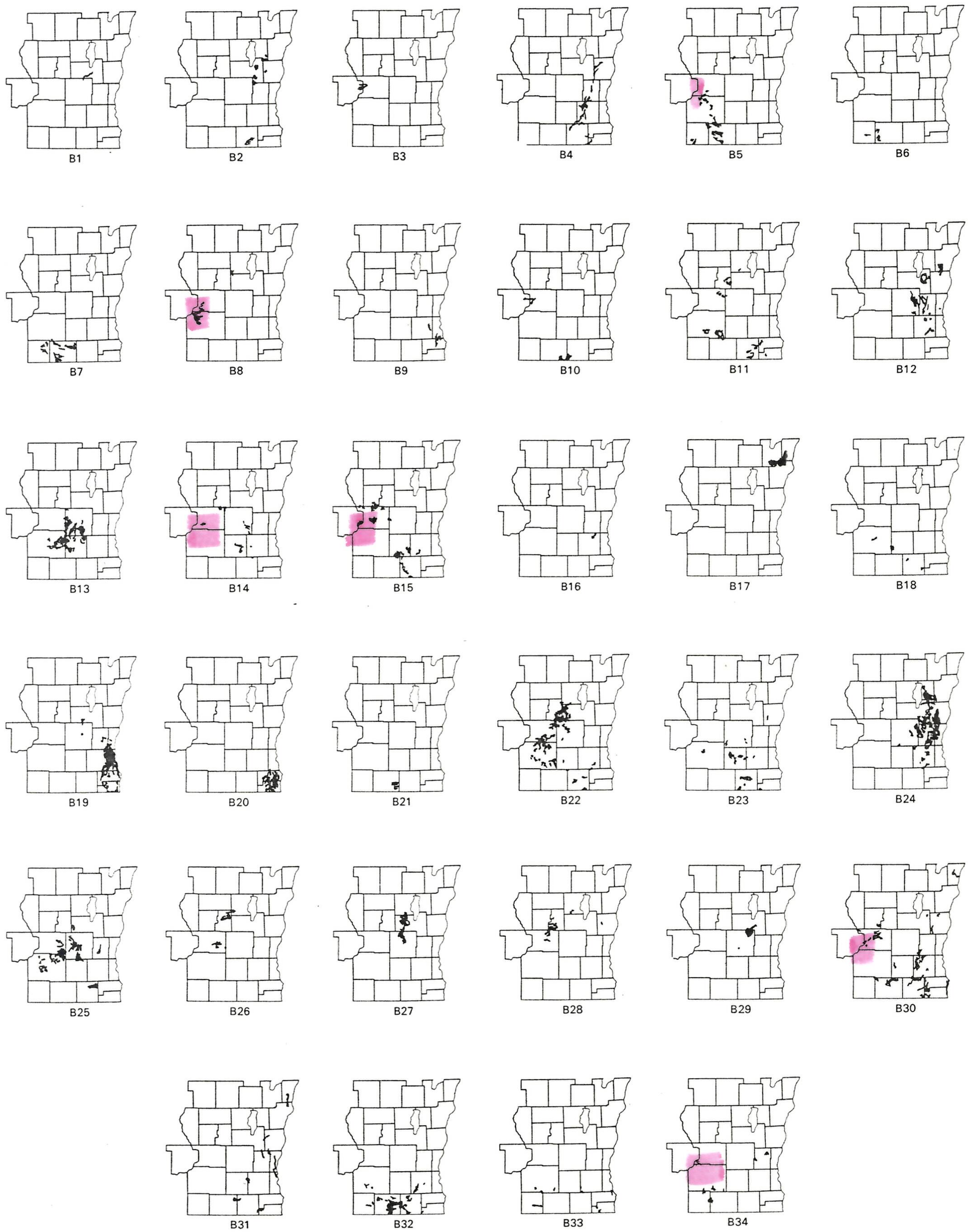
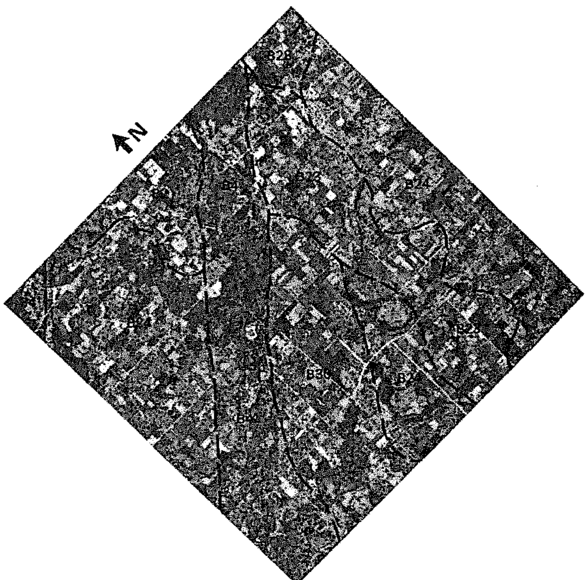


Figure 8-2. Sequence of maps showing distribution of soil associations in Soil Region B.



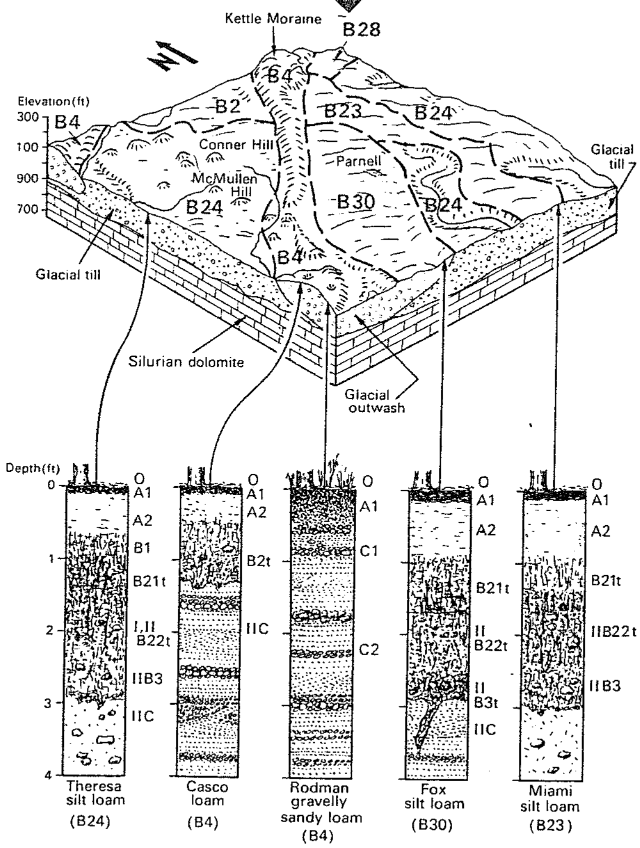


Figure 8-3. Aerial photo map of T.14N., R.20E., Sheboygan County. The area shown is 6 miles on a side.

Figure 8-4. Block diagram showing landscape positions of major soils of T.14N., R.20E., Sheboygan County.

Symbol	Percent $CaCO_3$ eq.
1	0-15
2	15-35
3	35-45
4	45-90

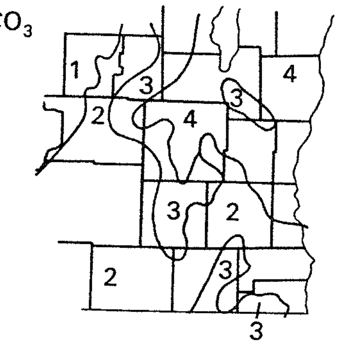


Figure 8-5. Map showing distribution of glacial tills of different carbonate contents in southeastern counties (after Owens, 1968).

The proportion of soils formed, at least in part, from aeolian silty coverings (leached loess) decreases northeastward in the region (Figs. 2-28, 2-29, 2-30; Plate 5). The detailed pattern of loess deposits is not fully understood. For example, the preponderance of silty upland soils in northern Jefferson County and the scarcity of them in southern sections of the same county have not been satisfactorily explained. Some observations indicate that loess was deposited most thickly on southwest-facing slopes in Columbia County (Rieger, 1947). Windblown sandy coverings are also notable in places, as in the vicinity of Columbus and Rio, northeast of Madison.

Available moisture-holding capacity of the soils varies with texture, particularly with respect to depth of fine-textured material over coarse deposits. In the nongrowing seasons when vegetation uses almost no soil moisture, soils become relatively moist throughout the landscape. Perched water tables appear over the Bt horizon in many medium-textured upland soils during winter and early spring.

The carbonate content of the glacial till decreases westward from well over 50% north of Milwaukee to less than 15% in Marquette County (Fig. 8-5). Clay content in the till also shows a regional trend of decrease from more than 50% on the east to less than 5% on the west (Fig. 8-6). Watson (1963) prepared a map showing the distribution of four major Woodfordian tills in Columbia County, which are, from east to west: (1) heavy sandy loam and loam with 60% or more $CaCO_3$ equivalent; (2) similar till but with 28 to 44% $CaCO_3$ equivalent; (3) sandy loam with 18 to 31% $CaCO_3$ equivalent; and (4) loamy sand

Symbol	Percent Clay
1	0-5
2	5-10
3	10-15
4	15-25
5	25-40
6	40-80

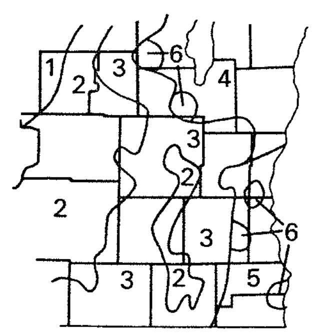


Figure 8-6. Map showing distribution of glacial tills of different clay contents in southeastern counties (after Owens, 1968).

and light sandy loam, with 5 to 19% $CaCO_3$ equivalent. Depth of leaching of soils is greatest in till of lowest carbonate and clay contents. G. B. Lee (personal communication, 1959) reported a lithosequence of soil series from southeastern Wisconsin in which thickness of solum increases with decrease in carbonate content of the underlying glacial till: LeRoy, 20 inches; Lomira, 32 inches; Theresa, 34 inches; Dodge, 38 inches; McHenry, 40 inches; and Pecatonica, 60 inches. The corresponding differences in percent $CaCO_3$ equivalent in the till range between 75 (LeRoy) and 20 (Pecatonica). Loess coverings of various thicknesses are all leached of carbonates in Region B.

Most of the well-drained soils are Hapludalfs (Gray-Brown Podzolics), but at sites of "ancient maple forests" (Curtis, 1959; Harper, 1963; Lee, 1949) are Argiudolls (Brown Forest soils; Pierce, 1951), with nearly black A1 horizons as thick as 9 inches.

It may be noted that in southeastern Wisconsin the "beta B" (Bartelli and Odell, 1960a,b), which is the argillic horizon at or near the upper boundary of calcareous glacial drift, occurs in various positions in the pedon: (1) as the lowest subhorizon of the solum (see dark horizon at a depth of 3 feet in Fig. 1-6), (2) as a subhorizon between the main B2 and the B3 horizons, and (3) as a subhorizon between the C1 and IIC2 horizons. The beta B subhorizon marks the deep subsoil zone to which percolating waters flush solutes and colloids seasonally, probably in the spring of the year.

The thirty-four soil associations (Fig. 8-2) in this region are grouped in the soil map legend (Plate 1) in order, from those with steepest slopes to those on nearly level terrain. In the following discussion these associations are regrouped with more emphasis on soil series than on topography.

B1, B16. *Knowles, Ripon, Morley, Casco, and Sisson silt loams and loams, with rocky land.*

- B1. Knowles and Morley silt loam association, with rocky land.
- B16. Knowles, Ripon, Casco, and Sisson loams association.

The Knowles silt loam, a Typic Hapludalf that formed from 20 to 36 inches of loess overlying limestone bedrock (Fig. 2-3), is prominent in two soilscapes: (1) a narrow strip of land (B1) along the Silurian ("Niagara") Escarpment in Fond du Lac and Dodge counties, overlooking the Horicon Marsh and other lowlands (Fig. 8-7); and (2) a rolling to undulating area in northeastern Waukesha County famous for its quarries from which Lannon building stone comes. These two soilscapes occupy only about 10,000 acres each, but they are distinguished from adjacent associations on the basis of presence of soils shallow to bedrock.

Associated with the Knowles on the escarpment (B1) are two soils formed from less than 20 inches of silt cover over calcareous shaley (Maquoketa Shale-derived) glacial till, namely, the Neda (Mollic Hapludalf), formerly mapped as Morley, and the Ashippun (Auqollic Hapludalf). The Sogn series (Lithic Hapludalf) is also present, where bedrock is as close as 15 inches to the surface.

In the Waukesha area a wider variety of soils is associated with the Knowles. The Ripon silt loam (Typic Argiudoll) is the dark equivalent of Knowles. Casco (Typic Hapludalf) has loamy sola 12 to 20 inches thick over calcareous outwash sand and gravel. The Sisson (Typic Hapludalf) is formed in calcareous lake-laid fine sand and silt.

These soilscapes are largely used for pasture and field crops.

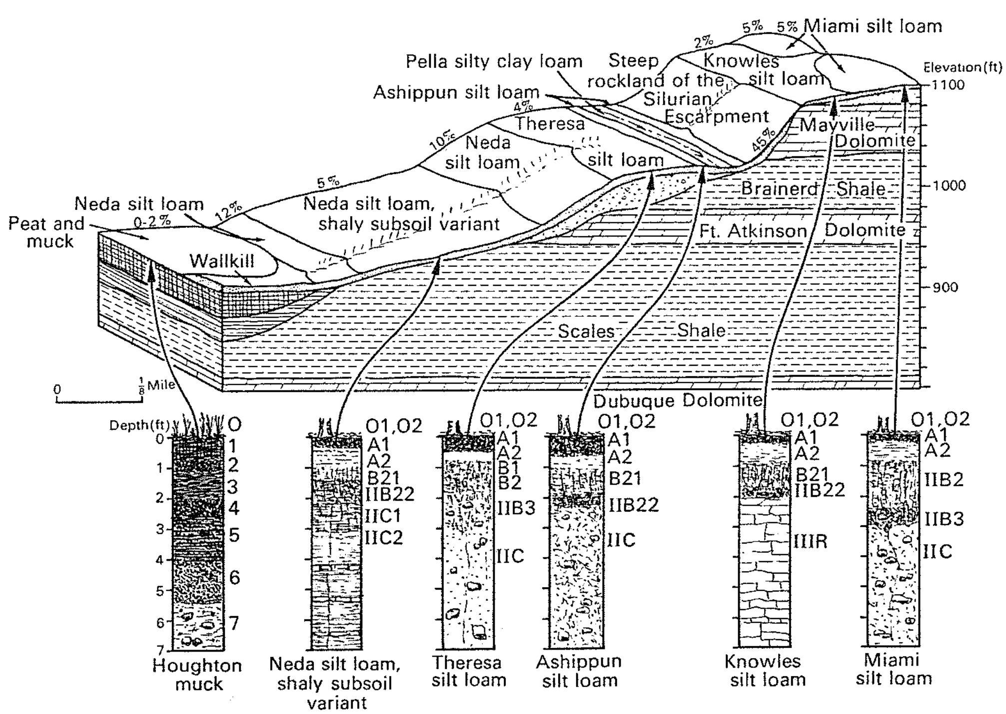


Figure 8-7. Block diagram showing landscape positions of representative soils of soil associations B1 and B8 in Sections 4 and 5, T.13N., R.16E., Dodge County.

B2, B12, B17, B24. *Theresa, Hochheim, and associated soils, shallow over stony, dolomitic glacial till.*

- B2. The hilly to rolling Hochheim, Theresa, and Brookston silt loam association.
- B12. The rolling to undulating Theresa, Hochheim, and Nenno silt loam association.
- B17. The rolling to undulating Theresa, Onaway, Fox, and Salter silt loam and loams association.
- B24. The undulating to rolling Theresa, Hochheim, and Nenno silt loam association.

Theresa (Typic Hapludalf; Figs. 8-7, 8-8) and Hochheim (Typic Argiudoll) soils are about 36 and 20 inches deep, respectively, over highly calcareous glacial till (see Fig. 8-4). They occur on convex slopes of drumlins and moraines, including some ridges in the Kettle Moraine complex. The Theresa is on slopes of 2 to 12% gradient; the Hochheim on slopes of 2 to 30% gradient. The Theresa soil has formed in 20 to 30 inches of loess covering. The Hochheim may be silty to a depth of 20 inches or may be somewhat sandy throughout. The subsoil in both cases is a dark clay loam. The sola are alkaline to neutral for the most part. The till adjacent to the Kettle Moraine becomes coarser in texture, differing from outwash in fabric more than in particle size distribution. The presence of lenses of stratified sand and gravel makes disposal of liquid waste hazardous in the C horizon. The native vegetation was dominantly maple-basswood forest, some of which still survives on steep lands, as in the Kettle Moraine area near Dundee in Fond du Lac County (Scholz and Trenk, 1959). Most of the area is now used for production of corn, oats, and hay. Alfalfa does particularly well on these soils.

The four soilscapes, totaling 880,000 acres or 2.4% of the land area of the state, are listed in order of decreasing relief.

The B2 association includes parts of the Kettle Moraine and other hilly land in which the two soils just discussed occur, along with depressional bodies of poorly drained black Brookston soils (Typic Argiaquolls). Around Lake Geneva in Walworth County these soils lie on long uniform slopes of 4 to 15% gradient. In Fond du Lac County, they are on shorter, steeper slopes.

The more extensive B12 soil association is characterized by shallower depressions, and these are commonly occupied by Nenno loam and silt loam (Aquic Argiudoll), a somewhat poorly drained associate of the Hochheim.

Onaway (Alfic Haplorthod) and some Ozaukee (Typic Hapludalf) soils are associated with Theresa soils in the northern outlier of this region, surrounded by reddish-brown clay soils in Brown, Manitowoc, and Kewaunee counties. The glacial till is pink to brown (the Munsell color notations are 7.5YR—10YR 5/4 for moist material). In lake basins the moderately well drained Salter loam (Typic Eutrochrept; Fig. 1-4) has formed on calcareous silts and fine sands. On small outwash plains is found the Fox silt loam (Typic Hapludalf; see Fig. 1-6). An interesting pattern of contrasting depths of leaching of carbonates has been found in this area (personal communication, Professor David M. Mickelson, Department of Geology and Geophysics, University of Wisconsin-Madison, 1975). The average depth in well-drained soils over till is about 44 inches in the B17 soil association and in associations of red clays (Region I) lying to the south thereof as far as the B region in southern Calumet and Manitowoc counties. In contrast, the depth of leaching averages about 23 inches in the red clay region (I) bordering the B17 soilscape on the Two Rivers and Denmark moraines and immediately beyond to the east, north, and west.

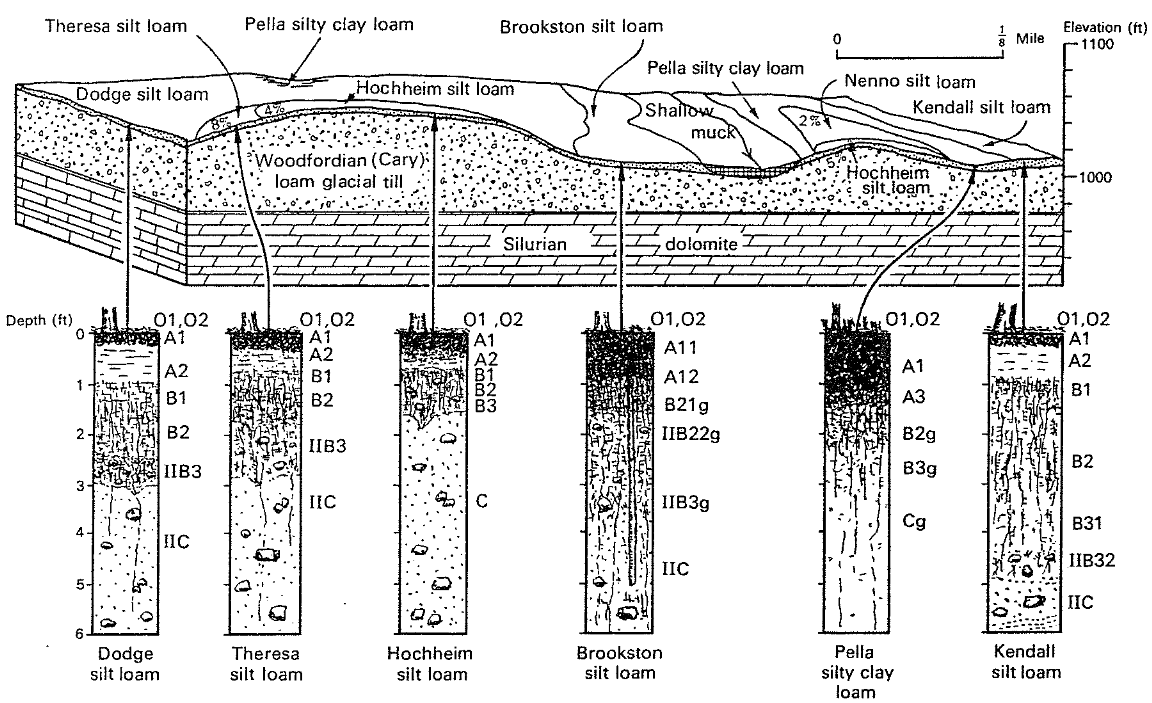


Figure 8-8. Block diagram showing landscape positions of representative soils of soil associations B24 and B25, Dodge County.

The most extensive soilscape in this group is the B24 association, composed chiefly of the same three soils as association B12.

B3, B6, B7, B10. *Pecatonica and associated silt loams, with clayey subsoils and some rocky land.*

B3. The hilly to rolling Pecatonica and Flagg silt loam, and Baraboo stony silt loam, association.

B6. The rolling to hilly Dubuque, Pecatonica, McHenry, and Whalan silt loam association.

B7. The rolling to hilly Pecatonica, Dodge, McHenry, and Whalan silt loam association.

B10. The rolling to hilly Flagg, Pecatonica, and Mingo silt loam association.

These soilscapes are interesting because they include truncated remnants of some of the oldest soils in the state (Fig. 2-17). Soils with and without glacial drift components are associated, which indicates that processes of mass wasting have stripped uplands of glacial deposits locally. Bleuer (1970) classified the glacial drifts under the Flagg and associated soils as Altonian and Illinoian in age (see Table 2-10). Young soils (on Woodfordian drift) are associated with the old soils (paleosols) in these soilscapes. The paleosols themselves are blanketed by aeolian silt in which the upper, younger horizons have formed. The Flagg and Pecatonica silt loams (Fig. 7-12) developed in 36 to 50 inches and 20 to 30 inches, respectively, of loess overlying paleosolic Bt horizons. These soils are from 4 to 8 feet deep over calcareous sandy loam to loam glacial till. The Mingo soils differ from the Flagg in being somewhat poorly drained.

Most of the soils listed in the soil map legend for these associations are well-drained Typic Hapludalfs. They occur in front of the end moraine of the Woodfordian ice advance (south part of Fig. 8-1) and in the vicinity of the east end of the Baraboo Range in eastern Sauk County. The Baraboo silt loam has formed in 20 to 40 inches of loess over quartzite bedrock. The Dubuque (and associated New Glarus, which has more than 6 inches of residuum on the limestone) and Whalan silt loams are commonly about 2 to 3.5 feet deep to limestone bedrock. The last-named soil has weathered glacial till in the Bt horizon (Figs. 2-2, 2-3). On the younger glacial drift are the Dodge (over loam till) and McHenry (over sandy loam till) silt loams.

Most of these areas are used for production of corn, soybeans, oats, and hay, but steep slopes, especially where rocky, are forested, as in the scenic Baraboo range. Soil association B3 is dominated in Columbia County by St. Charles (20% by area), McHenry (15%), Baraboo (15%), and Pardeeville (15%) soils (McColley, 1971).

B4, B18, B30, B31, B33, B34. *Fox and associated gravelly and silty soils over sand and gravel.*

B4. The hilly to rolling Casco, Rodman, Fox, and Lapeer loams association.

B18. The rolling to undulating Fox, Casco, and St. Charles (stratified substratum) silt loam association.

B30. The undulating to rolling Fox and Casco loams, and Boyer sandy loam, association.

B31. The undulating to rolling Fox, Will, Casco, and Fabius silt loam association.

B33. The nearly level and gently undulating Fox, Hebron, and Del Rey loams association.

B34. The nearly level and gently undulating Fox silt loam, and St. Charles (stratified substratum) and McHenry loams, association.

The Fox silt loam, a Typic Hapludalf with shallow silty cov-

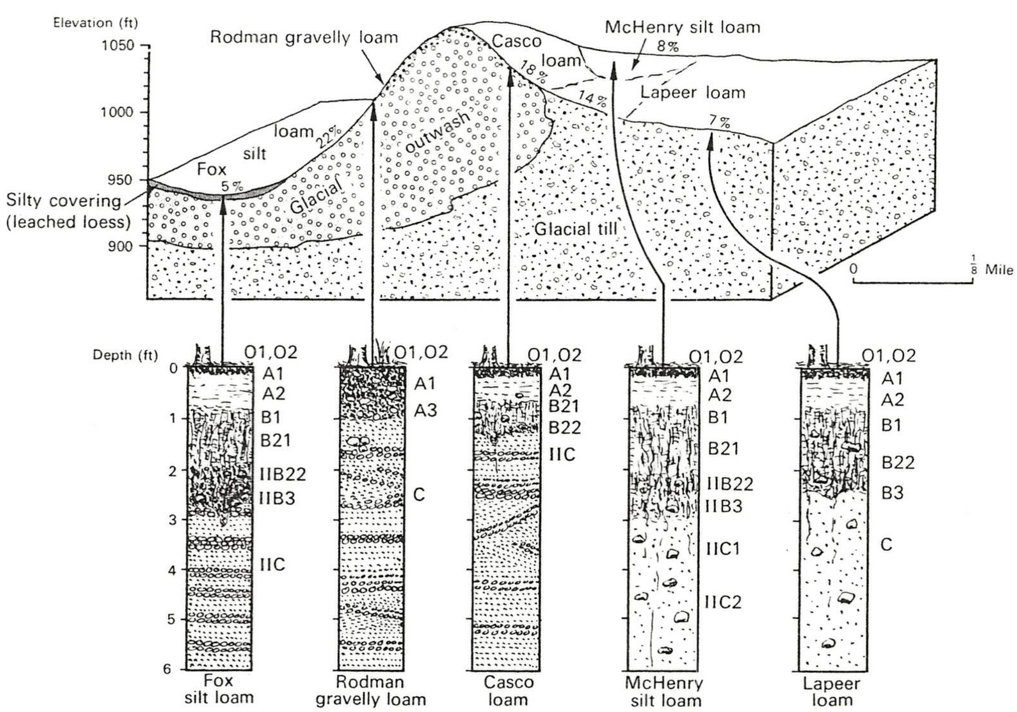


Figure 8-9. Block diagram showing landscape positions of representative soils of soil association B4, Dodge County.

ering (less than 20 inches thick, but the solum is 20 to 42 inches thick) over calcareous outwash sand and gravel (Figs. 1-6, 8-4, 8-9), is the most extensive soil in this group of soil associations that occupy about 2% of the land area of the state. In Rock County, a variant of Fox is underlain by calcareous sand in which is found a thick, weakly developed B3 horizon. The range of landscape conditions is considerable, from Kettle Moraine topography (B4) to nearly level outwash and lake plains (B33). A sequence of soils over calcareous outwash sand and gravel, in order of increasing thickness of silty covering, is Rodman (Typic Hapludoll; Figs. 8-4, 8-9), no silt; Casco (Typic Hapludalf; Figs. 8-4, 8-9) and Fabius (Aquic Argiudoll), 0 to 12 inches of silt; Fox (Typic Hapludalf) and Will (Typic Haplaquoll), 0 to 20 inches of silt; St. Charles, stratified substratum (Typic Hapludalf; Fig. 7-12), 36 to 50 inches of silt. The Boyer (Typic Hapludalf) soil has no silty covering, but has a sandy solum 20 to 40 inches deep over calcareous sand. Two soils in the association, both Typic Hapludalfs, formed over calcareous glacial till: Lapeer, with no silty covering, and McHenry with 20 to 36 inches of silty covering. Two other soils formed in calcareous lake-laid silts and clays with loamy coverings: Hebron (Typic Hapludalf) and Del Rey (Aeric Ochraqualf). Hebron and associated soils have free carbonates as shallow as 30 inches below the surface. Studies by Borchardt, Hole, and Jackson (1968) and Gaikawad and Hole (1965) indicate that the same suite of minerals is present in all of these soils, although the proportions of size-separates vary from one series to another. South of Milwaukee along the shore of Lake Michigan soil associations B30 and B31 are dominated by Boyer and Granby (Typic Haplaquoll) sandy loams.

Production of alfalfa-brome hay in tons (dry weight) per acre per year on these soils (under good management) is an index of available moisture-holding capacity of the soils: St. Charles (4 feet to coarse material), 4.75; Fox (30 inches), 3.0; Casco (15 inches), 2.75; Rodman (6 inches), none.

In the Kettle Moraine of Waukesha, Jefferson, and adjacent counties, Spinks sand with banded B horizon (mentioned by Robinson and Rich, 1960) occupies a higher position on flanks of ridges of Rodman soils than do the band-free Oakville and Tedrow sands. The Spinks soil may have formed from stabilized aeolian sands and the Oakville-Tedrow soils from aeolian and beach deposits that were periodically reworked by wind and water.

B5, B21, B22, B32. *Ringwood, Ogle, Plano, and associated dark, well-drained soils developed under former prairie.*

- B5. The rolling to undulating Ringwood, Durand, and Ripon silt loam association.
- B21. The gently undulating to rolling Ogle, Durand, and Pella silt loam association.
- B22. The gently undulating to rolling Plano, Saybrook, Ringwood, Elburn, and Pella silt loam association.
- B32. The nearly level and gently undulating Plano and St. Charles (stratified substratum), Warsaw, and Fox silt loam association.

The influence of the original prairie vegetative cover (Green, 1950) is shown by the dark color of the thick surface horizon of these soils. Most of them are Typic Argiudolls: Ogle, Plano; Ringwood, Saybrook, Ripon; Durand; Warsaw. They are listed here in order of decreasing thickness of silty covering, from as much as 50 inches (Ogle, Plano) to less than 20 inches (Warsaw), over calcareous glacial drift. Corresponding annual yields (tons, dry weight, per acre) of alfalfa-brome hay, under good management, range from 4.75 to 3.5. Depths of 2 to 4 feet of silty soil predominate in these landscapes. The other soils are the somewhat poorly drained Elburn (Aquic Argiudoll) and poorly drained Pella (Typic Haplaquoll), both associated with Plano and the deep silty St. Charles, stratified substratum phase, and with the shallower Fox silt loam. The last two soils have developed under forest cover (Typic Hapludalfs). The landscape position of the St. Charles, stratified substratum, is along the contact between till upland and outwash flat. The Ripon soil (Typic Argiudoll) is 20 to 42 inches deep over limestone bedrock. This entire group of productive soils occupies about 2% of the land area of Wisconsin, or 700,000 acres.

The deep (36 to 50 inches in the Ogle) and moderately deep (20 to 30 inches in the Durand) silty upper sola are the dark equivalents of the Flagg and Pecatonica, discussed in a preceding section. All four silt loams are underlain by old truncated subsoils formed in early glacial drifts (Altonian and Illinoian).

Named prairies under which some of these soils formed are Walworth and Rock prairies in the two counties of the same names, and the Arlington Prairie (also called the Empire or "High" Prairie; Engel and Hopkins, 1956) in Columbia and Dane counties.

In Columbia County, soil association B22 is dominated by Plano (50% by area) and Ringwood (15%) soils.

B8, B15, B26, B28. *Lapeer, Metea, and associated loams on sandy dolomitic glacial till, with some rocky land.*

- B8. The rolling to undulating Lapeer, McHenry, and Miami silt loam association, with rock outcrops.
- B15. The rolling to undulating Lapeer, Pardeeville, Boyer, and McHenry loams association.
- B26. The gently undulating to rolling Metea, Puchyan, Miami, and Lapeer loams association.
- B28. The gently undulating to rolling Lapeer, Pardeeville, and McHenry loams association.[1]

On glacial ground and end moraines of calcareous till on which patches of distinct loess covering are not extensive, the Lapeer (Typic Hapludalf) and Metea (Arenic Hapludalf) soils predominate. The Lapeer and its somewhat dark associate, Pardeeville (Mollic Hapludalf), overlie sandy loam till, whereas the Miami (Typic Hapludalf; Figs. 8-4, 8-7) overlies loam till. All three soils have less than 20 inches of silt cover. The McHenry (Typic Hapludalf; Fig. 8-9) has 20 to 36 inches of silty soil. This soil is underlain by pink till on the Marengo ridge, classified as a Tazewell moraine by Thwaites (Table 2-10) and so published by Flint (1945). Sandy coverings over these same tills characterize the Puchyan (15 to 36 inches of sandy deposit over silt over till) and the Metea (18 to 36 inches of sandy deposit over till) soils, both classified as Arenic Hapludalfs. It is apparent that considerable blowing of both silt and sand took place over these landscapes after deglaciation.

1. On the soil map, Plate 1, in T.16N., R.11E., B should read B28.

The Boyer soil (Typic Hapludalf) consists of 20 to 40 inches of sandy soil over calcareous outwash sand. These are all agriculturally productive soils, even though somewhat droughty as compared to deep silt loams of the region. Rock outcrops in soil association B8 indicate that excavation and even cultivation are not possible in places. Mixed into the sandy loam and loam Lapeer soil are some silt and clay particles of aeolian origin.

A detailed study in a gravel pit in Boyer and associated soils 2 miles southwest of Dekorra in Columbia County showed the presence of tongues of B2t horizon 5 to 6 feet deep and as much as 7 feet long and 2 feet wide at the tops, having the forms of cones and linear and branching wedges (as much as 10 feet long) (Yehle, 1954). Stratified gravel beds cross the tongues, with downward deflection and loss of carbonates in the tongues. These are not to be confused with ice-wedge casts (see page 19), but are the result of intense leaching localized by unknown factors that controlled patterns of percolation of water into the soil.

A Seaton-like soil is included in soil association B15 in Columbia County (McColley, 1971).

B9, B19, B20. *Morley, Varna, and associated silty soils over gray clayey glacial till.*

- B9. The rolling to undulating Morley, Blount, and Varna silt loam, and Ashkum silty clay loam, association.[2]
- B19. The gently undulating to rolling Morley, Blount, and Ozaukee silt loam, and Ashkum silty clay loam, association.
- B20. The gently undulating to rolling Varna and Elliott silt loam, and Ashkum silty clay loam, association.

The dolomitic, clayey (about 30% clay) substratum of these soils is glacial till (Figs. 2-12, 2-22, 8-10) containing considerable shale, derived from the Devonian Milwaukee Shale[3] in Racine and Kenosha counties and adjacent basin of Lake Michigan, and from the underlying Silurian ("Niagara") dolomites. The glacial drift is commonly brown and gray (10YR and 2.5Y colors) but under the Ozaukee soils is slightly pinker (7.5YR-5YR colors, transitional toward the 5YR-2.5YR colors of till under Kewaunee soils) (Fig. 8-11). The Ozaukee C horizon contains 40% calcium carbonate equivalent and in many places is thin (6 to 12 feet) over outwash or loamy till. Where silty clay loam till rests on loam till a white horizon of calcium carbonate accumulation occurs at the contact (Watson, 1961). All of the soils in these associations are formed in less than 20 inches of loess covering over the clayey till. Both forest and prairie vegetative covers have left their impress. The dark Varna (Typic Argiudoll) and Elliott (Aquic Argiudoll) soils formed under native grasslands. Barnes Prairie was the name given to a large body of these soils in Racine County. The lighter colored Morley (Fig. 8-10), Ozaukee (both Typic Hapludalfs), and Blount (Aeric Ochraqualf) soils were originally forested. The Morley soil solum is about 7 inches thicker and is developed in slightly thicker loess covering than the Ozaukee soils. Associated with Ozaukee are the somewhat poorly drained Mequon loams (Udollic Ochraqualfs) and in Ozaukee County, Martinton (Aquic Argiudoll) and Saylesville (Typic Hapludalf) loams on lacustrine deposits. In the lowlands are bodies of Ashkum (Typic Haplaquoll), many of which have been drained for crop production. The low permeability of the glacial till makes these landscapes unique in that in places farmers have installed both tile drains and runoff diversion terraces on the same slope, where the gradient is about 9%. This unusual combination of drainage and erosion-control practices accelerates removal of subsoil water and at the same time slows removal of surface water.

Pedersen's investigation (1954) of the Varna soil catena extended into Illinois and covered the entire geographic province of the association. He found the sola of the Elliott-Varna members of the catena in Wisconsin to be slightly shallower, more silty in the A horizon, and more clayey in the B horizon than corresponding soil profiles in Illinois. The differences he attributed to the age difference (possibly as much as 10,000 years) between the early Woodfordian (Tazewell) till landscape in several Illinois counties and the late Woodfordian (Cary) till landscape in Wisconsin. Pedersen suggested that the increasing proportion of the landscape occupied by the poorly drained Ashkum soil (Watson, 1961) from north (about 26%) to south (about 34%) may have been caused in part by gradual collapse of borderlands of depressions, as a result of removal of colloidal material from sola by lateral seepage waters moving through the soil just above the dense calcareous silty clay loam glacial till (bulk density, 1.8; 35% $CaCO_3$ equivalent).

In Sheboygan County a Theresa-like soil is associated with the Ozaukee series on reddish-brown till.

Illite and chlorite are the predominant clay minerals in both the Paleozoic shales and silty clay loam tills of southeastern Wisconsin (Dixon and Jackson, 1960) (Fig. 4-5).

B11, B13, B14, B23, B25, B27, B29. *Miami, McHenry, Lomira, Dodge, St. Charles, and associated silty soils on sandy, dolomitic glacial till.*

- B11. The rolling to undulating Miami, McHenry, Clyman (Crosby), and Brookston silt loam association.
- B13. The rolling to undulating Miami, Dodge, and Pella silt loam association.
- B14. The rolling to undulating McHenry, Lapeer, Miami, and Brookston silt loam association.
- B23. The gently undulating to rolling Miami, McHenry, and Brookston silt loam association, with peat and muck,
- B25. The gently undulating to rolling St. Charles, Dodge, Miami, and Pella silt loam association.
- B27. The gently undulating to rolling Lomira, LeRoy, and Knowles silt loam association.
- B29. The gently undulating to rolling Dodge, Lomira, and Knowles silt loam association.

These productive agricultural soilscapes occupy about a million acres, or nearly 3%, of the land area of the state. Soil mineralogy is mixed, providing an ample reserve of plant nutrients (Batson, 1940). Soils of the uplands are most extensive and are all underlain by calcareous glacial till. Bedrock comes close to the surface in a few places. Lowlands contain fertile black

2. A blank strip on the soil map, Plate 1, in T.6N., R.20E., interrupts a body of soil association B9, boundaries of which should be continued due south.

3. Watson (1961) reported finding in the glacial till some fossil spores of a Devonian plant, *Tasmites Chicagoensis.*

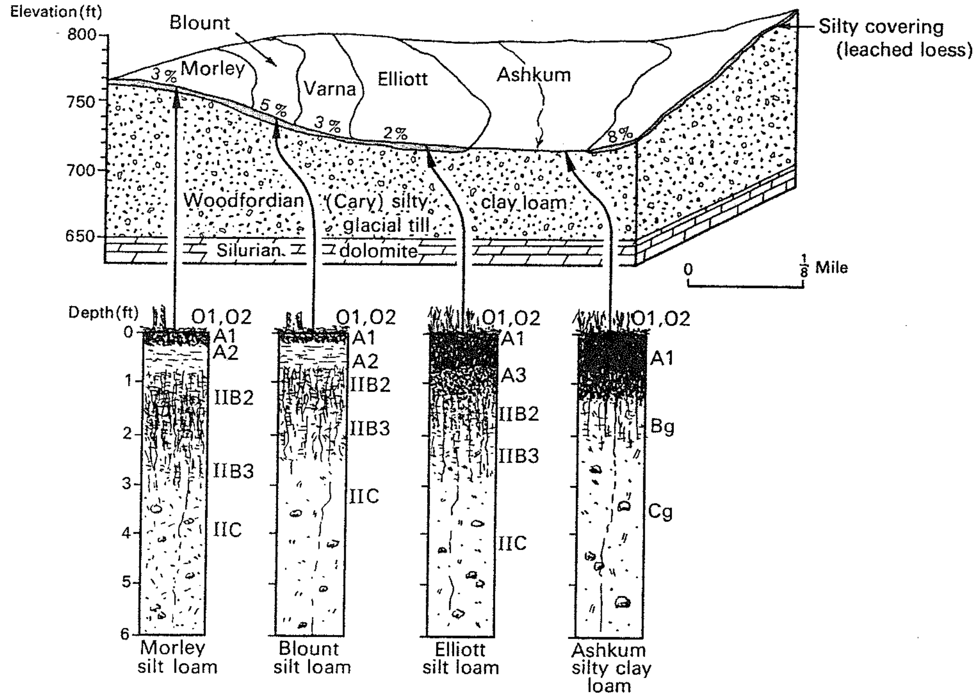


Figure 8-10. Block diagram showing landscape positions of representative soils of soil associations B19 and B20 in Section 29, T.3N., R.21E., Racine County.

soils, both mineral and organic. A dark, thick A1 horizon may extend from the lowlands to soils of footslopes. Thus, in some sections of Dodge County, Elburn soils occupy the place of Kendall soils in the St. Charles catena (see catenas numbers 47 and 49 in Table 18-1). Landforms are glacial moraines for the most part, but drumlins are prominent (Alden, 1905) (B13; Figs. 8-12, 8-13), particularly in Dodge County, where many field boundaries run parallel to them (Collins, 1971). This Woodfordian glacial drift is calcareous (dolomitic). Loess coverings are thought to have been deposited between 14,000 and 8,000 years ago, silts having been blown in part from the Mississippi and Wisconsin River valleys, in part from southwestern states, and in part from local till and outwash surfaces.

The naturally well-drained soil series (Typic Hapludalfs) are

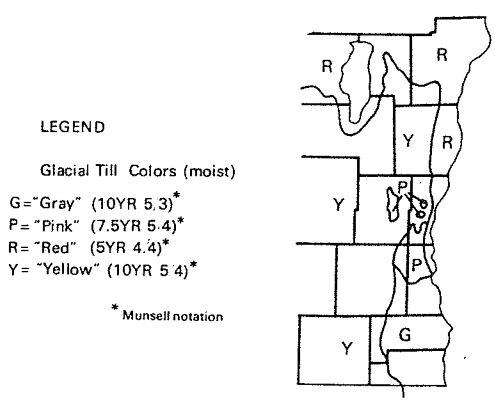
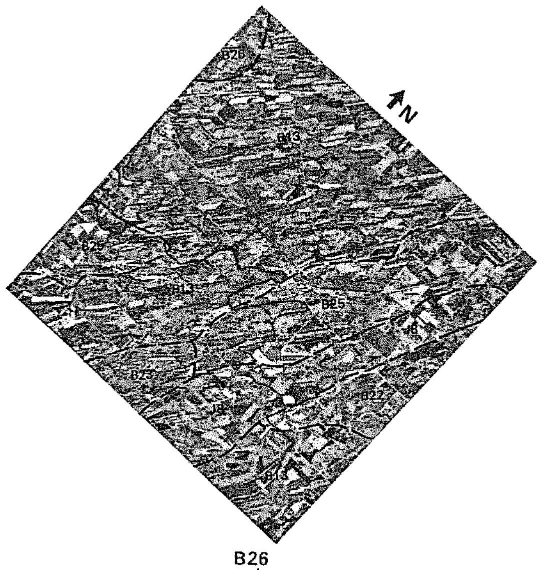


Figure 8-11. Map showing the distribution of glacial tills of four different colors in southeastern Wisconsin (after Watson, 1961).

differentiated on the basis of (1) depth of loess covering and (2) texture of the underlying glacial till. The Miami (on loam till; Fig. 8-13), LeRoy (on highly calcareous channery till), and Lapeer (on sandy loam till; Fig. 8-9) soils have less than 20 inches of silty coverings. The Dodge (on loam till; see Ciolkosz, 1967) (Figs. 8-8, 8-12, 8-13), Lomira (on highly calcareous channery till), McHenry (on sandy loam till; Fig. 8-9), and Knowles (over limestone bedrock; Fig. 8-7) soils have loess blankets 20 to 36 inches thick. The St. Charles and Kendall soil series (Figs. 7-12, 8-8, 8-13) formed in 36 to 50 inches of loess over sandy loam or loam till. In southern Dodge County the B2t horizon of a pedon has clay films containing about four times as much clay and organic matter and twice as much free iron as the natural soil blocks that the films coat (Buol and Hole, 1959). Miedema and Slager (1972) reported a profile clay illuviation index (see page 27) of 550 for a silty soil in this area. Depressions in the landscapes are occupied by the very poorly drained Pella (Typic Haplaquoll; Figs. 2-52, 8-8), bordered by the poorly drained Brookston (Typic Argiaquoll; Fig. 8-8) and Lamartine (formerly called Clyman and Crosby; Aquic Hapludalf; Fig. 2-52).

Soil texture influences available moisture-holding capacity as indicated by these annual yields (tons, dry weight, per acre) of alfalfa-brome hay: Lapeer, 3.0; McHenry, 3.5; Miami, 4.5; and St. Charles, 4.75.

These soils have been leached of carbonates to depths of 20 to 50 inches. White seams of secondary calcite along joints in the till attest to the translocation of carbonates by water down cracks. Soil reaction in the upper sola of these soils ranges from very strongly acid (pH 4.5) in deep silty upland soils, to neutral in soils overlying channery till, to calcareous in alkaline phases



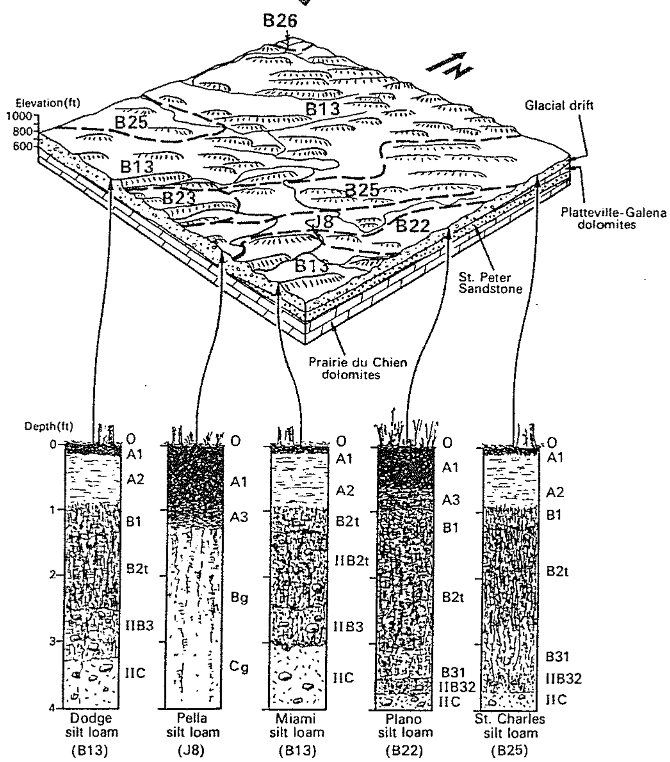


Figure 8-12. Aerial photo map of T.10N., R.13E., Dodge County. The area shown is 6 miles on a side.

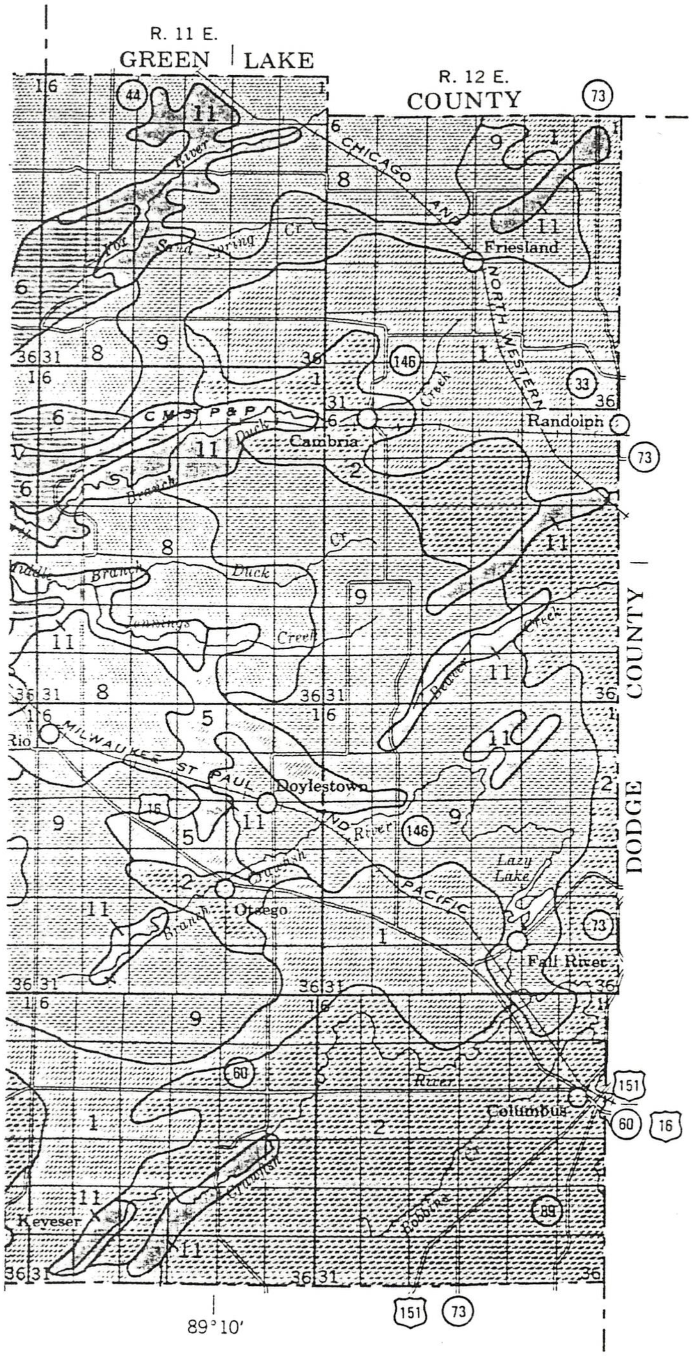
Figure 8-13. Block diagram showing landscape positions of major soils of T.10N., R.13E., Dodge County.

of Pella of lowlands in which snail shells are abundant all the way up to the soil surface.

In Columbia County, soil association B25 includes depressional soils (Typic Haplaquolls) that are more silty than the Pella series, which they otherwise resemble.

In soilscape B13, erosion on sides of drumlins has stripped the silty solum from the glacial till locally (Hole, 1956b), removing the solum of the original Miami silt loam and leaving in its place a primitive soil on stony, dolomitic sandy loam or loam (a soil like Hennepin sandy loam; Typic Eutrochrept). Alfalfa can do well on such a soil, but oats and corn cannot.

In southern Walworth County some bodies of Miami soil are underlain by pink (7.5YR 5/4) and reddish-brown (5YR 4/4) glacial tills—ranging in texture from sandy loam to plastic light clay loam—over a far more extensive area than that occupied by the older Wisconsinan drift called Tazewell by Thwaites (Flint, 1945). Pink till underlies Hochheim and Theresa soils in western Washington County.



U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

WISCONSIN RESEARCH DIVISION
COLLEGE OF AGRICULTURE AND LIFE SCIENCES
UNIVERSITY OF WISCONSIN

GENERAL SOIL MAP

COLUMBIA COUNTY, WISCONSIN

Scale 1:253,440

1 0 1 2 3 4 Miles

N

SOIL ASSOCIATIONS

1 — Plano-Griswold-Saybrook association: Well drained and moderately well drained silty soils that have a silty or loamy subsoil; underlain by sandy loam glacial till

2 — St. Charles-Ossian-Dodge association: Well drained, moderately well drained, and poorly drained silty soils that have a silty subsoil; underlain by sandy loam glacial till or silty sediment

3 — Mt. Carroll-Seaton-Dresden association: Well drained and moderately well drained silty and loamy soils that have a silty or loamy subsoil; underlain by stratified silt and sand, silty sediment, or stratified sand and gravel

4 — McHenry-Baraboo-St. Charles association: Well drained and moderately well drained silty soils that have a dominantly silty subsoil; underlain by sandy loam glacial till or quartzite bedrock

5 — Plainfield-Okee association: Excessively drained and well drained sandy soils that have a sandy or loamy subsoil; underlain by sandy sediment or sandy loam glacial till

6 — Boyer-Oshtemo-Dresden association: Well-drained sandy and loamy soils that have a loamy subsoil; underlain by sand or stratified sand and gravel

7 — Oshtemo-Plainfield-Briggsville association: Excessively drained to moderately well drained sandy and loamy soils that have a sandy, loamy, or clayey subsoil; underlain by sandy sediment, sand and gravel, or clayey sediment

8 — Lapeer-Wyocena association: Well-drained loamy and sandy soils that have a loamy subsoil; underlain by sandy loam or loamy sand glacial till

9 — Grellton-Gilford-Friesland association: Well drained, moderately well drained, and poorly drained loamy soils that have a dominantly loamy subsoil; underlain by sandy loam glacial till, stratified silt and sand, or silty sediment

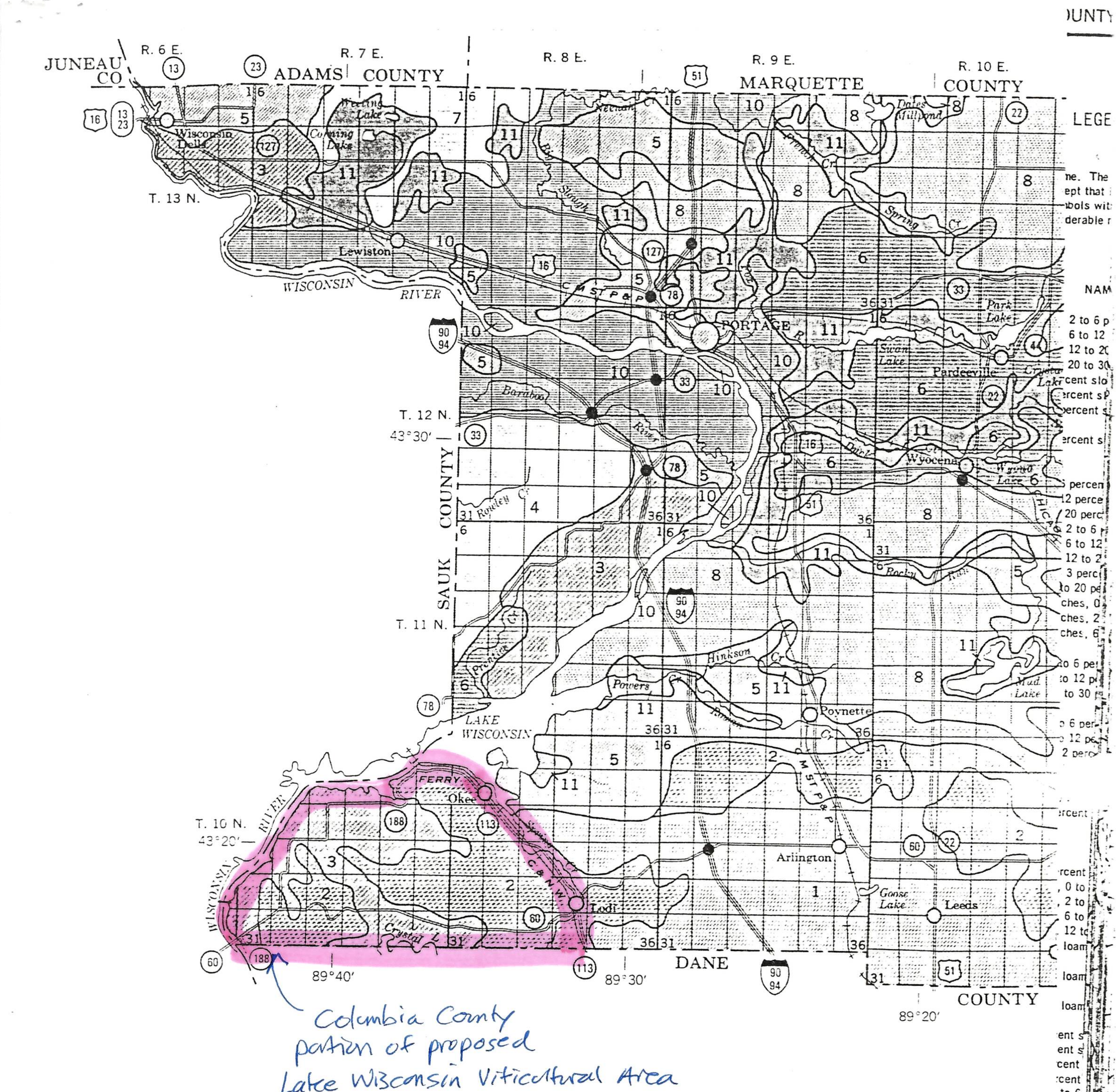
10 — Granby-Alluvial land, loamy, wet-Morocco association: Somewhat poorly drained to very poorly drained sandy soils that have a sandy subsoil and are underlain by sandy sediment; and loamy alluvial land

11 — Houghton-Adrian-Palms association: Very poorly drained organic soils; underlain in places by sandy or loamy sediment

Compiled 1976

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36



Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

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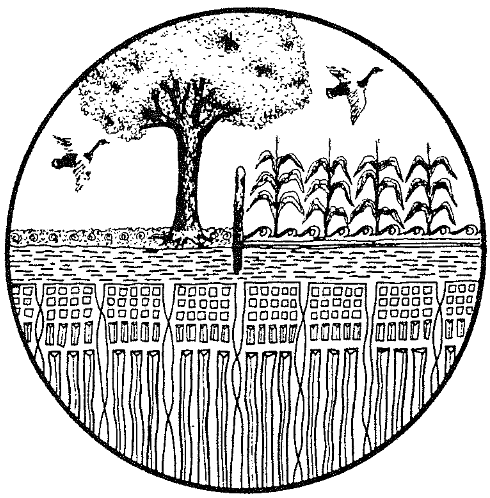
Charles Dean
April 2, 1991

Soil Guide for Wisconsin Land Lookers



by Francis D. Hole

Geological and Natural History Survey
University of Wisconsin-Extension

In cooperation with the Department of Soil Science,
College of Agricultural and Life Sciences
University of Wisconsin–Madison;
and the Soil Conservation Service,
U.S. Department of Agriculture

G2822
Bulletin 88
Soil Series 63

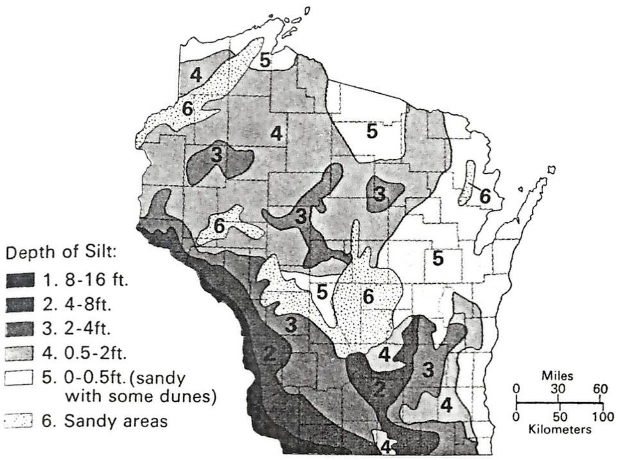


Figure 21. WIND-DEPOSITED SILT (LOESS) AND SAND

Large quantities of silt (loess) were blown in by dust storms during the ice age, from the Mississippi River flood plain north-eastward onto uplands. In sandy areas (6) the silt blanket did not stay but was blown still further probably because of erodibility of the sandy terrain. Soils that developed from the fertile silt (areas 1 through 5) have good capacities to hold water and nutrients for the benefit of plant growth.

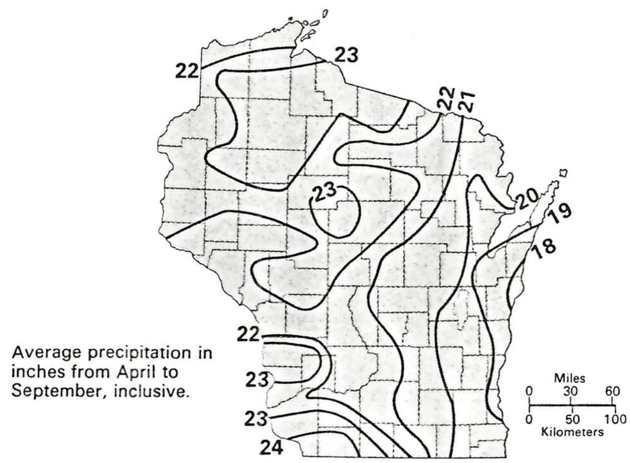


Figure 22. AVERAGE PRECIPITATION *(April to September, inclusive)*

The April to September rainfall is 23 to 24 inches in the far northern highland and at the southwestern corner of the state; and 18 to 21 inches in east central Wisconsin. Of the 31 inches of annual precipitation, 68 percent falls during these six months when plants are growing. The rainiest month is June; the driest, December. Soils are commonly saturated in April when the snow and ice melt. Soils are commonly driest during August through autumn.

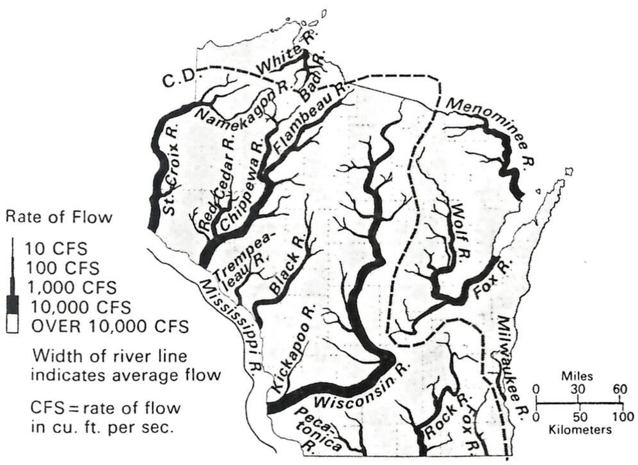


Figure 23. PRINCIPAL RIVERS AND THEIR AVERAGE FLOW

Thirty percent of the state drains to the St. Lawrence River basin, and the remaining 70 percent to the Mississippi River basin. The dashed line represents the continental divide (C.D.) between these two major basins. Peak flows are in March, April and June. The Wisconsin River drains 21 percent of the area of the state; the Chippewa-Flambeau system drains 17 percent; the Fox-Wolf system in northeastern Wisconsin drains 12 percent of the state.

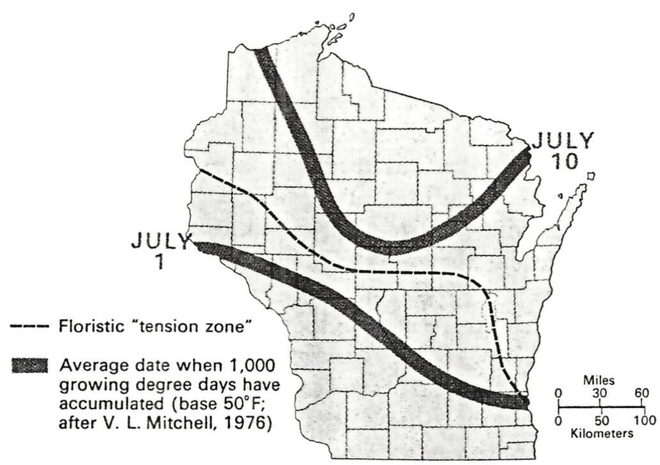


Figure 24. CLIMATIC ZONATION IN WISCONSIN

The difference in early growing season temperature between northern and southern Wisconsin is shown by the July 1–10 lapse time required for the same amount of solar heat to accumulate in the north as in the south. The floristic "tension zone" separates northern pine country from southern prairie-oak forest country.

10. Soils of Southeastern Wisconsin (Soil Region B)

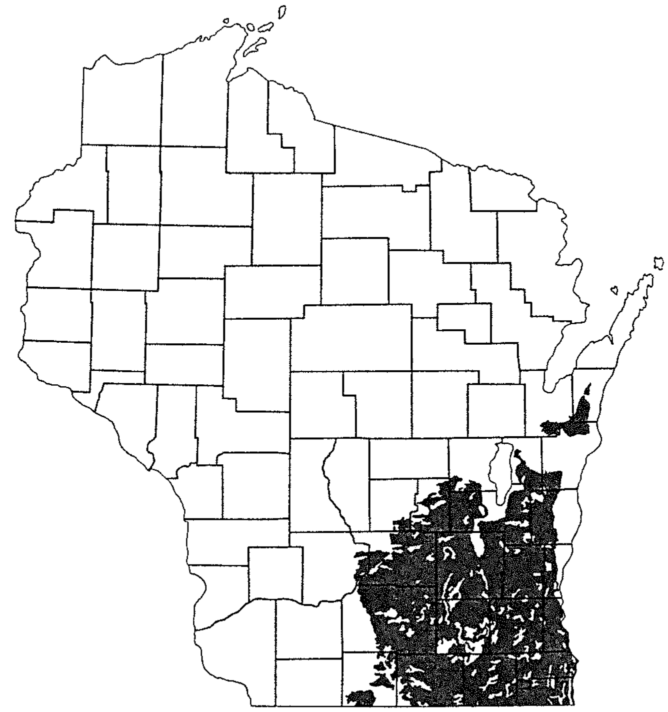


Figure 28. Distribution of southeastern loams and silt loams (Region B).

This region covers about 13% of the area of the state and consists of one major body and two others – one northeast of Lake Winnebago and a smaller one in southern Green County (Figure 28).

These are silty to sandy soils developed on **calcareous glacial drift** on landforms characteristic of recently glaciated terrain: moraines, drumlins, outwash plains, kames, and the serpentine eskers (Table 5). **Cuestas** are heavily blanketed and obscured by glacial drift. However, the Silurian ("Niagara") cuesta is still quite prominent, particularly near the southern end of Lake Winnebago. The three levels of the stair-step landscape are otherwise rather subdued and the glacial land forms just listed are present in most places (Figure 29).

Glacial deposits and loess were nearly all calcareous originally. Leaching by percolating rain water during the thousands of years since the glacier melted away accounts for the acidity of the upper meter of soil. But in most soils of this Region B there is finely divided lime (calcite) below the zone of leaching. Leaching is deepest in sandy soils. Sand content increases and lime content decreases in the glacial drift from Milwaukee westward to the Wisconsin River at Portage.

Two ages of glacial drift are recognized here. One, called "older" in Table 6, is probably 20,000 to 30,000 years old. The other, called "younger," is about 15,000 years old.

Table 5. Chart of kinds of Pleistoecene (ice-age) deposits and their landforms.

Kinds of materials		Kinds of landforms
Glacial till (ice-laid)	*Moraines* (sheet or belt of till)	*Ground moraine* (rolling to undulating till plain)
		End moraine (belt or ridge of rolling to hilly land marking a position of the ice front)
		Drumlins (stream-lined hills, shaped by the moving ice)
		Kettle (See Outwash, below)
Glacial outwash or *inwash* (deposited by rapidly flowing water)	*"Moraines"* (ridges resembling true end moraines)	*Kettle moraine* (one or more ridges [eskers] or chains of hills [kames] with deep natural pits [kettles] between)
	Plains (near level areas)	*Unpitted* (without kettles)
		Pitted (with kettles)
	Eskers (serpentine ridges)	Ridges of gravel deposited in former tunnels under stagnant glacial ice.
	Kames (conical hills)	Hills of gravel deposited in former caves under the glacier, in some cases at the upstream end of an esker; or hills resulting from slump during melting of buried ice
	Kettles (depressions without outlet)	Depressions in outwash (or till) created by the melting of a buried block of glacial ice
Glacial lake deposit (laid down in quiet water)	*Lake plains*	Stratified clay to very fine sand
	Beaches	Stratified sand and gravel
Dunes and *loess* (wind-blown)		Sand *dunes*
		Blankets: Of sand
		Blankets: Of silt *(loess)*

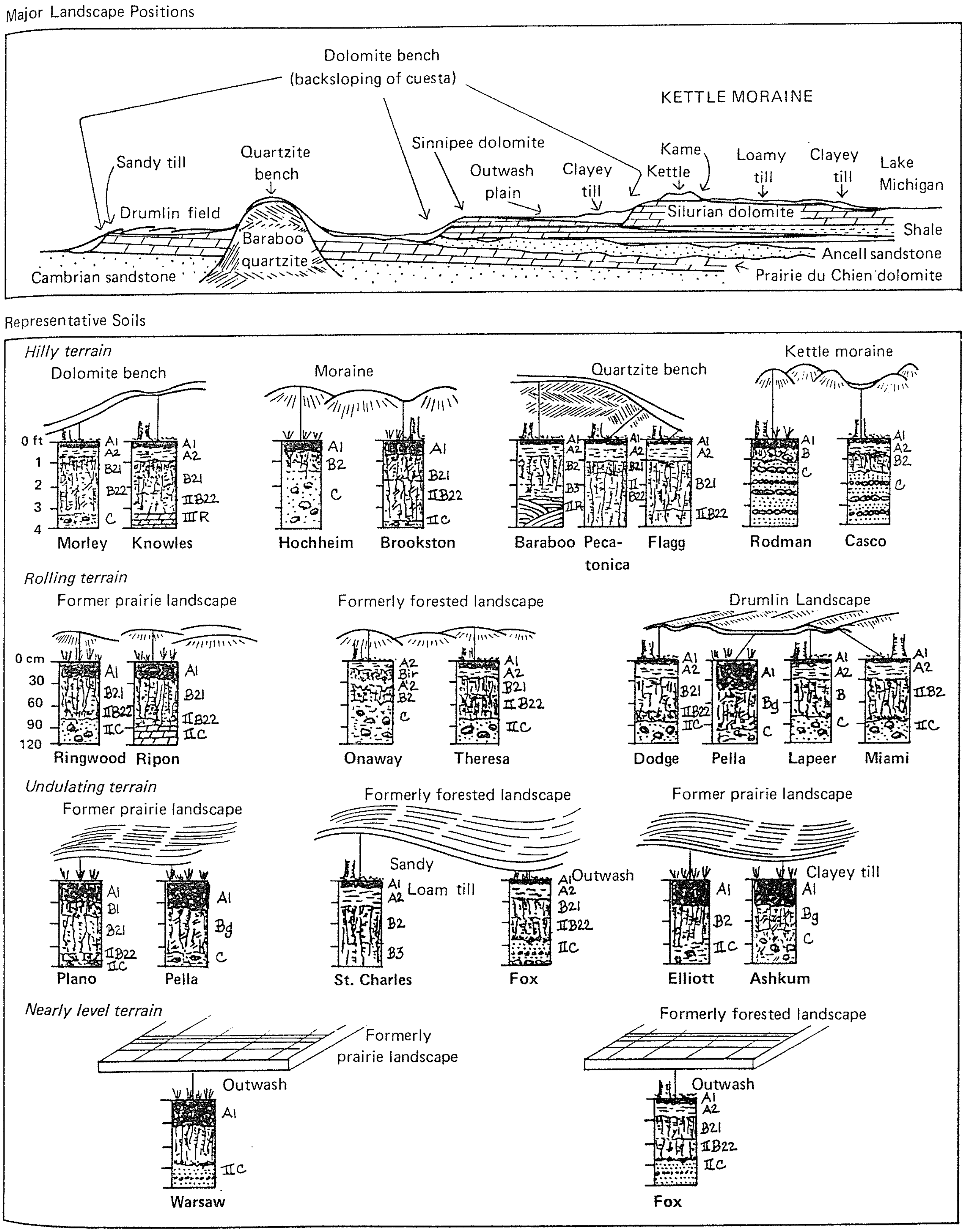


Figure 29. Landscape positions of some representative soils of southeastern Wisconsin (Soil Region B).

As in Region A, depth of loess cover is important to soil genesis and land use. Table 7 groups the soils of Region B with respect to this characteristic. It can be seen that in Region B there are no soils with an average of more than 105 cm of silty material, and that there are some soils without any distinct silt cover. These two differences from conditions in Region A result from Region B's greater distance from the Mississippi River Valley, from which the largest volume of loess was blown across the state by west winds.

It seems likely that wind-blown clay has gradually washed down into the main subsoil (B2t horizon) and into a dark zone (the "beta"-B horizon) at the bottom of the subsoil just above a coarse substratum. Erosion has in many places removed the mellow surface soil and exposed the sticky subsoil. Plants do not germinate nor do roots develop as easily in the clay-enriched B horizon as in the more friable A horizon.

The grouping of soils shown in Figure 29 is based on several factors: differences between prairie soils and forest soils; differences in texture of surface soil, ranging from silty clay loam to sandy loam; depth of silty soil; topography, ranging from rolling and hilly to nearly level; age of glacial drift; content of lime (carbonates) in the till. The Knowles silt loam is on glacial till shallow (about 30 inches or 75 cm) over dolomite bedrock. Where Maquoketa shale underlies the dolomite ledge, the glacial till is clayey and is the material in which the B horizon of the Morley silt loam formed. This soil is more extensive near Milwaukee, on glacial drift containing considerable amounts of Devonian shale. The Hochheim loam developed in glacial till that is so highly calcareous that soil organic matter has tended to accumulate in the topsoil, making it thick like that of a prairie soil. Wetland mineral soils of silty to silty clay loam surface texture include the Brookston, Ashkum and Pella series. Soils of the eastern glaciated portion of the Baraboo Range include the Baraboo silt loam, formed in nearly a meter of silty material over quartzite bedrock; and the Flagg and Pecatonica silt loams, formed in leached loess over older acid glacial till. The Kettle Moraine is characterized by the dark gravelly sandy loam called Rodman and associated shallow loam called Casco. There are patches of outwash and lacustrine flats scattered between bodies of these steeper soils. The Ripon series is the prairie equivalent of the Knowles, already mentioned. Where the sandy loam glacial till is deep the Ringwood soil formed under prairie. The Theresa soils (formerly forested) have deeper silty **sola** (surface and subsoil layers) and

Table 6. Relationship of some representative soil series of Soil Region B to relief and other factors

- HILLY SOILS
  - On dolomite bench—Knowles, Morley
  - On glacial moraine—Hochheim, Theresa, Brookston
  - On quartzite bench—Flagg, Baraboo, Pecatonica
  - On Kettle Moraine—Casco, Rodman, Fox, Lapeer
- ROLLING SOILS
  - Prairie soils—Ringwood, Ripon
  - Forest soils
    - On older glacial drift
      - Locally shallow to bedrock—Pecatonica
      - Deeper drift—Flagg
    - On younger drift
      - Locally shallow to bedrock—Lapeer
      - Deeper drift
        - Moraine landscape
          - Loam till
            - Mod. lime—Miami
            - High lime—Theresa, Hochheim
          - Sandy loam till—Lapeer
        - Drumlin landscape—Miami, Dodge, Pella
- UNDULATING SOILS
  - On clayey drift
    - Forest soils—Morley
    - Prairie soils—Elliott, Ashkum
  - On loamy drift
    - Older drift—Flagg, Pella
    - Younger drift
      - Till deep
        - Deep loess
          - Prairie soils—Plano
          - Forest soils—St. Charles, Dodge
        - Shallower loess
          - Moderate lime
            - Sandy—Lapeer
            - Loamy—Miami
          - High lime—Theresa, Hochheim
      - Till locally shallow—Drainage good—Dodge, Knowles
      - Outwash—Drainage good—Fox, Casco
- NEARLY LEVEL SOILS
  - On outwash
    - Prairie soils—Plano, Warsaw
    - Forest soils—St. Charles, Fox

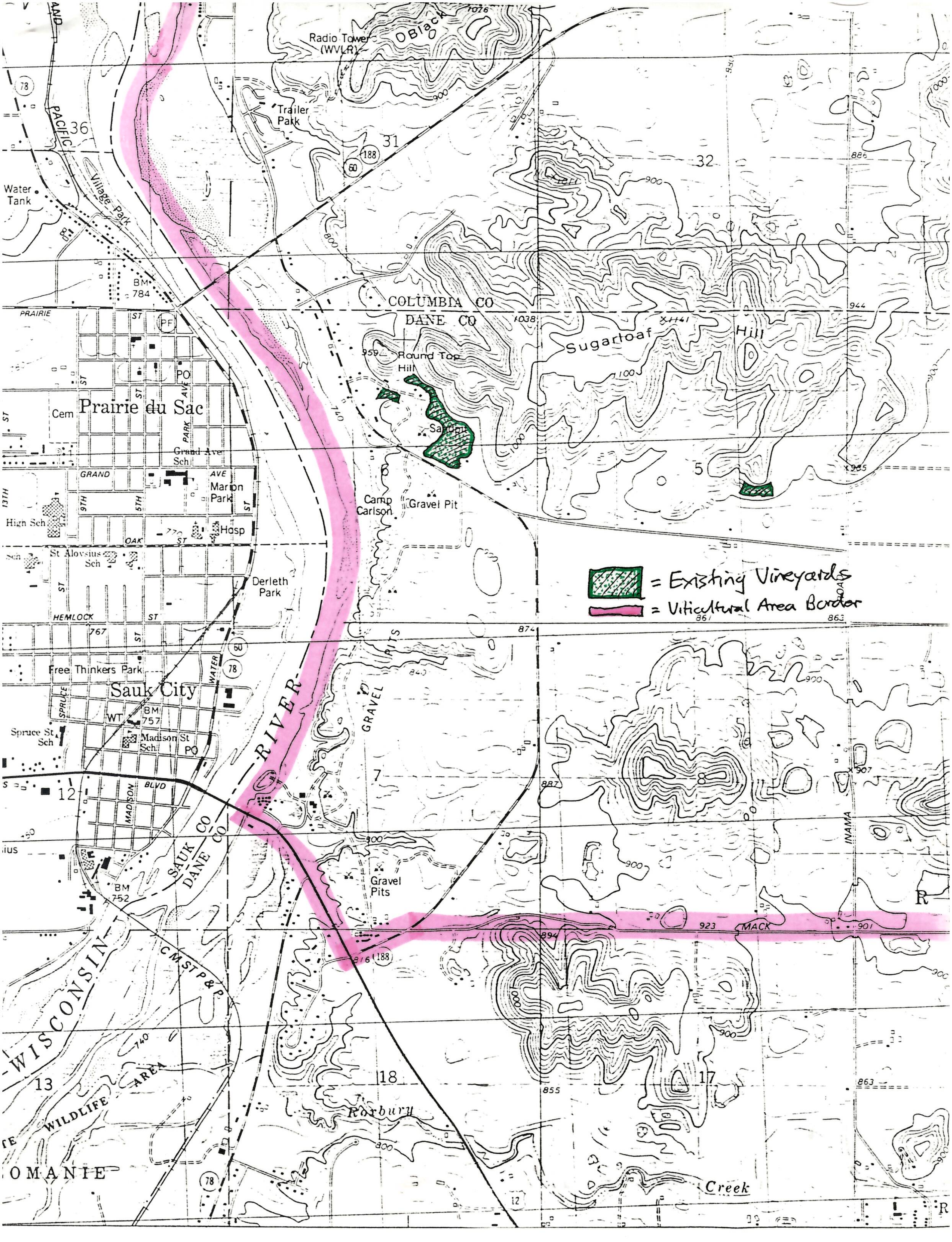
are slightly more leached than the Hochheim, but are on the same kind of highly calcareous glacial till. In the northern outlier of Region B, the Onaway soil shows evidence of podzolization through the presence of a Spodosol (Podzol) sequence of horizons above the normal clay-enriched subsoil (B2t horizon). The Onaway soil has a double profile, in this sense. It is likely that the Spodosol sequence has formed and disappeared during the thousands of years required to develop the B2t horizon. The Dodge soil is a common forest soil (Typic Hapludalf) of southeastern counties, found both on drumlins and on rises on moraines that have a moderately deep covering of leached loess. The Plano and St. Charles series are the prairie and forested soils of the deep silt blankets on undulating terrain, of loam to sandy loam glacial till. The Fox soil is underlain by glacial outwash. The Elliott soil is the prairie equivalent of the Blount (see page 57). The Warsaw and Fox soils are representatives of the prairie and forested areas on nearly level outwash flats.

This soil region is the most intensively urbanized one in the state. Considerable areas of these soils are being progressively withdrawn from agriculture. Severe erosion takes place locally during episodes of urban and suburban construction, and of intensive and careless cropping of sloping lands that are especially subject to urban pressures. Progress is being made in setting aside parcels of land as conservation and scientific areas where the vegetation and soils are still largely in their natural wild state.

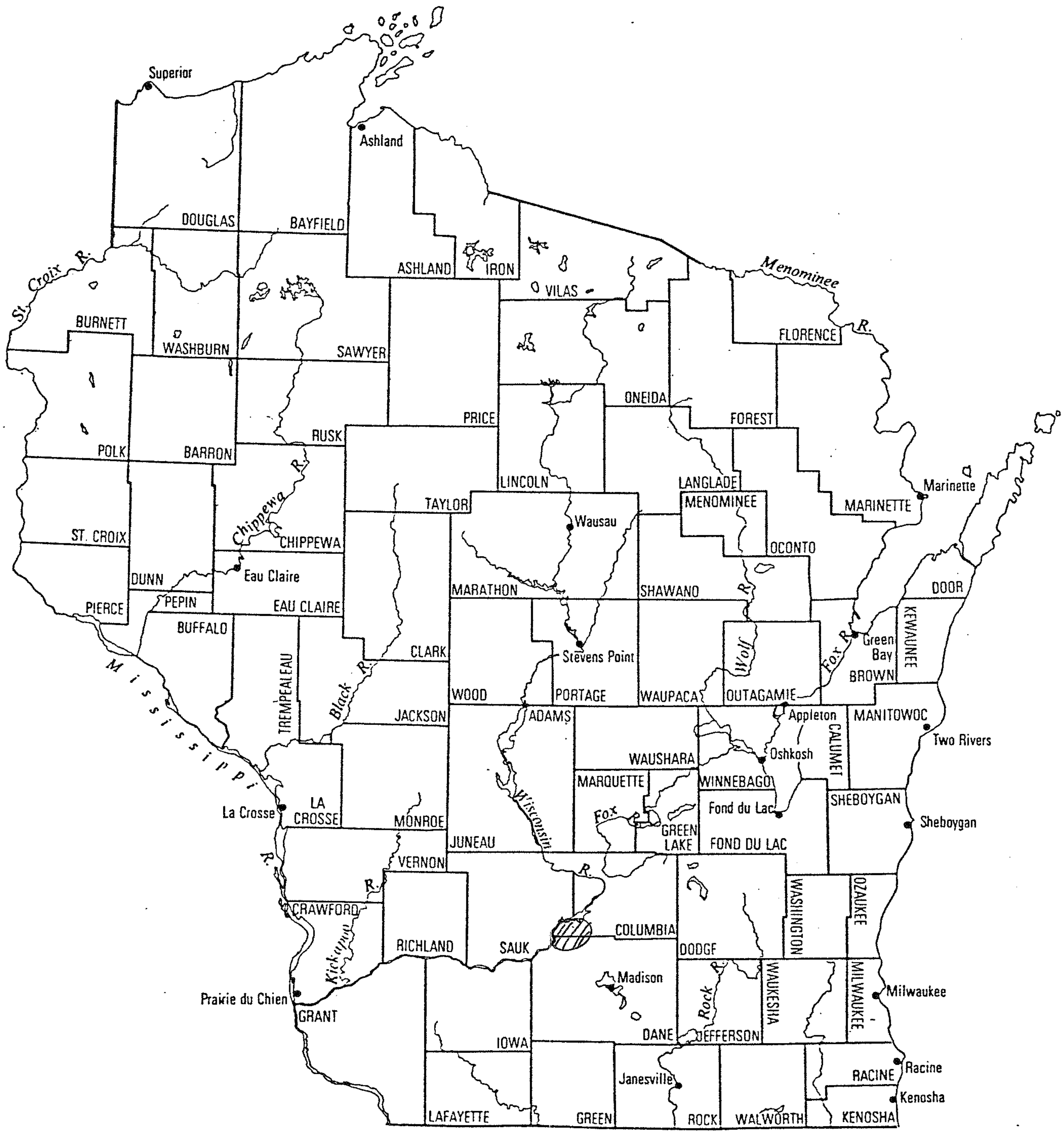
Table 7. Chart of representative soils[1] of southeastern Wisconsin as related to depth of leached loess cover.

Natural drainage condition	Thickness of leached loess or loamy cover				
	None	Av. 12" (30 cm)	Av. 15" (38 cm)	Av. 30" (75 cm)	Av. 42" (105 cm)
Excessively drained	Rodman sl (Typic Hapludoll)				
Well drained	Onaway l (Alfic Haplorthod)	Morley sil (Typic Hapludalf)	Casco l (Typic Hapludalf)	Knowles sil (Typic Hapludalf)	Flagg sil (Typic Hapludalf)
		Hochheim l (Typic Argiudoll)		Baraboo sil (Typic Hapludalf)	Pella sil (Typic Haplaquoll)
		Warsaw l (Typic Argiudoll)		Ringwood sil (Typic Argiudoll)	Plano sil (Typic Argiudoll)
		Fox l (Typic Hapludalf)		Ripon sil (Typic Argiudoll)	St. Charles sil (Typic Hapludalf)
				Theresa sil (Typic Hapludalf)	
				Dodge sil (Typic Hapludalf)	
Somewhat porly drained		Elliott sil (Aquic Argiudoll)			
Poorly drained		Ashkum sicl (Typic Haplaquoll)			
		Brookston l (Typic Argiaquoll)			

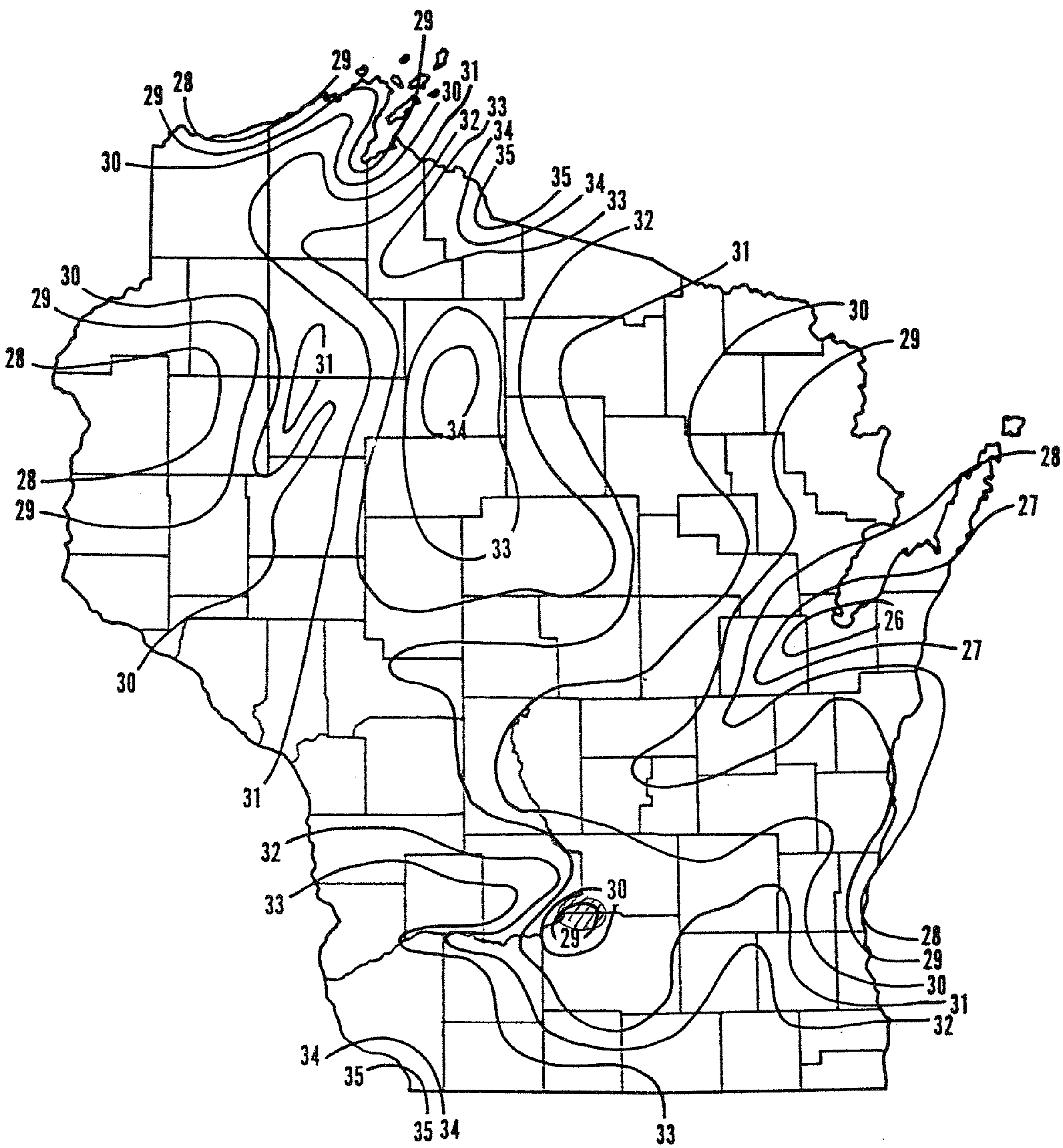
[1] Abbreviations of textures signify: l = loam; sil = silt loam; sl = sandy loam



= Existing Vineyards
= Viticultural Area Border
Radio Tower (WVLR)
Trailer Park
Water Tank
Village Park
PACIFIC
COLUMBIA CO
DANE CO
Round Top Hill
Sugarloaf Hill
Prairie du Sac
Cem
Grand Ave Sch
Marion Park
High Sch
Hosp
St Aloysius Sch
Camp Carlson
Gravel Pit
Derleth Park
Free Thinkers Park
Sauk City
Spruce St Sch
Madison St Sch
RIVER
GRAVEL PITS
SAUK CO
DANE CO
Gravel Pits
MACK
WISCONSIN
CMSTP&P
WILDLIFE AREA
MAZOMANIE
Roxbury
Creek

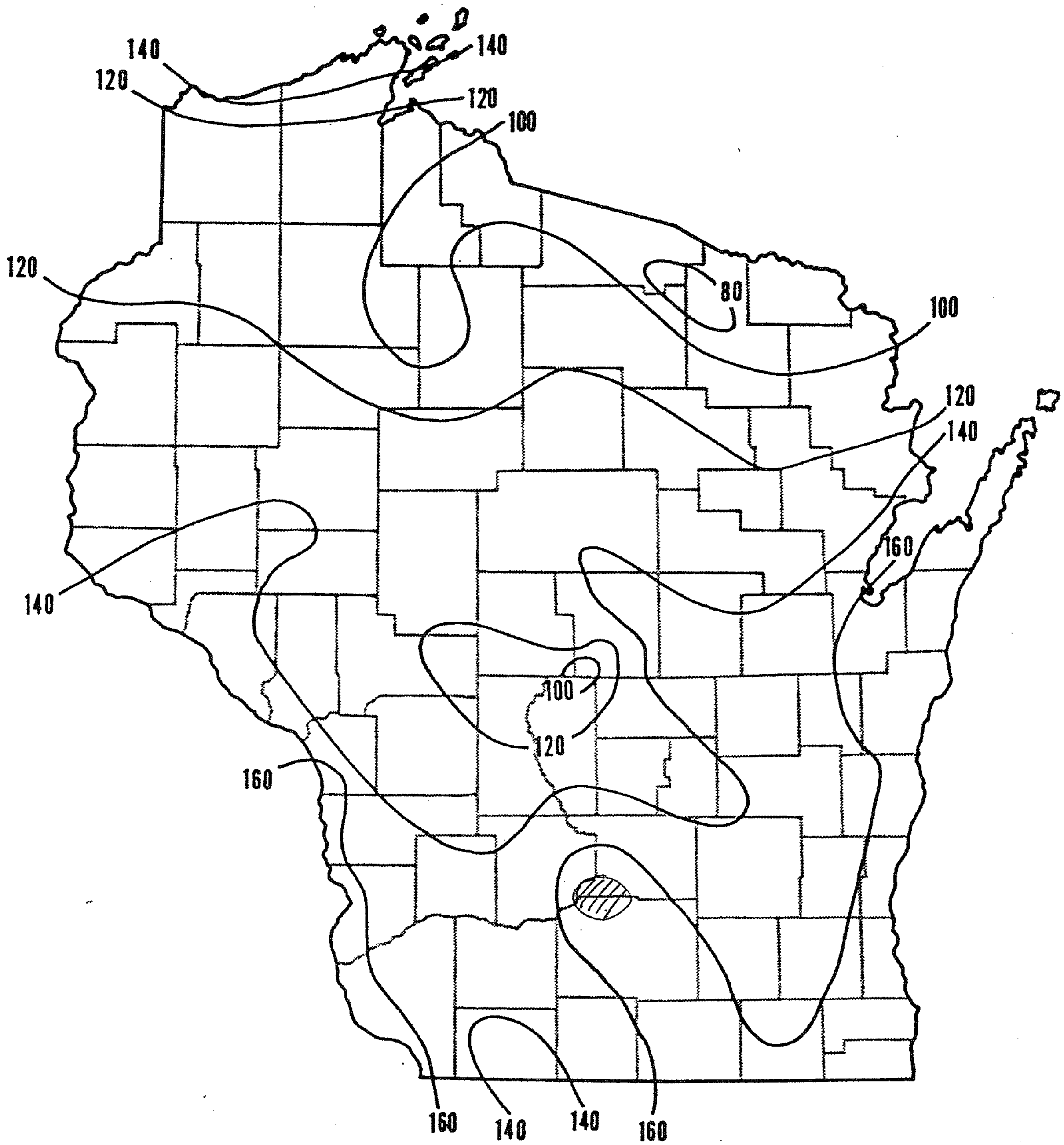


Index Map of Wisconsin showing Viticultural Area
in relation to rivers, counties, and cities.



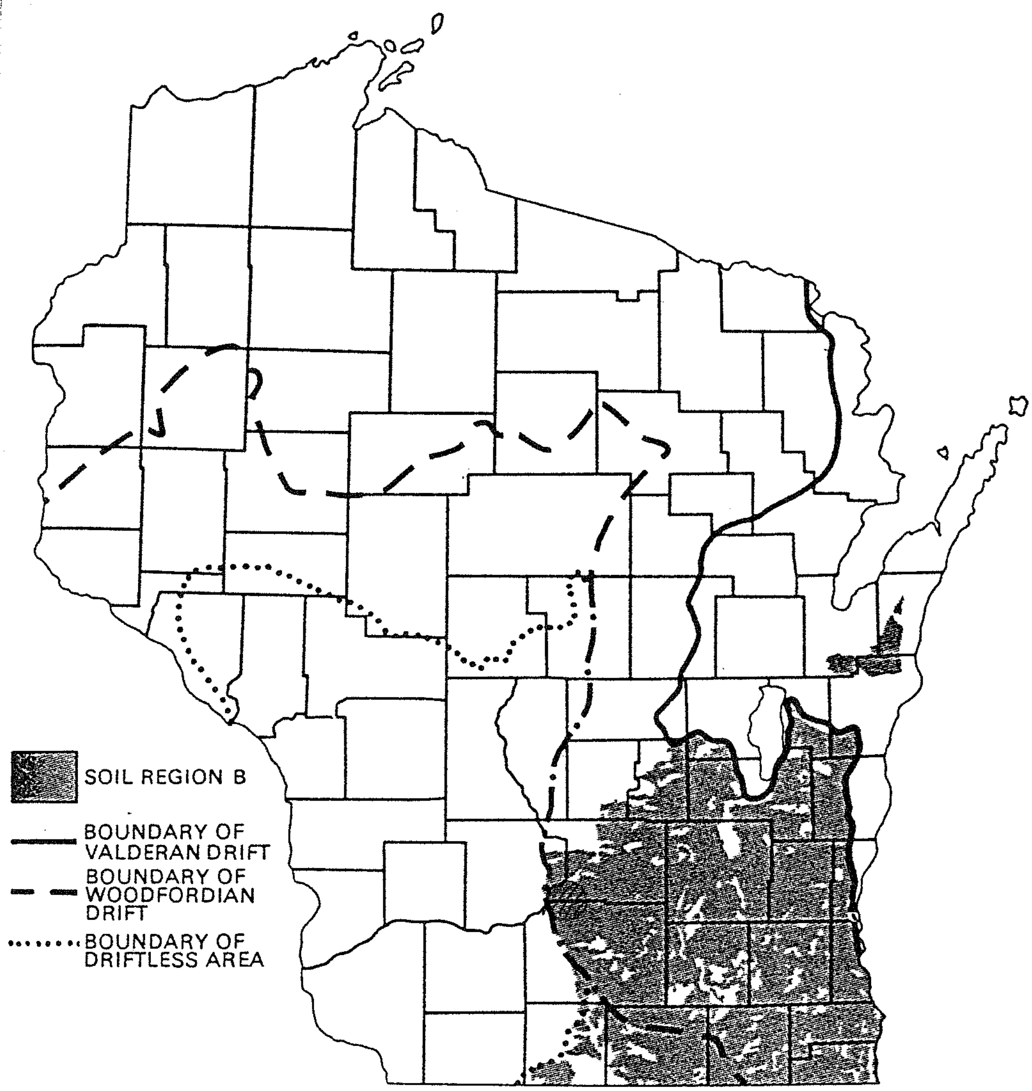
Average Annual Precipitation (inches)
showing Viticultural Area "island."

Climate



Average Length of Growing Season (days)
showing Viticultural Area location.

C



Index Map showing geographic relationship of Soil Region B to major glacial boundaries and Viticultural Area.

Soil

THE CLIMATE NEAR THE GROUND

Rudolf Geiger

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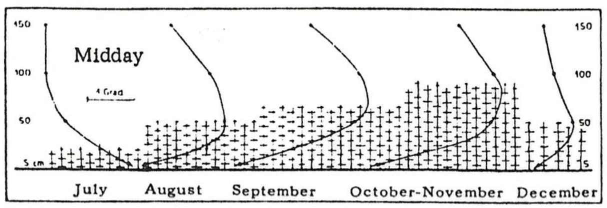
PREFACE

Anyone who merely turns the pages of this new edition will find that 48 percent of the figures are familiar to him from the third edition. But whoever reads it will discover that no three consecutive pages of text have been transferred unaltered. The enormous development that has taken place since 1950, particularly the surprising extension in the practical applications of micrometeorology, have made it necessary to rewrite the book. The rounding off of our knowledge also permitted the material to be arranged more clearly.

In producing this work, I had in mind two aims which were linked more closely to each other than I had at first dared to hope. The new edition was to be a clear and vivid textbook for those who were just taking up the study of microclimatology, and at the same time a reference work for those already familiar with the subject. For the first task I had in mind the students who would be regarding with horror the insurmountable barrier of an apparently unlimited and ever-increasing pile of literature, and thus were in need of real assistance. I was thinking also of colleagues working in related sciences, who have no time to study our literature; and finally, but not least important, I was thinking of all who work on the land, in forests and gardens, the architects, geographers, country planners, entomologists, doctors, transportation engineers, and others who—without having studied much physics—were anxious to acquire a knowledge of the rational physical principles governing the meteorologic laws that they have to put into practice. For the benefit of all these, I have at all times made renewed efforts to state the facts in the simplest and most uncomplicated manner possible. I have also tried at all times to improve the style so that the reader would be able to go on his way lightly, where the author had expended patient effort, tenacious industry, and much scrutiny of the material to be selected and the form of representation to be used. The extent to which I have been successful in providing genuine help to the reader remains to be seen.

The book should, in addition, everywhere lead up to the present-day status in research, and thus be of assistance to those already familiar with the subject. To stay within the required limits of space permitted only brief references to be made, in each section of microclimatology, to results that were useful and that pointed the way to the future. The novice will easily pass over these, whereas to the initiated they will provide access to the literature on the subject. This new edition is therefore at the same time a now turn our attention to plant communities where the individual members, in their growth and form of leaves, present a more horizontal structure.

The first example to consider is a flower bed planted with antirrhinum in a Munich garden [5]. Figure 155 shows the temperature profile. In July, when the plants are small and form an open type of cover, the midday temperature profile (upper diagram) is still similar to that over bare ground. In August, however, when the plants are fully grown, the dense leaf structure raises the zone of maximum temperatures to a higher level much more markedly than happens in grain, with its vertical type of structure (Fig. 148). The active outer surface lies just under the upper surface of the stand of plants. At night, when the upper surface of the plants radiates, the cooler air can sink to the ground more easily than in grain crops; therefore the minimum always lies at the ground surface in flower beds (lower diagram).



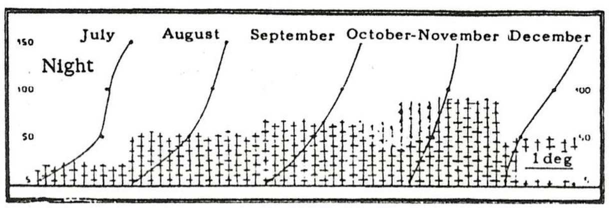


Fig. 155. Temperature profiles above a flower bed near Munich, during growth.

Leaf structures are not always as dense and close together as in flower beds. Where rows of vegetables, potatoes, beets, and the like, are planted in drills in a field, circumstances are rather different. L. Broadbent [571] was able to show, in investigations on a potato crop at Rothamsted, England, that the midday maximum temperature was at a height of 30 cm in a thickly planted crop 60 cm high, and at 10 cm in the sparsely planted. In contrast to Fig. 155, when the ground was dry the minimum was observed to be at the radiating upper surface of the crop. This is similar to the temperature variation observed by A. Mäde [551] in a Berlin potato field in 1936; the lower left-hand diagram in Fig. 149 shows the temperature difference observed during the day in comparison with the grassland base station on the top left. In

Rothamsted the temperature minimum was displaced only to the 10-cm level when the ground was wet. This was also the level of highest air humidity when the ground was wet, while with dry ground strong evaporation from the leaves raised its level to 30 cm. Short-term wind fluctuations may cause rapid changes in the temperature profile, as shown in the figures published by Broadbent.

J. M. Hirst, I. F. Long, and H. L. Penman [574] measured temperature and humidity relations at night at six different heights between 10 and 320 cm over a potato field at the same place. In a normal night, with deposition of dew, the gradient of water-vapor pressure was directed both from above and from below toward the upper surface of the crop. Investigations like those of A. Raeuber [579], with five different varieties of potatoes near Rostock, make it possible to discover the essential conditions for life of various potato parasites.

J. Justyák [576] analyzed a 5-year set of observations made in tomato fields at Debrecen in Hungary. There were plantings of various densities, with the plants arranged in rows in east-west and north-south directions. In these, soil temperature and moisture, air temperature, and vertical temperature gradients were investigated.

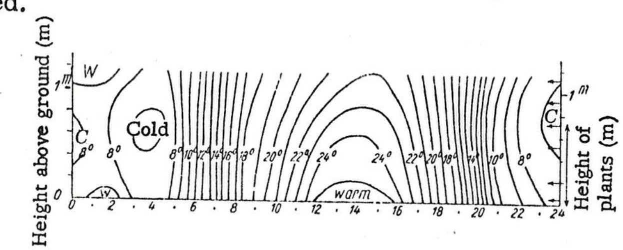


Fig. 156. Temperature variation during a typical midsummer day in a field of Jerusalem artichokes. (After A. Mäde)

Figure 156 shows the diurnal temperature variation in a Jerusalem artichoke (*Helianthus tuberosus*) field near Müncheberg (Brandenburg), after A. Mäde [578a]. Temperatures were recorded on a sunny day (4 August 1935) at heights marked by arrows on the right of the diagram, by six resistance thermometers free of radiation errors. The pattern of these temperatures resembles that of the mean temperature in August. The vertical temperature distribution at heights from 10 to 170 cm was investigated in Japan by R. Taguchi and H. Okumura [583] in a plantation of mulberry trees that were cut down every year and renewed by sprouting.

From the macroclimatologic point of view, German vineyards lie near the northern limit of the area in which vines can be cultivated. They are therefore by compulsion dependent on situations which have a microclimate that is especially sunny, warm, and free of frost. An introduction to living conditions on a vineyard terrace has been given by O. Linck [578] in a very readable, well-illustrated book which should be of interest to microclimatologists as well as botanists.

The microclimate of a "wine mountain," as it is called in German, is made up of many individual factors. To begin with, the term "mountain" indicates that the sunny slopes of hills are selected for the cultivation of grapes. The climate of terrace vineyard is therefore that of a slope, which will not be dealt with until Sec. 44. This type of climate is altered artificially by terracing. These flatter surfaces, on which the vines are planted, are easier to work and are bounded on the side toward the mountain by a stone terrace step, the microclimatic effect of which was discussed in Sec. 20. In many places the vineyards are divided by stone walls. These have been built through centuries by the laborers in the vineyard, collecting loose stones and building them into walls at the sides. They run down into the valley and form a shelter against the wind, hence providing warm spaces, which however do not impede the flow of colder air down into the valley. If the holes between the stones have not been blocked by fine accumulated dust, these stone walls have low thermal conductivity. They therefore become strongly heated during the day and act as sources of heat; they are correspondingly cool and moist deeper down, and in addition to promoting the growth of xerophytic surface flora they also support deep-rooted bushes and even trees by means of which their protective influence is increased.

The type of country in which the hill is situated is of equal influence. If its foot lies near a river or a lake shore, extra warmth is obtained through specular reflection, which was described on pp. 16f. If the hill is topped by a cold plateau, there will be an increased risk of night frosts through cold air flowing down at night (see Sec. 42). As a protection against this, the upper boundaries are often shut off by thick hedges or woods. According to R. Weise [588], the locations safest from frost in Franconia are surrounded by a crescent of slopes from SE through E round to W, and are open only toward the SW (see Sec. 54).

But the vines themselves, and the manner in which they are trained, also play a decisive role in creating the microclimate of the wine mountain, or, as it is called in the wine-producing country, the Wingerts or Wengerts. This aspect of vineyard climate, determined as it is by plants, is clearly the easiest to investigate, because this part of the hill is level. This is usually the case in the research reports that follow, but there are also exceptions to this rule.

The first instrumental measurements were made in 1928 by R. Kirchner [577] in the Palatinate wine district. They became known at a much later date, when K. Sonntag [582] began his research there. He recognized that a basic distinction had to be made between the climate of the rows of vines and that of the open

lanes between them. Figure 157 shows the observed temperature distribution for midday (left) and at night (right) on and after a sunny September day of 1933. The sun is able to penetrate to the ground in the lane, which runs N-S, producing high surface temperatures and a large temperature gradient close to it, similar to the conditions in an open-planted vegetable field (see Fig. 156). In the rows of vines the highest temperatures are found below the outer active surface where the foliage gives protection from the wind, but these highest values are naturally much lower than in the lanes. At night, the lowest temperatures are found at the level of the radiating surfaces of the leaves (not at the ground in the lanes, which are shielded), which means that the dew formed is collected to the advantage of the plants. "Even outside the vineyard," K. Sonntag wrote, "an iron pole was dry from the ground up to the level of the stems, but was covered with water droplets above the level of the leaves." This double influence of the outer active surface of the vines and of the solid ground can be seen also in the temperature profiles measured by Y. Tsuboi, Y. Nakagawa, and I. Honda [585, 586] in Japanese vineyards.

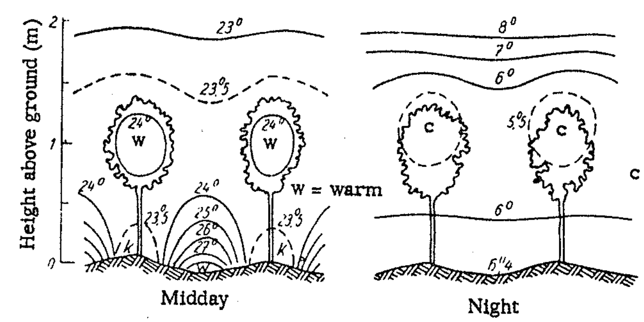


Fig. 157. Temperatures at midday (left) and at night (right) in a Palatinate vineyard on 17 September 1933. (After K. Sonntag)

R. Weise [588-590], O. Jancke [575], and H. Burckhardt [572, 573], in particular, advanced our knowledge of vineyard climate considerably. The influence of the height of the vine, with the distance between the rows constant, was investigated by Burckhardt in a level vineyard at Mussbach in the Weinstrasse district of Germany. The top of the foliage of the higher-trained Sylvaner grape reached 150 cm, while that of the lower was 90 cm above the ground and the distance between neighboring rows was 120 cm in both groups. Simultaneous readings with six psychrometers, including adjacent open ground, in August 1952 gave the following picture: the temperature decrease above the ground, such as that in Fig. 157, was found to exist in the N-S lanes between 10:00 and 14:00 only. In the higher growth, the temperatures were lower both by day and at night in comparison with the adjacent bare land, because of extensive shading. In the low growth there was hardly any difference between the lane temperatures and the bare land. The humidity gradient showed a lapse with height both by day and at night, greater in the low vines than over bare land, and greater in the high vines than in the low.

The crown area of the vines was subject to radiative heating and evaporation loss by day. In the higher vines the first of these was greater because of its greater leaf area, while in the lower vines the second factor was the larger. The temperature is therefore higher in the area of the grapes, in the taller vines, compared with the temperature at the same level in the lanes between them, and also higher than that of the shorter vines. However, since the grapes in the latter are closer to the ground, this balance out. Grapes of both taller and shorter vines enjoy the same kind of temperature in the warm hours at midday. This explains why the fear of the vintner that the yield of grapes will be reduced if they are trained too far from the heat-dispensing ground is not justified. Water-vapor pressure is, however, always higher over the vines that are trained higher because the mass of transpiring leaves is greater.

This result agrees with the observations of R. Weise [589] that in the Würzburg wine country the higher form of training (Frankish stem training) does not show a loss of heat during the day, in comparison with the lower form (Frankish head training). The first form, however, allows the cold night air to flow away more easily in the comparatively foliage-free space in the lower layer of air, and therefore runs less risk of frost damage than the second form. This has been proved recently by R. Weise [590] in the published results of measurements he made inside the vine shoots.

Then in August 1957 H. Burckhardt investigated the difference between an open form of planting, with a distance of 3 m between the rows of 2.1-m-high vines, which is desirable because of the advantages it offers in ease of working, and a normally trained vineyard with 1.2 m between rows of vines 1.1 m high. The microclimate of the lanes in the widely planted vines was more balanced, and the air more settled, than in the normal style, and gave the cold night air a better chance to flow away. However, the temperature was rather lower during the day in the area where the grapes were growing than in the normal vineyard, which is confirmed by the greater acidity that can be observed in grape juice from open vineyards. The relative humidity was also somewhat higher, and this increases the risk of infection by fungus diseases.

N. Weger [587] demonstrated the practical consequences of the considerable differences in the microclimate of two vineyards only 3 m apart in the Geisenheim area. The difference was apparent in the quality of the grapes and in the incidence of pests. Practical

viticulture may derive great advantages from such measurements, provided they are made with the necessary instruments, and the requisite amount of time is devoted to them.

Frost danger and the method of dealing with it are discussed in Sec. 54.

It is only a short step from the microclimate of the vineyard to that of the orchard. O. Takechi and J. Kikuchi [584] investigated the microclimate of a lemon orchard in Japan. The height of the crown area was 2 m, which is low in comparison with German orchards. The microclimate of two stands of different densities was investigated. In the summer of 1953 the amount of light in the denser orchard was 63 percent of the lighter, the relative humidity 10 to 20 percent higher, and the fluctuation of the ground surface temperature was 8.3 against 10.4 deg, caused mainly by the maximum being lower. Two-hourly temperature profiles have been published for the range -30 to +200 cm for both of these orchards. R. Schröder [580, 581] investigated coffee plantations in the tropics, and pointed out the great influence on microclimate of artificially shaded crops and unshaded crops, and made the first measurements in South America. Orchards in Germany, however, bear a strong resemblance to thinly planted woods. It is therefore more appropriate if we now turn to the study of meteorologic problems in forests.

important distinction than that between a forest and the normal type of cultivated land which also has a plant cover, during the growing period at least.

At the present time it is certain that any increase in precipitation due to the presence of a forest is bound to be very small. It is also known that the presence of forests has a moderating influence on climatic extremes. However, the extent of this influence is even harder to assess. When it becomes a question of the whole economy of nature, as in this case, it is necessary to keep in mind and in sight, as A. Schmauss often said, that "everything fits in with everything else." This is particularly true when the living processes of plants are involved, since these are able to mask the physical relations as a result of their ability to make adaptations to circumstances. No one has yet tried to find out, for example, what reciprocal influence the ability of the forest to regulate water flow might have on climate.

There is no doubt that the influence of the forest is the greater the more inhospitable the nature of a territory is to the growth of trees. In the boundary zones between arid and humid climates, at the tree line in mountains and polar regions, and in regions of frequent storms or constant strong winds, the beneficial effects of forests may become very great. There is here a very great and rewarding field open for scientific investigation.

CHAPTER VII

THE INFLUENCE OF TOPOGRAPHY ON MICROCLIMATE

The discussion was introduced in Chapter II by considering the microclimate of a level surface without vegetation. Then in Chapters V and VI this presupposition was abandoned, and the mutual influences of vegetation and microclimate on each other were studied. Now the assumption that the ground is level will also be abandoned, and the influences exerted on microclimate by the topographic variations of the terrain will be investigated.

The first idea that comes to mind is that topographic influences must be much more noticeable during the day than at night. When the sun is shining, slopes of different inclination and orientation receive different amounts of heat, and the equalizing currents of air set in motion (such as up-slope or anabatic winds) determine the microclimate. The orientation of the slope is therefore of decisive importance. At night, the temperature distribution is regulated by the downward flow of air that has been cooled in contact with the ground. The orientation of the slope is of no importance, but differences of height become significant. The paragraphs that follow will therefore be arranged according to the time of day.

Consideration of topographic influences soon leads to new questions. When only level ground was considered, for example, microclimate was restricted to the lowest few meters of the atmosphere, and we ventured out of this shallow layer only occasionally, to obtain a better understanding of some process or other. When the land is one of strong relief, however, microclimate must be extended farther and farther into deeper layers. There is a continuous transition from the microclimate of a furrow in a plowed field to the climate of a long mountain valley, which is one of the subjects of study in general climatology. Since this is a textbook of microclimatology, the exposition will of necessity become all the more brief, the more closely we approach problems that are dealt with in textbooks on general climatology.

40. Insolation on Various Slopes

Sloping ground is described by its angle of inclination, or gradient, and the direction toward which it faces. These two quantities determine the situation or exposure of the slope. The connection between angle of inclination and gradient is as follows:

Slope:	0.1°	0.5°	1°	3°	7°	11°	27°
Gradient:	1:573	1:115	1:57	1:19	1:8	1:5	1:2

A west slope means a slope facing toward the west; a valley running N-S therefore has a west slope on its eastern side and an east slope on its western side (care must be taken when consulting references).

Slope climate or exposure climate is determined, in the first place, by the different amounts of direct solar radiation and heat received by an inclined surface as compared with a horizontal surface. This difference can have great significance; for example, a surface inclined at 20° facing toward the south, even allowing for the high degree of cloudiness in Germany, receives roughly twice as much radiation in January as a horizontal surface. The amount of radiation it enjoys is equivalent to a substantial displacement toward the equator.

The climate of a slope has therefore always been of significance. The German wine industry depends on it. In agriculture and horticulture it decides the quality of arable land and whether it will be possible to cultivate certain species of plant. The early strawberries that are on sale in Tokyo two months in advance of the main crop are grown on the steep terraces of Shizuoka, the exposure climate of which has been described by S. Suzuki [754]. In looking for sites for hospitals and sanatoriums, an attempt is made to find sunny slopes. Extreme slopes of 90°, that is, walls facing various directions, are of great importance in the architecture of dwelling houses, town planning, technology, and the cultivation of fruit on trellises. We are already familiar with some of the effects from the microclimate of stand borders in Sec. 37. This is of such importance that illumination engineering has already developed into a separate profession in German building technology.

Beginning with direct solar radiation, which is the thing first experienced by the observer, it is a simple mathematical operation to compute the quantity of radiation falling on a surface in any position and elevation, given the intensity and direction of solar radiation. K. Schütte [752] has devised a simple procedure for carrying this out. There are five factors involved: the geographic latitude, the declination of the sun (period of the year), the altitude of the sun (time of day), the angle of the slope, and the direction in which it faces. Sometimes it is desirable to have instantaneous values, or hourly average values, or diurnal or monthly totals of radiation intensity. Sometimes only duration of sunshine and times of sunrise and sunset are required; occasionally the values to be measured are for cloudless periods (with various

degrees of atmospheric turbidity), and at times it is desired to correlate radiation received with the state of cloudiness. It is obvious that no set of tables can satisfy all requirements. The summary given in Table 85 will help the reader to consult the published tables most suited to his purpose; this is only a selection of the material available.

The astronomically possible sunshine duration and the actual amount recorded at Karlsruhe in a series of measurements extending over several years have been tabulated by J. v. Kienle [745]. The analysis is for the eight principal directions and for slopes inclined at 0, 15, 30, 45, 60, 75, and 90°, and also shows the hours of sunrise and sunset. Figure 185 gave the data for walls (90°) in graphic form. The summary in Table 85 is only for published measurements of radiation intensity. At one time people were satisfied with theoretical computations that excluded the effect of the atmosphere. By this means R. Gessler [737] computed the extraterrestrial radiation received by sloping surfaces on 17 selected days, for latitudes and slopes at intervals of 15° and for principal directions. M. R. Pers [750] made a similar theoretical analysis, using a general transmission coefficient of 0.8 for the atmosphere.

The works quoted in Table 85 are all based on actual measurements (over as many years as possible) and therefore come closer to reality. It may be readily discovered what a great difference there is if, as in Group A, only direct solar radiation is used as a basis and the total or horizontal radiation as measured is adopted to give a calculated value for the slope; or on the other hand whether the radiation-measuring instrument itself is tilted at the angle under consideration and thus the important effect of sky radiation (and reflected radiation from the ground) is also captured. Group B comprises the works that have used this new and highly welcome technique, which is much more valuable for practical purposes. Naturally the figures available in Group A are much more comprehensive and cover many aspects of the problem, while those in Group B are sparser, but are closer to reality.

The basic laws of irradiation of slopes are illustrated by Fig. 199. It is based on measurements of direct solar radiation in cloudless weather during the years 1930 to 1933 at Trier (49°45′N), made by W. Kaempfert [741]. The abscissa is the angle of slope in degrees, and the ordinate is local time. The figure consists of nine diagrams, for three directions of slope and three selected days, the figures printed on the isopleths being the quantity of radiative heat received, for cloudless skies, with a normal amount of atmospheric turbidity.

Since the gradient scale of each diagram begins with a slope of 0°, the left-hand margin of each shows the radiation received on the horizontal; this is therefore identical for each set of three in the same column (daily sunshine duration) and also for the isopleths block that is used to measure soil moisture and is dependent on its accidental properties. Comparison of the slopes is made possible by the two scales showing soil moisture in weight percent. The N slope is moister throughout; in the period of fair weather in the autumn, 20 percent is reached at the time of strongest drying, whereas a decrease to 10 percent is found on the S slope.

Heigel also investigated [858] the dependence of phenologic processes on exposure and height, on the slopes of the Hohenpeissenberg. Blossoms of the sweet cherry suffered a delay of 2 days for every 100 m of height in 1951; the difference between N and S slopes amounted to 5 to 7 days. The harvest of winter rye, on the other hand, responded primarily to height and was delayed when scattered widely (type of soil!) by 7 days per 100 m on the average. The dandelion (*Taraxacum officinale*) had an extremely sensitive reaction to sunshine duration on the slope, in the opening of its flowers. Comparing plants on the N and S slopes only, with equal gradients of 18° to 20°, the following dates for flowering were found in 1954:

Elevation (m):	820	860	900	940
South slope:	25 April	27 April	2 May	11 May
North slope:	9 May	17 May	(no vegetation)	

In 1953 and 1954 K. Kreeb [864] observed the development of 19 plant species in the grass cover of an oak and hornbeam forest on the SSW and NNE slopes of the Körschtal near Plochingen, Neckar. Because weather conditions differed in these two years, the unfolding of leaves and blossoming of each plant species occurred at different dates, but the time sequence was the same. The longitudinal growth of leaves was also measured on both slopes. This was, for example, on 19 March 1954, for *Milium effusum*, 8 cm on the SSW slope against 5 cm on the NNE, while on 26 March the lengths were 12 compared with 5 cm, and 17 and 10 cm on 9 April.

45. Mountain, Valley, and Slope

Section 44 was mainly concerned with the influence of the direction of a slope on the local climate; the effect of elevation or relative height will now be considered.

The best point of departure is the distribution of night temperatures. Let us consider a valley cutting into a high plateau, as shown in cross section in the sketches in Fig. 235. If the rules for the movement of cold air given in Sec. 42 applied here, the valley would contain an enormous lake of cold air, as shown in the top sketches. The effect of the greater dimensions here is that individual circulations are built up between the air that is cooling on the slope and the reservoir of warmer air above the valley floor,

as shown in the lower sketches in Fig. 235. These circulations were observed directly and measured photogrammetrically by F. W. Nitze [827], using balloons fitted with small lamps. A lake of cold air therefore develops only near the bottom of the valley. Since a layer of cold air near the ground remains over the plateau above, an intermediate zone, known as the thermal belt, develops on the slope, where temperatures are higher at night. This corresponds to the night inversion above level ground.

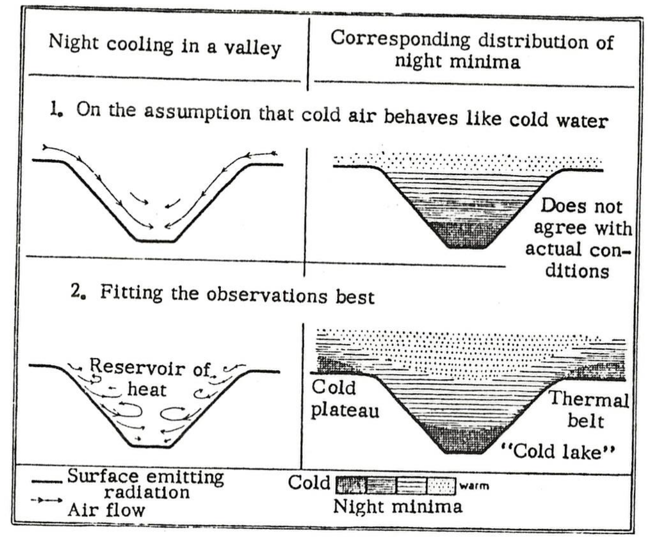


Fig. 235. Development of the thermal belt.

This vertical division into three zones can be recognized from temperatures recorded by F. D. Young [892] at five different heights, during the night of 27-28 December 1918 on the slopes of the San José Mountains in the Pomona Valley, California. The lowest curves for 0 and 8 m in Fig. 236 show the freezing temperatures in the lake of cold air at the bottom of the valley; they run almost horizontal in the undisturbed period before sunrise. At 15 m the warm thermal belt is being approached; the temperature distribution is much more varied. The warmest zone is at 68 m, above which (84 m) temperatures decrease again.

During the day, a division into three zones is maintained, but the temperature pattern is different. These laws of temperature distribution were the subject of a study by R. Geiger, M. Woelfle, and L. P. Seip [883] on the Grosse Arber (1447 m) in the Bavarian Forest in 1931 and 1932. A few years later (1935-1938), G. L. Hayes [885] set up four pairs of stations on an E-W ridge in the Priest River Experimental Forest in the Rocky Mountains. These were in the valley (700 m altitude) inside and outside the forest, on the hillside at 820 and 1160 m, and on the ridge at 1676 m, one station with a north and one with a south exposure. This investigation

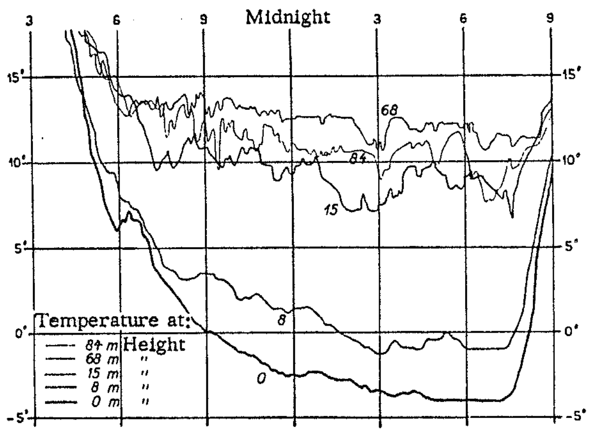


Fig. 236. Night temperature variation at five different heights in a valley in California. (After F. D. Young)

was designed primarily to determine the risk of forest fires as a function of position on the slope and exposure, but it contains a wealth of diagrams showing isopleths of air temperature, relative humidity, and wind speed for an average August day, as a function of height above sea level, and also shows the differences of these elements measured on the N and S slopes. Another investigation was carried out in the Bavarian Forest, on the Grosse Falkenstein (1308 m), by A. Baumgartner, G. Hofmann, G. Kleinlein, and G. Waldmann [876-879, 891, 616]. Also worth consulting is the series of measurements made by S. Morawetz [889] in the summer of 1951 at four stations differing in height by only 65 m, in West Steiermark, Austria, since they give a good picture of the slope zones and sites in the valley.

Figure 237 shows the arrangement of observation points in the investigation carried out on the Grosse Arber. Stations with meteorologic shelters were set up in the valley in the SW (Bodenmais, 665 m) and in the E (Seebachschleife, 645 m), on the hillsides at Kopfhäng (1008 m) in the SW, on a level area in the N at Mooshütten (946 m), and also on the peak (1447 m). Along the line of crosses 99 measuring points were set up for taking readings of night temperatures near the ground.

Figures 238 and 239 give the averages of the shelter readings for 25 clear days in May and June in the form of curves showing the diurnal air-temperature and relative-humidity variations. Since

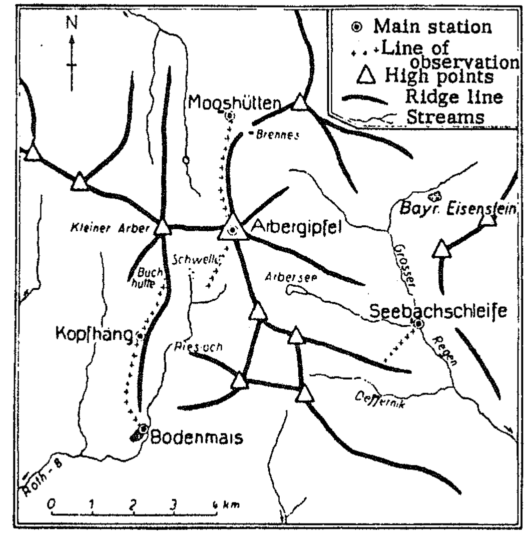


Fig. 237. Experimental setup on the Grosse Arber, 1931-1932.

the weather was fair and the year advancing, it was warmer at midnight than it was 24 hr earlier. The valley site, which is coldest and moistest at night, is warmest and driest during the day. The

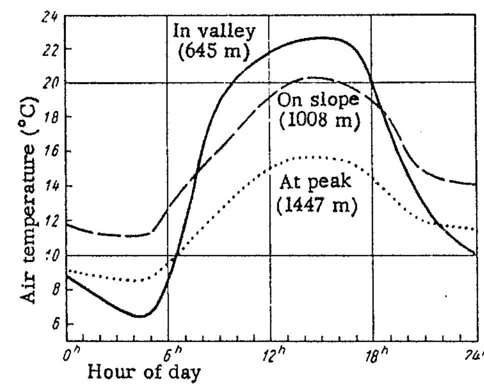
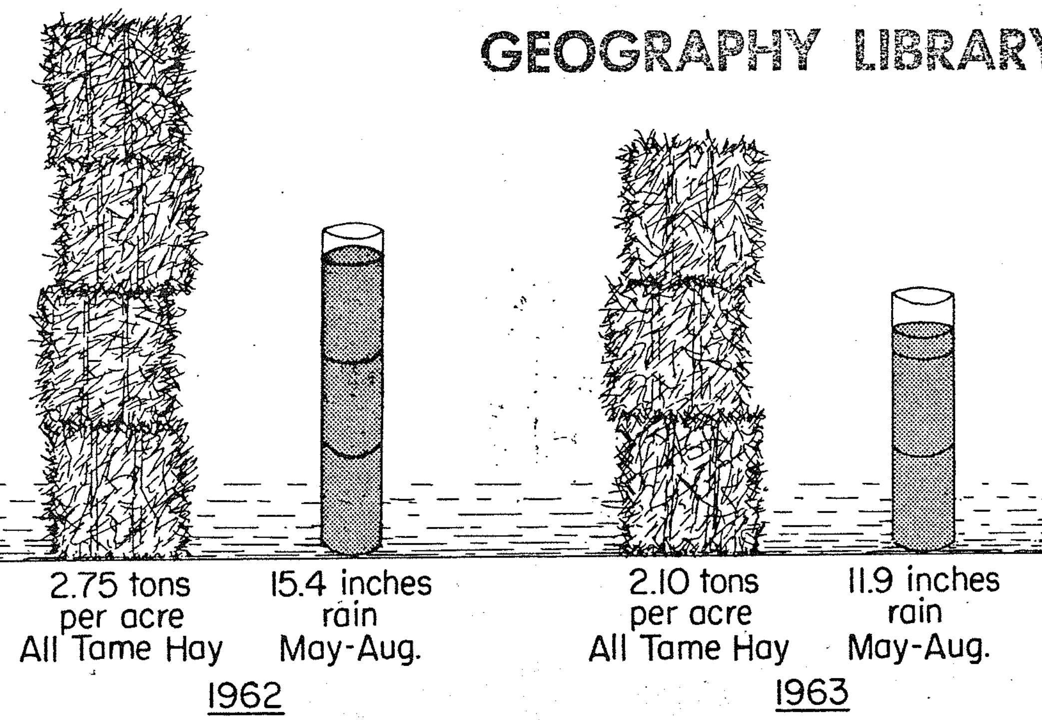


Fig. 238. Diurnal air-temperature variation on bright spring days on the Grosse Arber.

bottoms of valleys therefore enjoy a "continental climate." The hillside station is warmest at night, its daytime features depend on its relative height, and its relative humidity is about average. While the air enclosed in the valley undergoes a steep rise in temperature in the forenoon, the rate of temperature increase with time does not exceed a certain value at the station on the SW slope,

WISCONSIN WEATHER

Causes, Variations, and Effects



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August 1967

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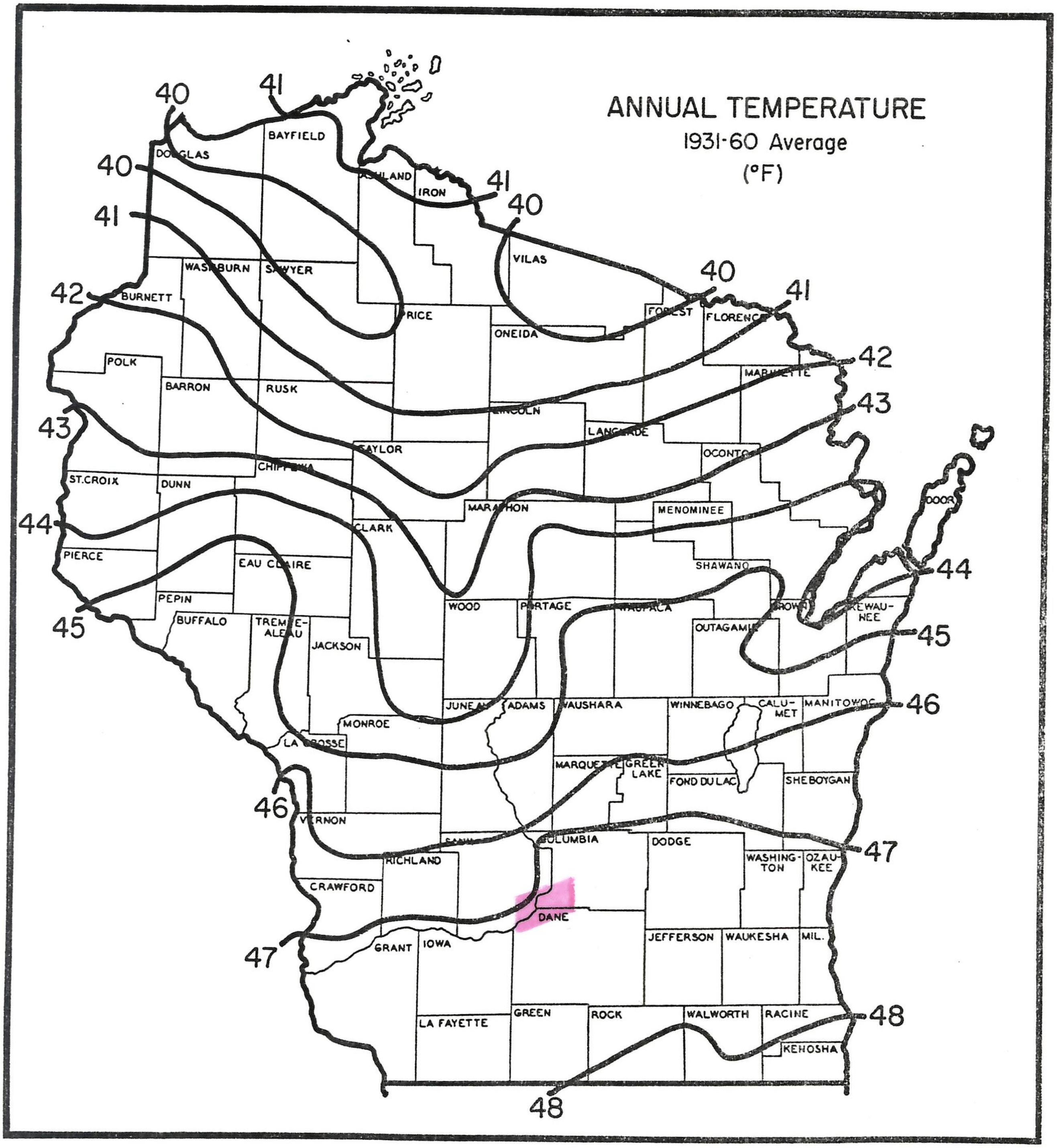
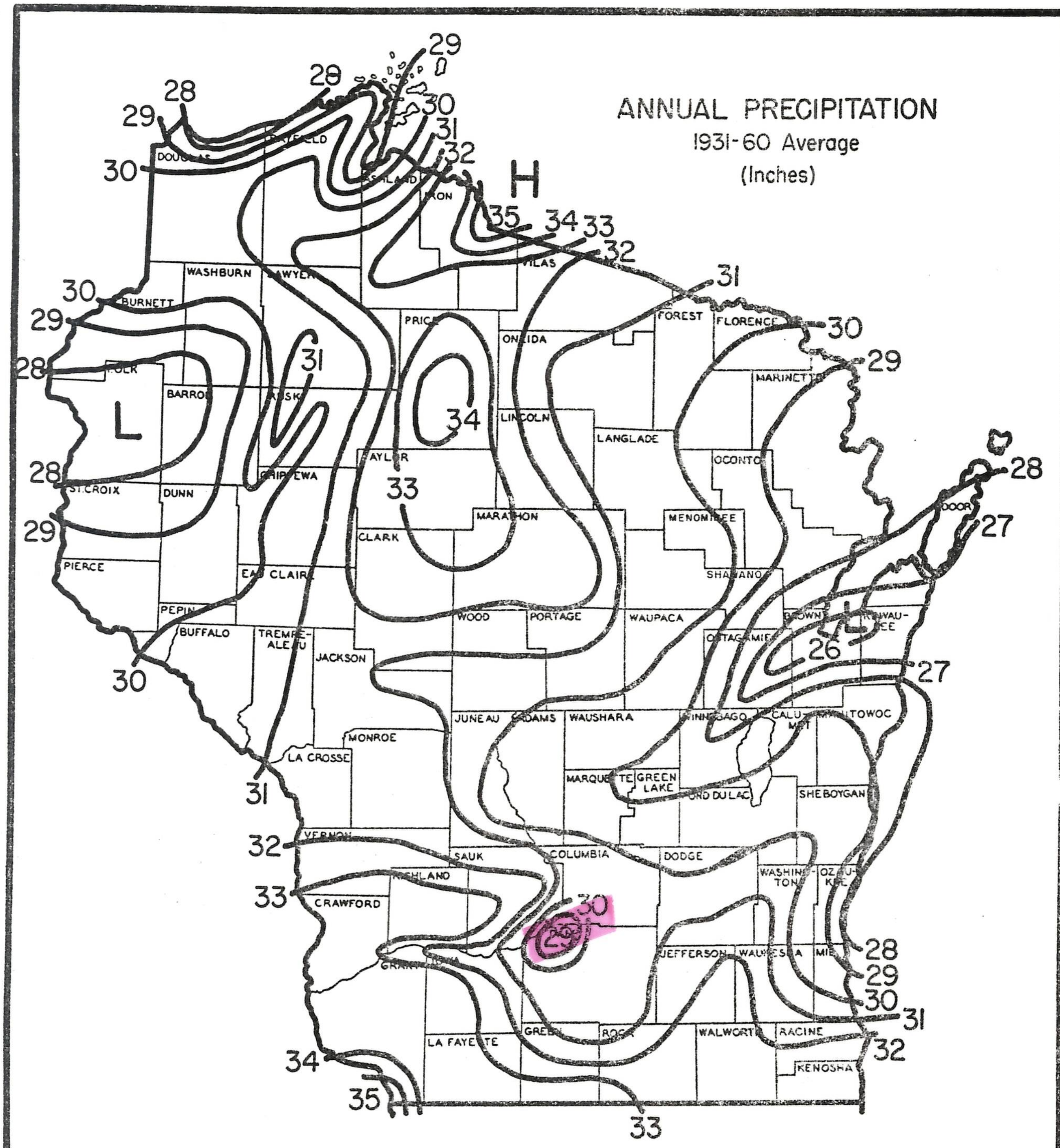


WISCONSIN TEMPERATURES

The location of Wisconsin near the center of the North American continent gives our State a typical continental climate with the associated large annual range in temperature. This range is to some extent modified by our neighboring Great Lakes, Lakes Superior and Michigan, due to the relative coolness of these large bodies of water in summer and spring and their relative warmth in autumn and winter. The effect of the lakes on the temperature field extends inland for a considerable distance, particularly in spring when winds are often northeasterly, and in summer when a lake breeze often develops on sunny days with light winds. During winter, when northwesterly winds prevail, the effect of Lake Michigan on temperatures in the shoreline areas is less. Added cloudiness over the lakes tends to keep minimum temperatures higher in shoreline areas, and frequent mild onshore winds south and southeastward of Lake Superior exert a moderating influence on these areas. The effect



WISCONSIN PRECIPITATION

Agriculture in Wisconsin is blessed with one of the most favorable rainfall climates in the world. Maximum rainfall occurs just preceding and during the season of maximum plant growth. Droughts are rare and usually not too severe, and any dryness developing, as a rule does not become critical until late summer. A secondary rainfall maximum, in the mean, occurs over most of the State in early fall.

The principal source of moisture for Wisconsin rainfall is the Gulf of Mexico and the tropical waters of the Atlantic and Caribbean Sea. Much of this moisture, particularly during the summer months, may have been deposited on and re-evaporated from the land areas upwind to the south and west of the State. The large scale features of the rainfall pattern over the North American continent east of the Rocky Mountains are characterized by a wide sweep of moderate rainfall out of the Gulf Coast region and tapering off in amounts northward and west-

WISCONSIN WEATHER

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Richard S. Palm

Anthony R. deSouza

University of Wisconsin
Eau Claire, Wisconsin

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and trees. One person was killed when a car was picked up off Highway 27 and thrown 70 yards away. A tornado also demolished 15 homes and damaged 35 others in Rib Mountain in Marathon County on August 31, 1977. The storm also moved into Wausau and destroyed a mill and lumber yard and several homes. Total losses in the county exceeded $3.5 million. One of the most unusual incidents related to storms occurred on August 21, 1975. During a tornado a woman on a houseboat on Lake Pepin reported seeing a second houseboat flying overhead!

A classic example of a moving thunderstorm hit west central Wisconsin on July 15, 1980. The storm originated over the Dakotas in the wake of a cold front, and was strengthened by an upper air disturbance. During the afternoon the storm moved east across Minnesota at about 35 miles per hour. Then, about 7:30 p.m. over the Twin Cities, it increased in intensity and picked up speed moving across Pierce, Dunn, Eau Claire, southern Chippewa and Clark counties at 70 miles per hour. The storm contained downdrafts of straight-line winds of one to six blocks wide, and they obtained speeds in excess of 100 miles per hour. Individual storm cells, which were continually regenerating themselves, were so intense that they literally blasted to the ground strong upper atmosphere winds. Damage caused by the straight-line winds exceeded $160 million, the greatest natural disaster in recent Wisconsin history. Eau Claire county losses were the worst. Ten thousand trees were flattened, hundreds of homes were blown down, and electrical power was disrupted for up to a week.

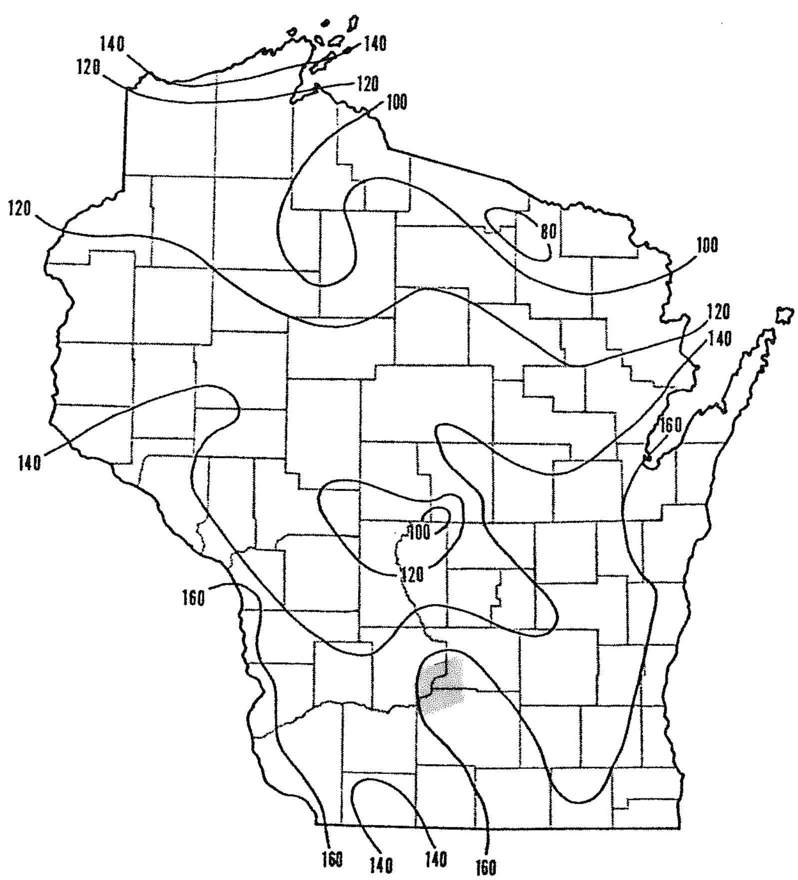

Figure 4.28 Average Length of Growing Season (Days).

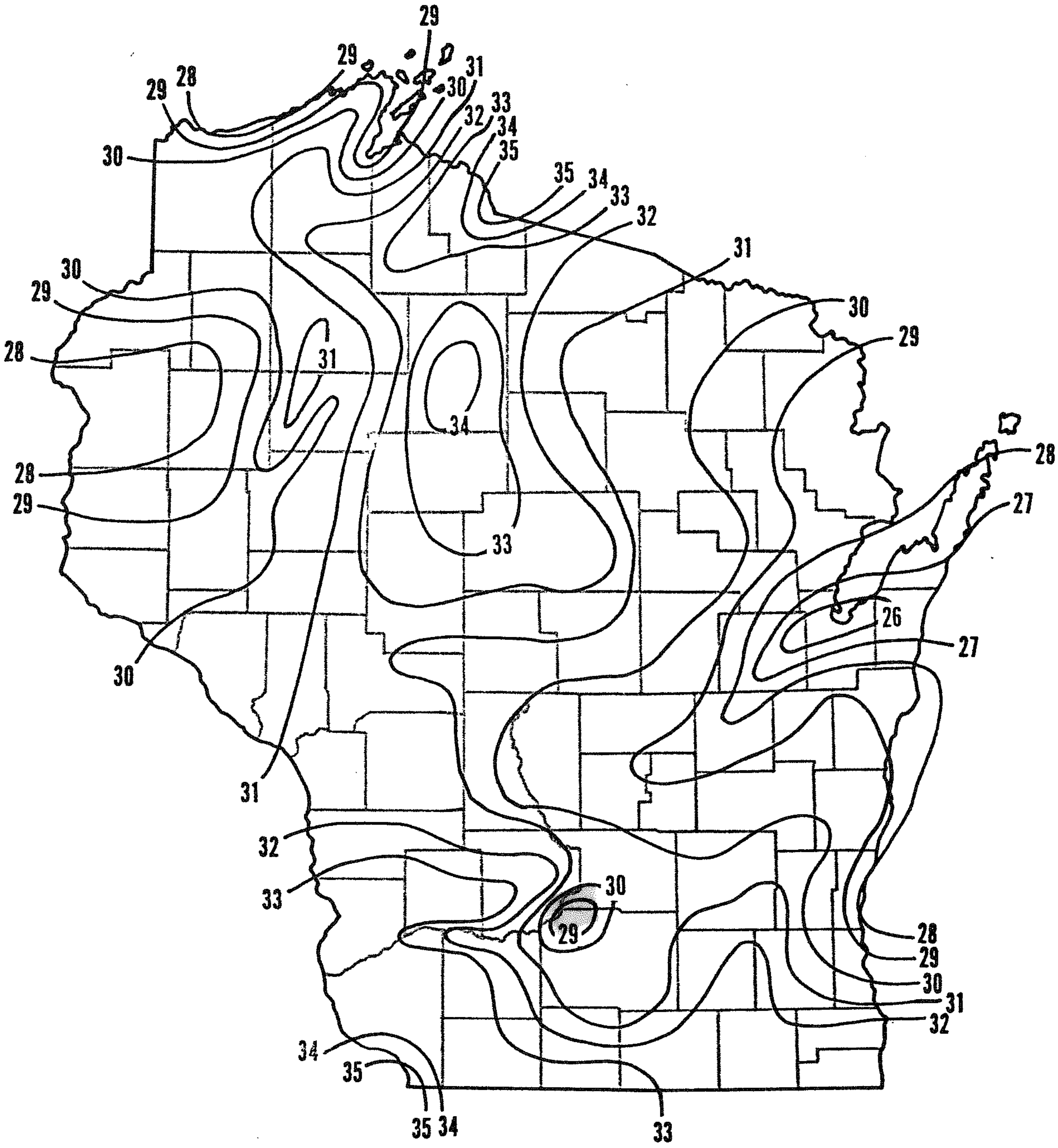

Figure 4.41 Average Annual Precipitation (inches).

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1 NAME

rec'd 10/4/90

HISTORIC
Kehl Winery

AND/OR COMMON
Wollersheim Winery

2 LOCATION

STREET & NUMBER Highway 188, 1/2 mile South of Highway 60
(SW 1/4, NW 1/4, Sec. 6, T-9-N, R-7-E)

_NOT FOR PUBLICATION

CITY, TOWN
Town of Roxbury __ VICINITY OF

CONGRESSIONAL DISTRICT
2nd

STATE	CODE	COUNTY	CODE
Wisconsin 53578	55	Dane	025

3 CLASSIFICATION

CATEGORY	OWNERSHIP	STATUS	PRESENT USE	
_DISTRICT	_PUBLIC	X OCCUPIED	_AGRICULTURE	X MUSEUM
X BUILDING(S)	X PRIVATE	_UNOCCUPIED	_COMMERCIAL	_PARK
X STRUCTURE	_BOTH	_WORK IN PROGRESS	_EDUCATIONAL	X PRIVATE RESIDENCE
_SITE	**PUBLIC ACQUISITION**	**ACCESSIBLE**	_ENTERTAINMENT	_RELIGIOUS
_OBJECT	_IN PROCESS	X YES: RESTRICTED	_GOVERNMENT	_SCIENTIFIC
	_BEING CONSIDERED	_YES: UNRESTRICTED	X INDUSTRIAL	_TRANSPORTATION
		_NO	_MILITARY	_OTHER:

4 OWNER OF PROPERTY

NAME
Mr. and Mrs. Robert P. Wollersheim

STREET & NUMBER
State Trunk Highway 188

CITY, TOWN
Prairie du Sac X VICINITY OF

STATE
Wisconsin 53578

5 LOCATION OF LEGAL DESCRIPTION

COURTHOUSE, REGISTRY OF DEEDS, ETC. Dane County Courthouse

STREET & NUMBER
210 Monona Avenue

CITY, TOWN
Madison

STATE
Wisconsin 53709

6 REPRESENTATION IN EXISTING SURVEYS

TITLE
Wisconsin's Historic Preservation Plan: Volume II, The Inventory

DATE
1975 _FEDERAL X STATE _COUNTY _LOCAL

DEPOSITORY FOR SURVEY RECORDS State Historical Society of Wisconsin

CITY, TOWN
Madison

STATE
Wisconsin 53706

7 DESCRIPTION

CONDITION		CHECK ONE	CHECK ONE
X EXCELLENT	__DETERIORATED	X UNALTERED	X ORIGINAL SITE
__GOOD	__RUINS	__ALTERED	__MOVED DATE______
__FAIR	__UNEXPOSED		

DESCRIBE THE PRESENT AND ORIGINAL (IF KNOWN) PHYSICAL APPEARANCE

The Kehl Winery is located in the extreme northwestern corner of Dane County on the west face of an unnamed hill overlooking the Wisconsin River and the twin cities of Prairie du Sac and Sauk City in adjacent Sauk County. The site is located on a single property ownership in excess of seventy acres, though the nomination is concerned only with the two original buildings and "cave" which constituted the original winery, an area of approximately 1.6 acres. Access to the site is gained from State Trunk Highway 188, which borders the west edge of the property ownership, via a private road leading to a visitors' parking area adjacent to an old, presently-unused, gravel pit. Visitors park their conveyances here and walk several hundred feet up the hill to the site.

"The Cave". Peter Kehl constructed a tunneled wine cellar into the hill in 1857. The cellar was an arched enclosure about 35 feet deep and 15 feet wide with limestone quarried from the hillside used for the barrel vault. During its first year of existence, the cellar served as Kehls' living quarters. Recently, a datestone for the vault was discovered by the current owners, and it bears the date, "1857". It was incorporated in new foundations for a chicken coop.

Kehl House. In 1858 the Kehls built a handsome and substantial limestone two-story house, with a one-and-one-half-story wing, on the site. The masonry is unusual in this "T"-plan house, employing squared, tooled blocks and rubble in the same wall planes. Overlaying all are tooled, raised mortar joints to emulate random ashlar construction by masking rubble construction, where used. Rusticated quoins are handsomely tooled, and a carved datestone is found on-center in the gable of the main facade. Most window openings have flat lintels, though segmental arches are found on those in the main facade and are flanked by ornamental brackets. Clearly laid up by an accomplished mason, the house is crowned by a fanlight framed by a massive, elaborately-carved decorative stone ornamented with grapes and vines. The house has seventeen rooms, nine of which were used as bedrooms, and a partial basement. Lean-to sheds have been added to the side and rear, and two dormers have been placed on the rear of the wing's roof.

Winery. This building was built starting in 1859 of large, more-or-less regular limestone blocks in the northwest wall, and rubble in the other walls. It is a large two-story building with a hipped roof and regular window openings with flat lintels. Large, central entrances with double doors on the northwest and northeast facades have a segmental arch with finely-cut voussoirs. There is a denticulated cornice and the corners have large cut-limestone quoins. The use of stone in the winery indicates it was probably laid by the same mason who built the house.

The cellar was built with three parallel stone barrel vaults joined by arched doorways. The roof is supported by two clear-span bolted wooden scissors trusses, located at the hipped roof's two apexes, which carry rafters and boards. In the second story, therefore, there are no interior vertical supports. The first story also is very open, but has posts to carry the floor beams above. Currently, the first floor is used as a wine museum and sales area, and the second floor is used for storage. Wine-making is carried on in the cellar.

Other Buildings. Two other buildings are located within the site. A barn was built late in the nineteenth century and additions have been built on to it. A chicken coop is of similar vintage and has been recently and heavily modernized for other uses. Neither of these buildings is held to be significant for purposes of this nomination. In front (northwest) of the barn are the remains of the foundations for a silo no longer in existence

8 SIGNIFICANCE

PERIOD	AREAS OF SIGNIFICANCE -- CHECK AND JUSTIFY BELOW			
__PREHISTORIC	__ARCHEOLOGY-PREHISTORIC	__COMMUNITY PLANNING	__LANDSCAPE ARCHITECTURE	__RELIGION
__1400-1499	__ARCHEOLOGY-HISTORIC	__CONSERVATION	__LAW	__SCIENCE
__1500-1599	__AGRICULTURE	__ECONOMICS	__LITERATURE	__SCULPTURE
__1600-1699	X ARCHITECTURE	__EDUCATION	__MILITARY	__SOCIAL/HUMANITARIAN
__1700-1799	__ART	__ENGINEERING	__MUSIC	__THEATER
X 1800-1899	__COMMERCE	__EXPLORATION/SETTLEMENT	__PHILOSOPHY	__TRANSPORTATION
__1900-	__COMMUNICATIONS	X INDUSTRY	__POLITICS/GOVERNMENT	__OTHER (SPECIFY)
		__INVENTION		

SPECIFIC DATES 1857; 1858; 1859-67 BUILDER/ARCHITECT

STATEMENT OF SIGNIFICANCE

The Kehl Winery buildings are architecturally significant for their unusual masonry construction and historically significant as the representatives of an early Wisconsin industry.

The house is in a vernacular style which in the 1850's was found in southeastern Sauk and northwestern Dane counties. The walls are constructed of a combination of rubble and quarried blocks. Raised mortar joints conceal this unusual type of construction and create the effect of the random ashlar masonry that was developed in the nineteenth century by German masons working around Sauk City. The high level of craftsmanship of the walls extends to the tooled, rusticated quoins and the ornament in the gable.

The winery (1859-1867) is said by Richard W. E. Perrin to be "...a distinctly German building..."[1] and shows some Neo-Classical influences in the denticulated cornice. The coffered soffit and jambs on the main entrance are notable as fine examples of detailing.

The site has a long history as a winery. From 1847-1849 the property was owned by Agoston Haraszthy de Moksca (c. 1812-1869). Haraszthy immigrated to the United States from Hungary in 1840 and eventually founded the village of Haraszthy which since has become Sauk City. He is said to have owned a brickyard, store, and sawmill, planted the state's first hopyard, and begun the first ferry service across the Wisconsin River.[2] The area reminded him of the Rhine valley, and he experimented with viticulture using European vines. However, these vines were unable to withstand Wisconsin's winters, and after two disastrous seasons he moved to California where he was much more successful. By 1862 Haraszthy had imported 100,000 European vines to that state and had written his extensive book Grape Culture, Wines, and Wine Making. He is known as "the father of modern California viticulture."[3]

Peter Kehl (d. 1870) was the descendent of four generations of German wine-makers. He acquired the property in 1857 and built "The Cave" which served first as his home until the house was built in 1858 and later as a wine cellar. Kehl planted native American wines which could tolerate the winters, and he built a healthy business selling his wine to Catholic churches and Milwaukee hotels. After Kehl's death the business was operated by his son Peter, who began producing brandy. In 1899 a frost destroyed the vines and the winery was closed. A local brewery rented the wine cellars and for some time the second floor of the winery was used as a dance hall.

Wine-making was an industry that was encouraged throughout the United States in the nineteenth century by both federal and state governments. The earliest commercial wineries were in Pennsylvania, Ohio, and Indiana,[4] but by 1847 viticulture was begun in Nauvoo, Illinois, and it gradually developed into a major industry in the lower midwest. The Kehl Winery is a rare example of this early phase of the wine industry in Wisconsin. Today it is in use as a producing winery, and it has the state's only commercial vineyard.[5]

(continued)

9 MAJOR BIBLIOGRAPHICAL REFERENCES

See attached sheet.

10 GEOGRAPHICAL DATA

ACREAGE OF NOMINATED PROPERTY 1.6

UTM REFERENCES

	ZONE	EASTING	NORTHING		ZONE	EASTING	NORTHING
A	1 6	2 8 0 3 5 0	4 7 9 6 2 3 0	B			
C				D			

VERBAL BOUNDARY DESCRIPTION

LIST ALL STATES AND COUNTIES FOR PROPERTIES OVERLAPPING STATE OR COUNTY BOUNDARIES

STATE	CODE	COUNTY	CODE

11 FORM PREPARED BY

NAME / TITLE
Biruta Erdmann and Richard Cleary

ORGANIZATION
State Historical Society of Wisconsin

DATE
August 20, 1975.

STREET & NUMBER
816 State Street

TELEPHONE
608/262-9504

CITY OR TOWN
Madison

STATE
Wisconsin 53706

12 STATE HISTORIC PRESERVATION OFFICER CERTIFICATION

THE EVALUATED SIGNIFICANCE OF THIS PROPERTY WITHIN THE STATE IS:

NATIONAL ___ STATE X LOCAL ___

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665). I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

STATE HISTORIC PRESERVATION OFFICER SIGNATURE

TITLE Director, State Historical Society of Wisconsin DATE 10-14-75

FOR NPS USE ONLY

I HEREBY CERTIFY THAT THIS PROPERTY IS INCLUDED IN THE NATIONAL REGISTER

DATE

DIRECTOR, OFFICE OF ARCHEOLOGY AND HISTORIC PRESERVATION DATE

ATTEST:

KEEPER OF THE NATIONAL REGISTER

Form No 10-300a
(Rev 10-74)

UNITED STATES DEPARTMENT OF THE INTERIOR
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NATIONAL REGISTER OF HISTORIC PLACES INVENTORY -- NOMINATION FORM

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CONTINUATION SHEET ITEM NUMBER 8 PAGE 2

8. Significance (continued)

Footnotes

[1]Perrin, Richard W. E., Historic Wisconsin Buildings. Milwaukee Public Museum, 1962. p. 81.

[2]Church, Charles F., "The Wollersheim Winery," Wisconsin Trails. Vol. 15, #3, p. 4.

[3]Adams, Leon D., The Wines of America. Houghton Mifflin. Boston. 1973. p. 185.

[4]Ibid., p. 21.

[5]Church, op. cit., p. 4

Form No 10-300a
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CONTINUATION SHEET   ITEM NUMBER 9   PAGE 2

9. Major Bibliographical References (continued)

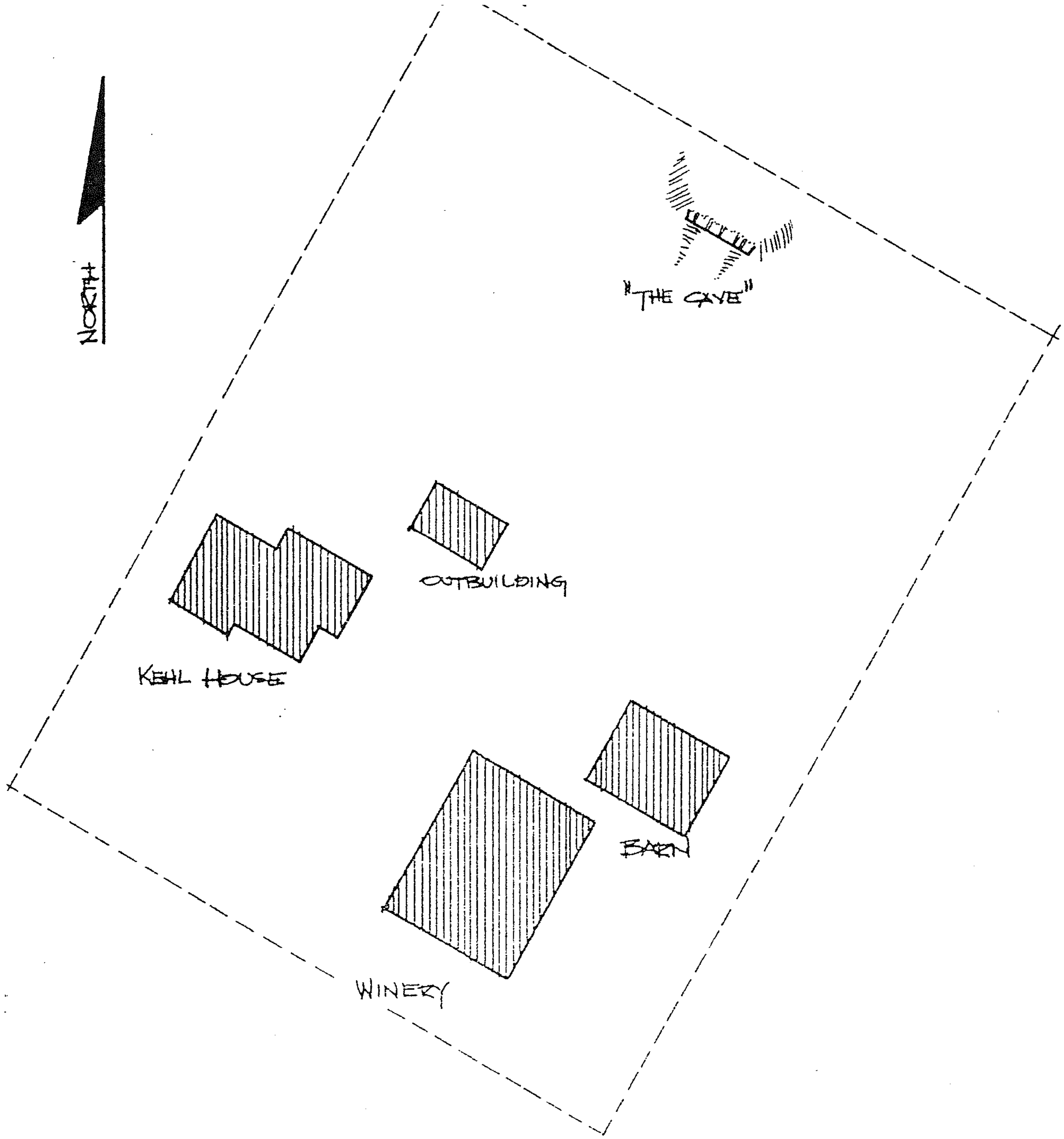
Adams, Leon D., The Wines of America. Houghton Mifflin Company, Boston. 1973.

Church, Charles F. "A Vintage Dream Comes True at the Wollersheim Winery," Wisconsin Trails, Vol. 15, No. 3 (Autumn, 1974), pp. 4-6.

Perrin, Richard W. E. Historic Wisconsin Buildings: A Survey of Pioneer Architecture, 1835-1870. Milwaukee Public Museum Publications in History, #4, pp. 80-84.

____________________. The Historic American Building Survey: Wisconsin Architecture. United States Department of the Interior, National Park Service, 1965, p. 25.

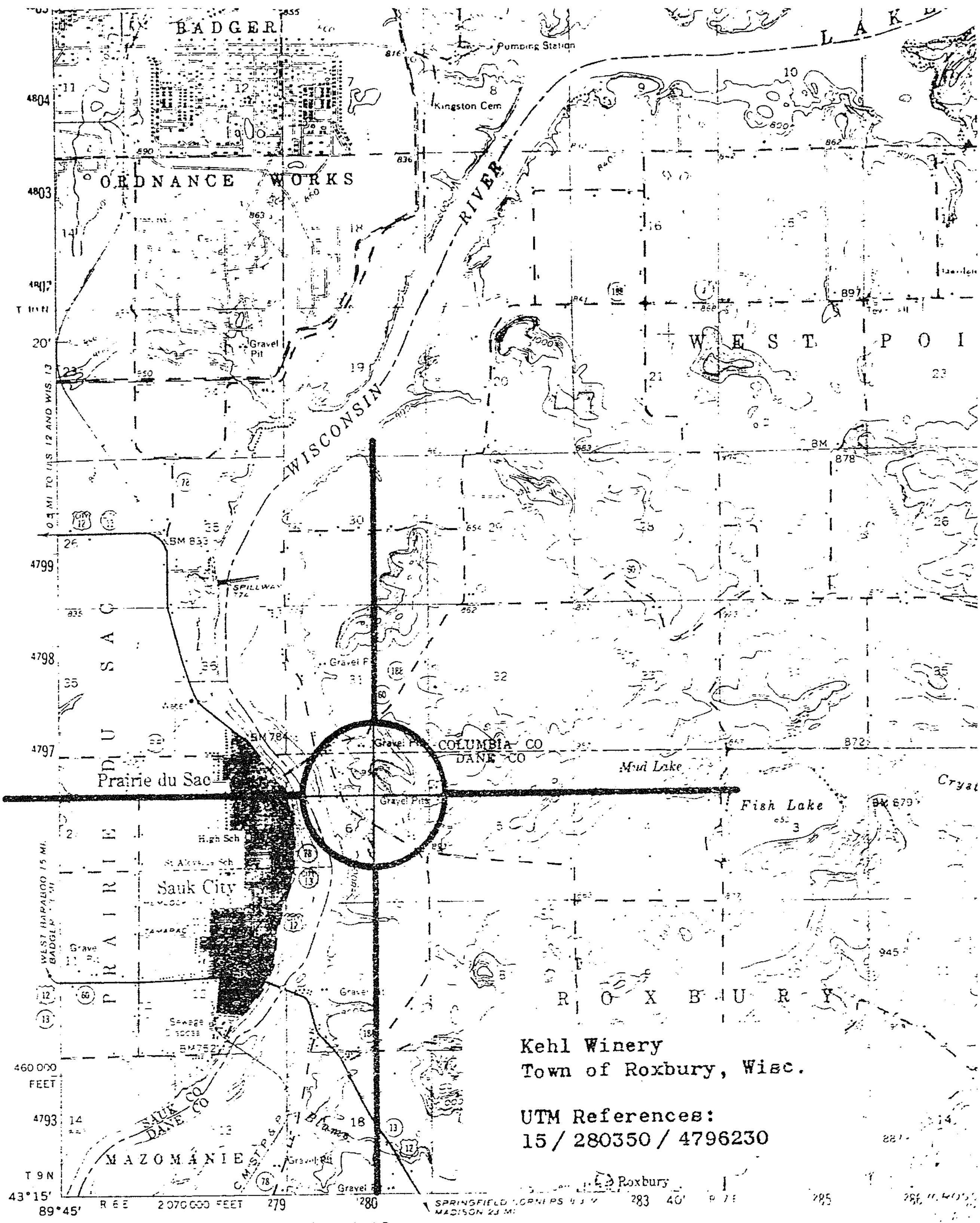
Dictionary of Wisconsin Biography. Madison: State Historical Society of Wisconsin, 1960, for Haraszthy see p. 158.



KEHL WINERY (WOLLERSHEIM WINERY)
WISCONSIN

NO SCALE

J.M.D.



Mapped, edited, and published by the Geological Survey
in cooperation with State of Wisconsin agencies

Control by USGS and USC&GS

Topography from aerial photographs by photogrammetric methods
Aerial photographs taken 1956 and 1959. Field check 1959

Polyconic projection. 1927 North American datum
10,000-foot grid based on Wisconsin coordinate system, south zone
1000-meter Universal Transverse Mercator grid ticks,
zone 16, shown in blue

Red tint indicates areas in which only
landmark buildings are shown

UTM GRID AND 1959 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

Form No. 10-301a
(Rev. 10-74)

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DATE ENTERED

SEE INSTRUCTIONS IN *HOW TO COMPLETE NATIONAL REGISTER FORMS*
TYPE ALL ENTRIES -- ENCLOSE WITH PHOTOGRAPH

1 NAME

HISTORIC Kehl Winery

AND/OR COMMON Wollersheim Winery

2 LOCATION

CITY, TOWN Town of Roxbury ___VICINITY OF STATE Wisconsin COUNTY Dane

3 PHOTO REFERENCE

PHOTO CREDIT Jeffrey M. Dean DATE OF PHOTO 1975

NEGATIVE FILED AT State Historical Society of Wisconsin

4 IDENTIFICATION

DESCRIBE VIEW, DIRECTION, ETC. IF DISTRICT, GIVE BUILDING NAME & STREET PHOTO NO 1 of 4

Three-quarter view of the Winery from a position north-northwest of it.

GPO 892-454

DATE ENTERED

SEE INSTRUCTIONS IN *HOW TO COMPLETE NATIONAL REGISTER FORMS*
TYPE ALL ENTRIES -- ENCLOSE WITH PHOTOGRAPH

1 NAME

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3 PHOTO REFERENCE

PHOTO CREDIT Jeffrey M. Dean DATE OF PHOTO 1975

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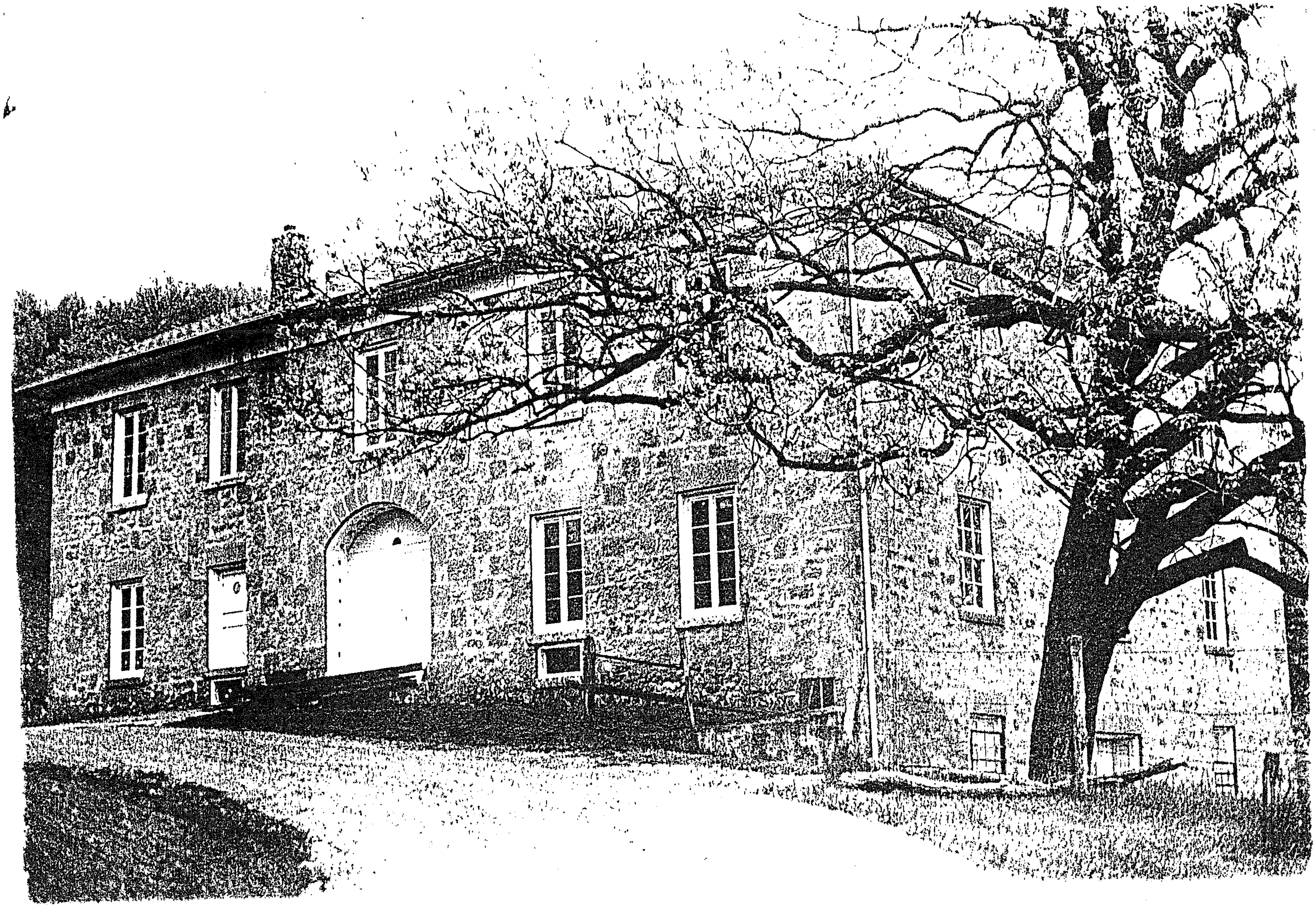
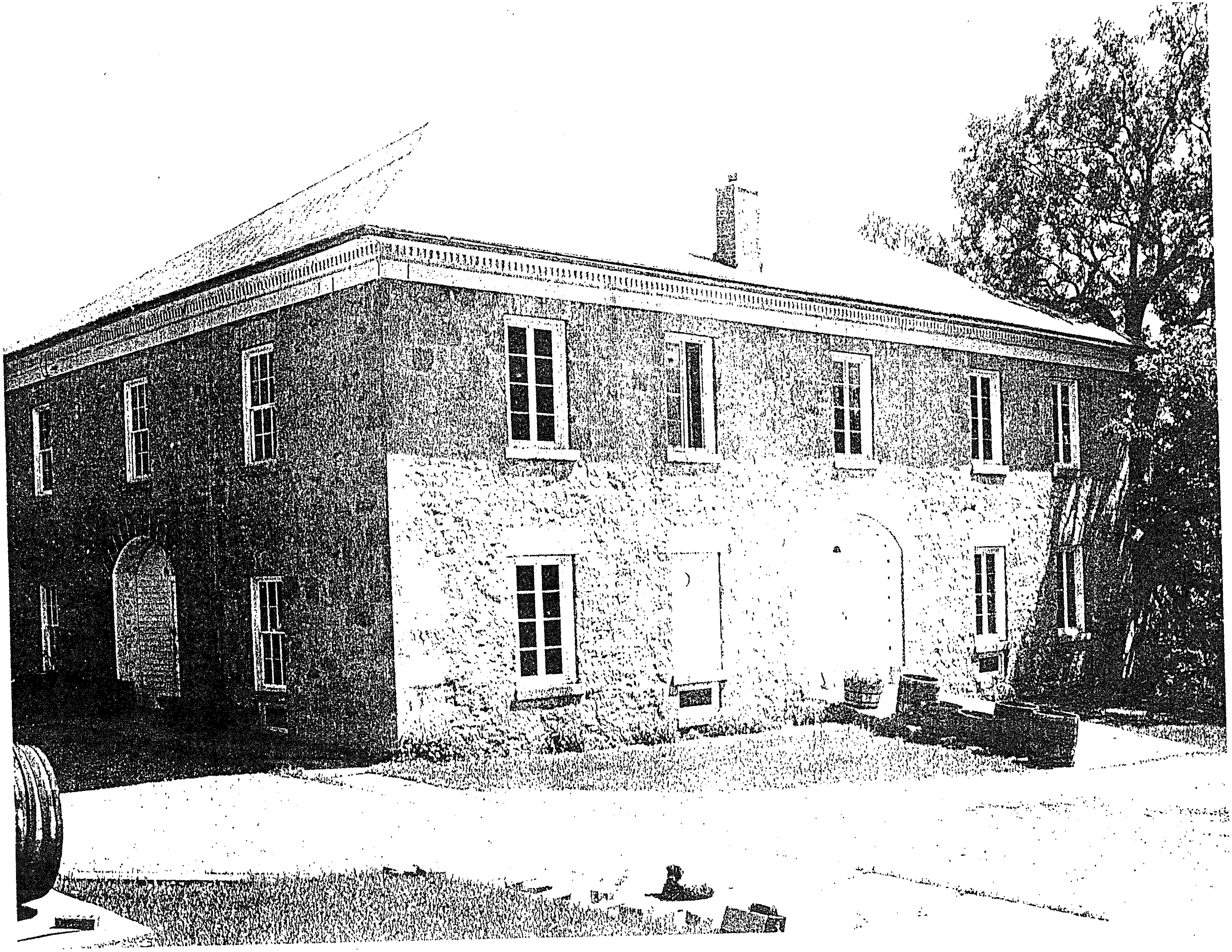
4 IDENTIFICATION

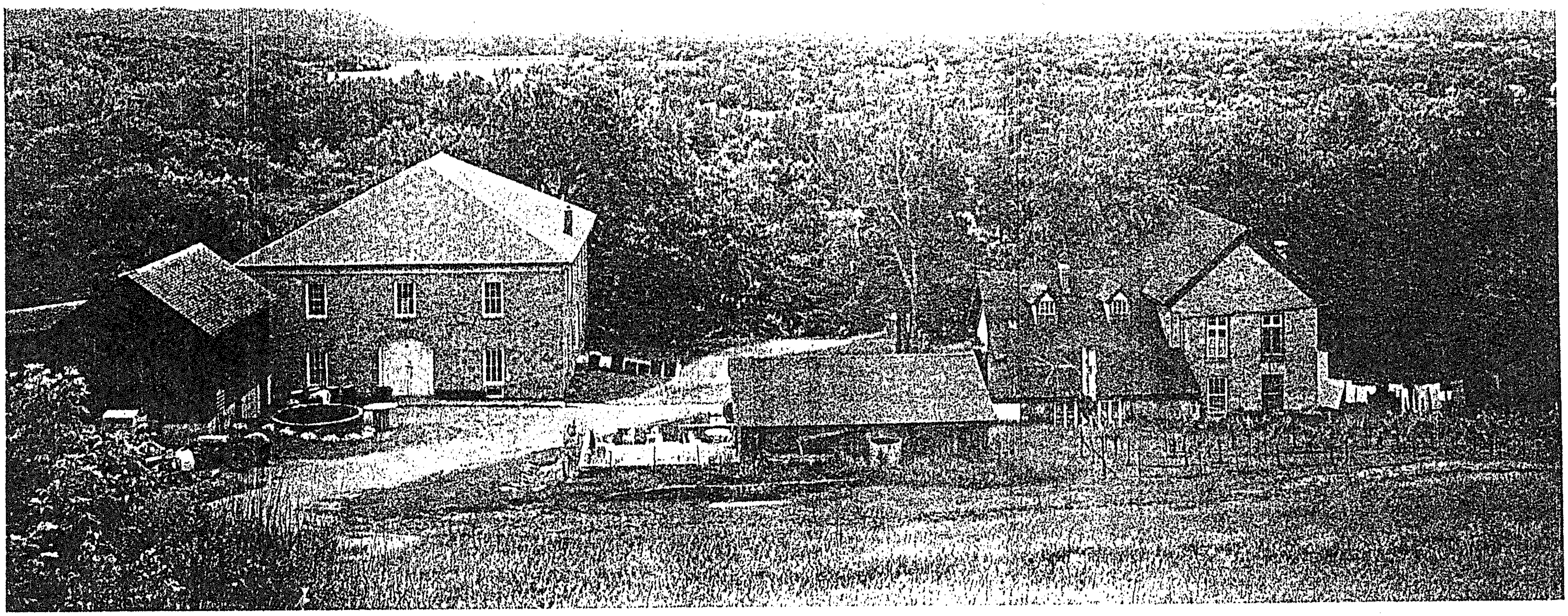
DESCRIBE VIEW, DIRECTION, ETC. IF DISTRICT, GIVE BUILDING NAME & STREET PHOTO NO. 2 of 4

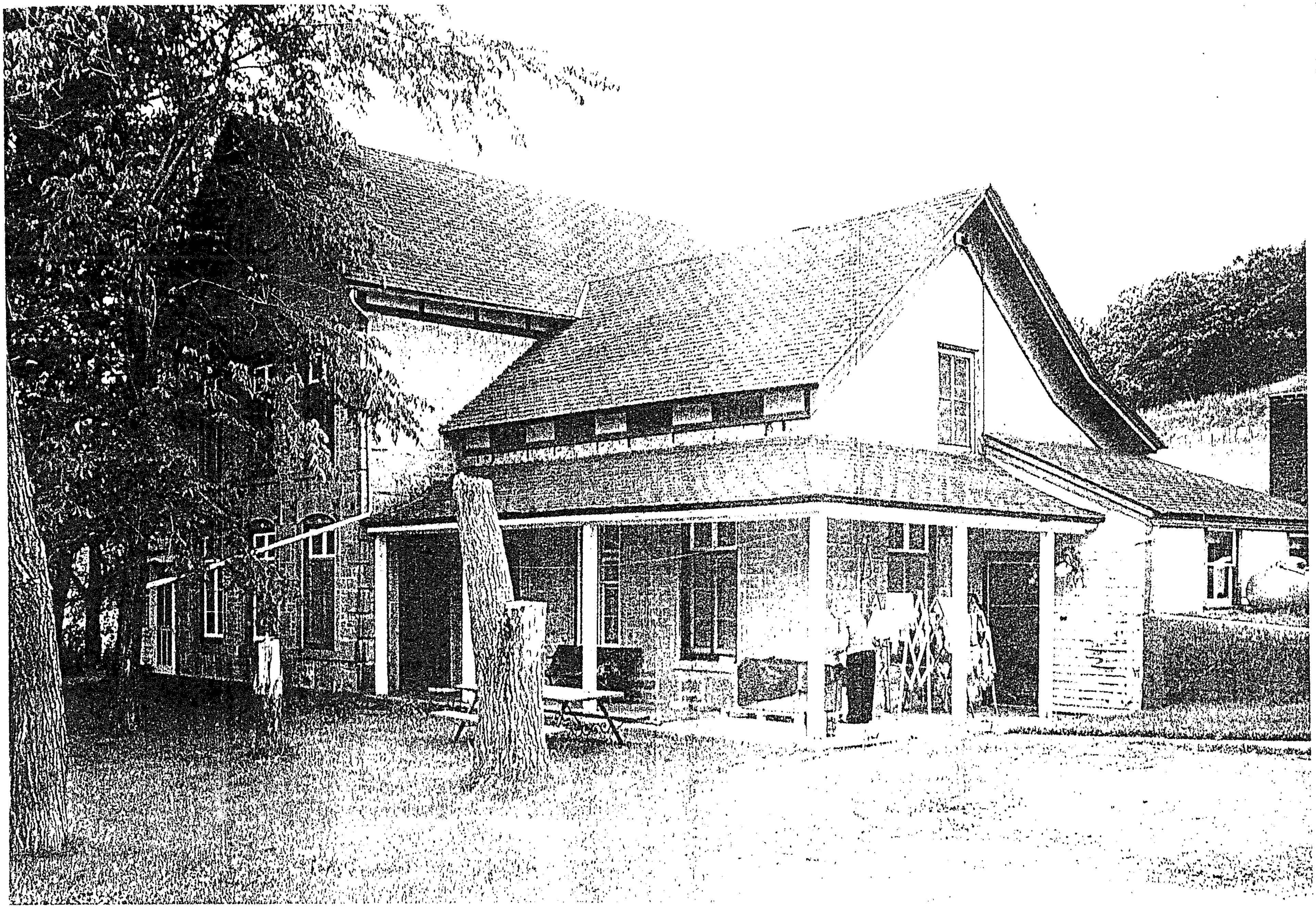
Overall view of winery complex and Wisconsin River from the hill to the northeast.

GPO 892-454









Lake Wisconsin Chamber

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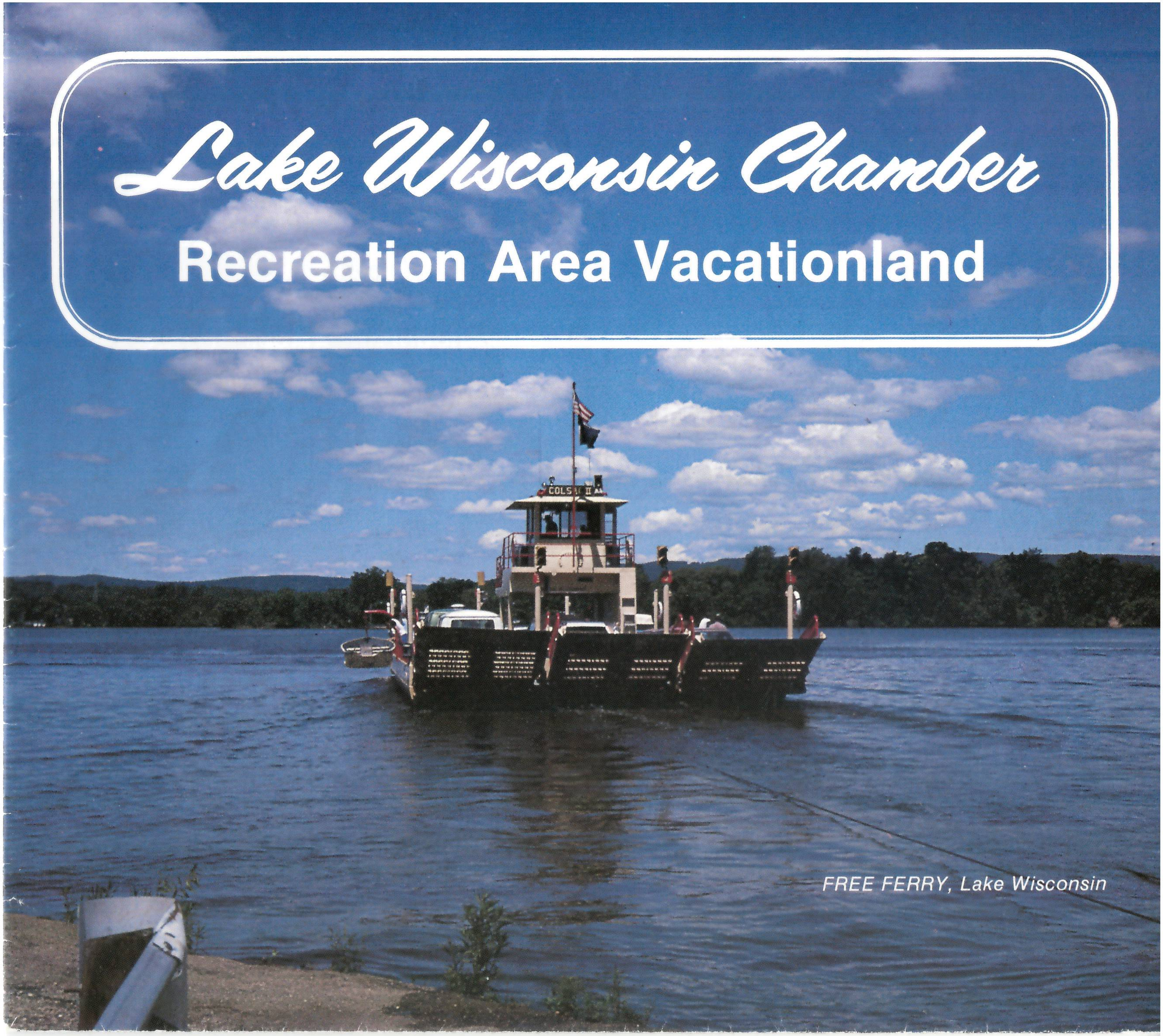

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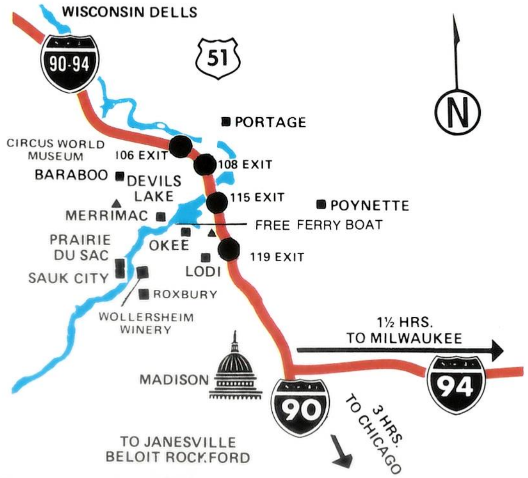

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LODI AREA
April 29 - Garage Sale Day
June - 9 & 10 - Old Fashion Days
July 1 - Lodi Art Fair
July 12-16 - Lodi Union Fair
Aug. 5 & 6 - Susie the Duck Days
Nov. 19 - Holiday Open House

POYNETTE AREA
Jan. 29-30 & Feb. 4-5 - Winterfest World Champ. Softball Tournament
June 16-17-18 - Fireman's Picnic

OKEE AREA
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Red Man Tournament Operation Bass Place — Lake Wis.
Capital City Ski Team Shows Every Weekend Friday
Headquarters: Fisherman's Cove (Okee Bay) Call for Dates-592-4805
Jan. 28-29 - Yamafest, Fisherman's Cove

WIS. RIVER WALLEYE RALLY
March 15-April 15; $25 entry; Catch & Release; Info at Bait Shops.

LAKE WISCONSIN SPRING FISHING CONTEST — May 6-14
FALL FISHING CONTEST & RAFFLE — Info at Bait Shops and Resorts.

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