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TRANSACTIONS

of the Wisconsin Academy of Sciences, Arts and Letters

Volume 83 • 1995

125th Anniversary Issue

Transactions welcomes articles that explore features of the State of Wisconsin and its people. Articles written by Wisconsin authors on topics other than Wisconsin sciences, arts and letters are occasionally published. Manuscripts and queries should be addressed to the editor.

Submission requirements: Submit three copies of the manuscript, double-spaced, to the editor. Abstracts are suggested for science/ technical articles. The style of the text and references may follow that of scholarly writing in the author's field, although author-year citation format is preferred for articles in the sciences, author-page number format for articles in the humanities. Please prepare figures with reduction in mind.

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Part Two: Current Articles

From the editor

And girlish April went ahead of them.
The music of her trailing garment's hem
Seemed scarce a league ahead. A little speed
Might yet almost surprise her in the deed
Of sorcery; for ever as they strove,
A gray-green smudge in every poplar grove
Proclaimed the recent kindling.

The lines are from the opening portion of John Neihardt's epic poem "The Song of Three Friends." They evoke the spring of 1822 when the famous band of one hundred trappers, the Ashley-Henry men, set out from St. Louis to the beaver country of the upper Missouri River. A sense of adventure, of new beginnings, and of still-unfolding springtime pervades Neihardt's lyric depiction of the scene.

In February, 1870, **Dr. John Wesley Hoyt** of Madison addressed several hundred people gathered in the Assembly Chamber of the Wisconsin State Legislature to consider the feasibility of forming a Wisconsin Academy of Sciences, Arts and Letters. As he describes the occasion in a letter of reminiscence written forty years later in February, 1911, this undertaking also was begun with a sense of new beginnings and of high adventure. Indeed, the embarkation was not without obstacles, especially the opposition of those who, while admitting that such an institution might be very useful, felt that the attempt to organize such a comprehensive society was quite premature at such an early stage in the history of the State. Undaunted, and lured, as it were, by "girlish April . . . scarce a league ahead," Hoyt presented a plea of such conviction, invoking the spirits of Christ and Emerson, that his dream for the immediate formation of the Academy carried the day. Accordingly, just a month later, on March 16, 1870, the Academy was formally chartered and incorporated by "the people of the State of Wisconsin, represented in Senate and Assembly." Hoyt was himself elected to serve as the Academy's first president from 1870–1875.

The Act of Incorporation charged the Academy with encouraging research in "the material, metaphysical, ethical, ethnological and social sciences," with undertaking "a progressive and thorough scientific survey of the State," with advancing both the fine and useful arts, including original invention, with fostering philological and historical research, with the formation of appropriate libraries and museums (!), and, finally, with "the diffusion of knowledge by the publication of original contributions to science, literature and the arts." Just two years after the Academy's incorporation the first volume of *Transactions* appeared. It reported on Academy proceedings for 1870–1872 and carried a lengthy presidential report on the founding of the Academy, lists of officers and members, the Academy's charter and constitution, and an impressive number of original scholarly articles.

In a commemorative address to those gathered at the Fiftieth Anniversary Meeting of the Academy in 1920, **Professor Thomas Chrowder Chamberlin** looked back at the Academy's heady beginnings. Then at the University of Chicago, Chamberlin had been another of the original incorporators of the Academy and had served as President of the University of Wisconsin and as president of the Academy from 1885–1887. In this address, Chamberlin noted how the Academy was formally inaugurated largely upon the ideals, fond hopes, and aspirations of those who planned it, and especially on the tenacious vision of Dr. Hoyt. "Scarcely a dozen of those who signed the call for the convention," he observed, "were productive workers in any of the fields embraced within the purposes of the Academy."

Among these dozen or so early contributors who were to set the tone for the future of the Academy, Chamberlin singled out **Dr. Increase Allen Lapham,** the first General Secretary of the Academy and editor of *Transactions,* who was "at once a botanist, a zoologist, an archeologist, a geologist, and a meteorologist. He was a distinguished example of the best order of the old school of all-around students of natural science." Lapham served as Wisconsin's state geologist; he collected what was to become the nucleus of the University of Wisconsin's enormous herbarium; and he was largely responsible for the establishment of the U.S. Weather Service.

Chamberlin also took special notice of such lights as Lapham's friend and coworker, **Dr. Philo Romayne Hoy,** a person who "bubbled over with enthusiasm" for naturalistic investigations, and **Dr. William Francis Allen,** whose papers "set a high standard of true original investigation in humanistic lines"; of "the sprightly literary contributions of the inimitable **Dr. James Davie Butler,** and of the notable contributions of the Academy's fourth president, **Professor Roland Duer Irving,** who "took an active part in leading geological inquiry along sound scientific lines."

Upon completion of this anniversary address, Chamberlin himself was presented the honorary degree of Doctor of Science by President Birge of the University of Wisconsin. The citation noted Chamberlin's half-century of contributions to the Academy and to the State of Wisconsin, including his direction of the Wisconsin Geological Survey and praised the "spirit and temper of science" which he had embodied in his life and work.

1995 marks yet another significant milestone for the Academy, the 125th Anniversary of its founding. To commemorate the occasion, I have selected for this special anniversary issue of *Transactions* a colorful sampling of articles written by the illustrious founders and scholars identified above. All of the articles, except for Hoyt's reminiscence on Abraham Lincoln, appeared in the first five volumes of *Transactions.* Although necessarily limited in number, they represent some of the diversity of interest and expertise of the early contributing members of the Academy. They still make marvelously engrossing reading, whether for their pioneering scientific observations and insights (viz., the articles by Irving, Lapham, and Chamberlin), or their zoological (Hoy), anthropological (Butler), and political (Allen and Hoyt) interests. Like Neihardt's "gray-green smudge in every poplar grove," these articles proclaim "the recent kindling" of scholarly productivity by these and many other members in the earliest "Aprils" of the Academy. Moreover, the contribution by the ever-productive Lapham on Oconomowoc Lake seems peculiarly noteworthy, since its writing was completed during the afternoon of September 14, 1875, on the very evening on which Lapham died.

Also in this issue of *Transactions* we include four new contributions, all of which relate in one way or another to Wisconsin dairying and agriculture. John Cross writes about an "endangered species," dairy farming in the expanding Milwaukee metropolitan area. Kamela Schell and John Wedberg discuss the interactive effects of picnic beetles and corn borers on sweet corn, while Eric Jorgensen and Lyle Nauman document small mammal distribution associated with cranberry production in south-central Wisconsin. Finally, Ken Parejko and Douglas Wikum present results from their monitoring of manure runoff, resulting from two different management strategies, at five sites in the Lake Tainter watershed in Dunn County.

Special issues involve the special efforts of many. For helping to make this issue of *Transactions* possible, I wish to acknowledge especially the extra efforts of managing editor Patricia Duyfhuizen and her student interns Cynthia Barber, Jennifer Fandel, Sheri Jackson, and Gretchen Toth, and the valued advice and collaboration of Faith Miracle, editor of the *Wisconsin Academy Review.* Very special thanks are also extended to Academy staff members Gaile Burchill, Robert Lovely, Jean Sebranek, and Helen Vukelich, all of whom spent many hours word-processing the entire articles by Irving, Lapham, Butler, Allen, Chamberlin, Hoy, and Hoyt from the early issues of *Transactions* so they could appear in print once again. Finally, a word of appreciation to the State Historical Society for providing some of the photographs that accompany the reproduced articles.

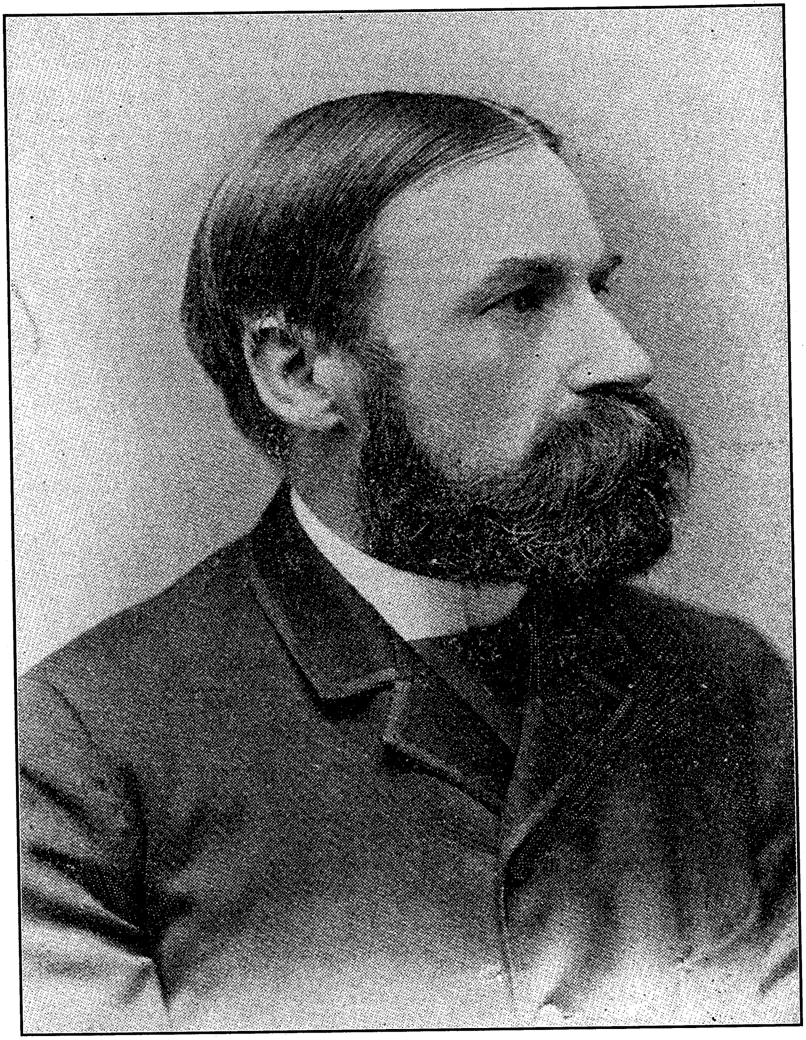
Now let me join all of those taking part in the Wisconsin Academy's many anniversary celebrations this year by offering a toast to the next 125 years and to many more springtimes, new beginnings, and adventures for the Academy and for *Transactions.* May "girlish April" always beckon with "the music of her trailing garment's hem," and may our collective efforts, year after year, continue to "proclaim the recent kindling."

Bill Urbrock

The Wisconsin Academy of Sciences, Arts and Letters was chartered by the State Legislature on March 16, 1870, as a membership organization serving the people of Wisconsin. Its mission is to encourage investigation in the sciences, arts and letters and to disseminate information and share knowledge.

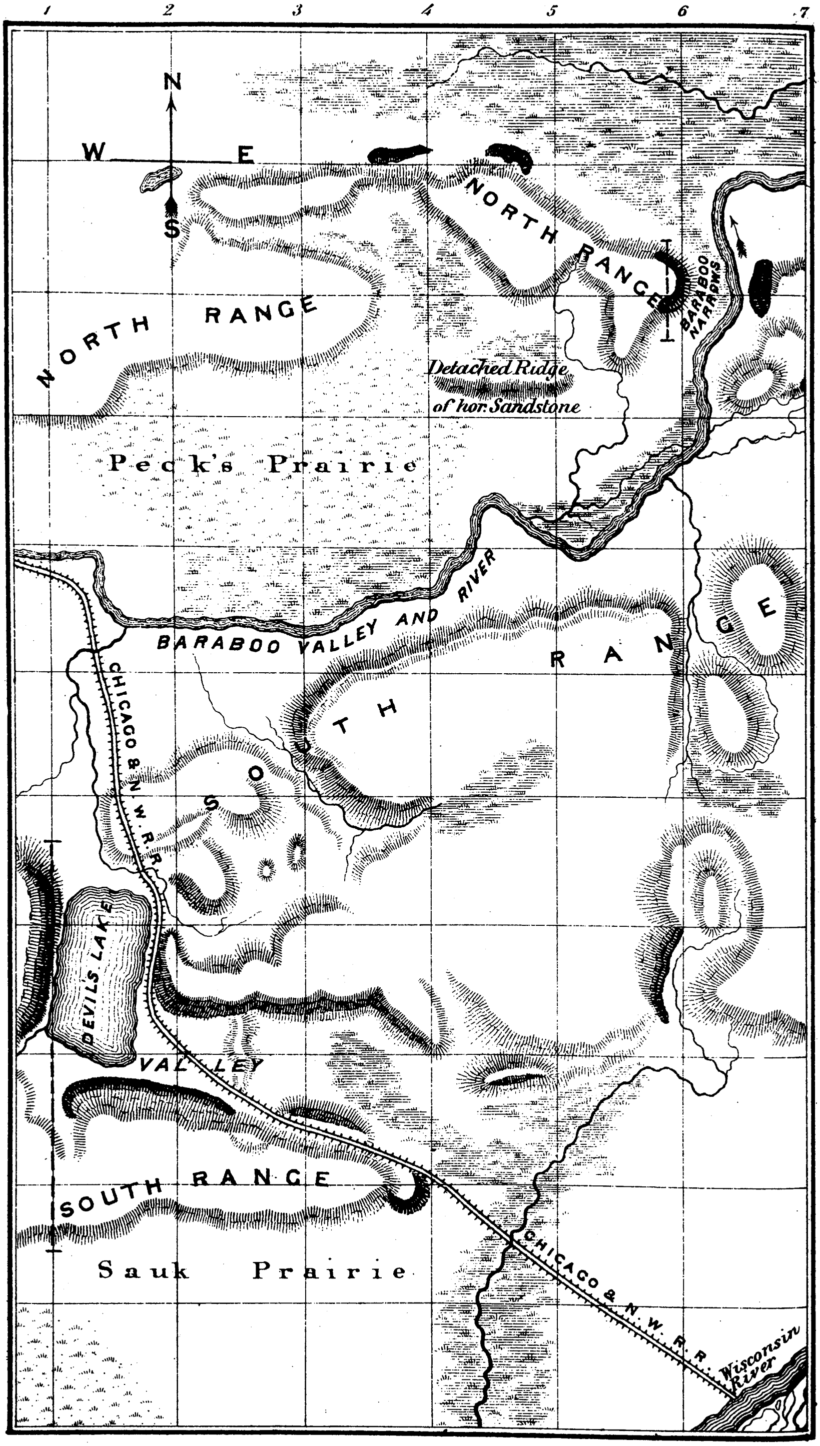
Part One:
125th Anniversary Articles

Managing Editor's note: We have prepared the anniversary articles to recreate the look of the originals, preserving their "old style" margins, headings, and punctuation. —T.A.D.



Roland Duer Irving, E.M., Ph.D.
(1847–1888)

Professor of geology, mineralogy, and metallurgy at the University of Wisconsin; comissioned geologist for Wisconsin Geological Survey and United States Geological Survey; fourth president of the Wisconsin Academy, 1882–1884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Detached Ridge of hor. Sandstone
Peck's Prairie
BARABOO VALLEY AND RIVER
SOUTH RANGE
CHICAGO & N.W. R.R.
DEVILS LAKE
VALLEY
SOUTH RANGE
Sauk Prairie
CHICAGO & N.W. R.R.
Wisconsin River

THE AGE OF THE QUARTZITES, SCHISTS AND CONGLOMERATES OF SAUK CO., WIS.*

BY ROLAND IRVING, E.M.

Professor of Geology, Mining and Metallurgy at the University of Wisconsin

Through the central portion of the county of Sauk, Wisconsin, run two ranges of hills or ridges, having an east and west trend, and a height varying from a mere rise above the general prairie to an altitude of five hundred feet. The width from north to south never exceeds three or four miles, and in places is much less than one mile. The total lengths from east to west, or rather, the exact points at which the peculiar rocks which make up the ridges give place to the ordinary country rock, are not as yet accurately known. These lengths, however, seem to be from fifteen to twenty miles.

The rock material of the ridges is mainly a hard dark-colored quartzite; with this in some places are siliceous and talco-siliceous schists, and two or three kinds of conglomerate. The dip of the strata, which, though in some places obscure, is in others very marked—and can *everywhere* be determined by careful observation—is *uniformly* toward the north. The angle varies from 20 deg. to 25 deg. in the south range, to 75 deg. to 80 deg. in the north.

The occurrence of these bold ridges in the midst of a prairie country, together with the marked contrast between their upturned and metamorphosed layers and the entirely undisturbed strata of the Potsdam and Calciferous epochs, which for miles around form the country rock, has caused much speculation and discussion. From time to time, during the past twenty years, brief notices have appeared in various journals and reports, but no careful investigation of the localities in question seems ever to have been attempted. In most of these notices, or rather in most of those that are not absurdly inaccurate in their statements and wild in their ideas, the main point under discussion has been the relative age of the metamorphic strata. Do they, or do they not, antedate the Potsdam period? Are they the results of local metamorphism on the Potsdam sandstones, or are they the remnants of pre-existing rocks? The advocates of the former theory have had the last word in the discussion.

* This paper has already been published, with some slight differences, in the American Journal of Science and Art for February, 1872.

The facts recorded in the present article are the results of a series of visits made to the localities by the writer, during the months of September, October and November of this year (1871), and they will, I think, be seen to prove beyond all doubt or cavil, that the quartzites and schists antedate entirely the Potsdam epoch, i.e., are either Huronian or Laurentian in age.

Of all of the notices mentioned, none are more than brief mentions and only a few seem to have any value at all. Dr. Shummard, in Owen's report on Wisconsin, Iowa and Minnesota, makes the first mention of the quartzite. He gives no opinion. Dr. James G. Perceval, in the report of progress of the Wisconsin survey for 1856, refers again to the quartzites, calling them merely "metamorphic sandstones," but intimating that they result from a change on the Potsdam sandstones. Mr. James Hall, in his report of progress to the Governor of Wisconsin for 1860, gives by far the most accurate description I have been able to find. He refers the quartzites unhesitatingly to the Huronian—but gives no proofs whatever. His pamphlet did not fall into my hands until after my own investigations were entirely completed. In the first volume of his final report, Mr. Hall again mentions the quartzites, but still more briefly, expressing the same opinion as before, and still giving no proofs. In 1864 there appeared in the American Journal of Science and Art (II, vol. XXXVII, p. 226) an article by Mr. Alexander Winchell of Michigan, in which he describes, among others, some fossils from the conglomerates overlying the quartzites; and upon them bases his claim that the quartzites are a downward continuation of the Potsdam sandstones. He himself never visited the localities. Finally, Mr. James H. Eaton of Beloit College, in a paper read before the Wisconsin Academy of Science, in February, 1871, expresses the same opinion though on somewhat different grounds. The foregoing list includes everything of any value that has been published on the subject.

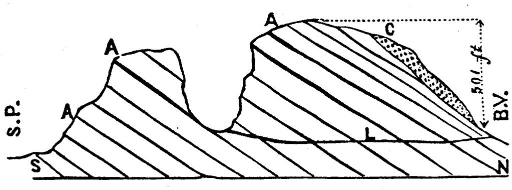
The accompanying map includes those portions of the two ridges where most of my observations have been made.

I. The South Range, to which my attention was first directed, presents, on approaching it from Sauk Prairie on the south, a bold, and, in places, precipitous rise from the plain of from 350–450 feet. The northern side of this ridge has however, in all places as yet studied, a much more gradual slope down to the valley of the Baraboo river, this slope being in many places determined by the northward dip. Running entirely through this ridge is a deeply cut valley, which has at first for about two miles, a direction slightly north of west, and then turns due north quite abruptly. This northern end holds the Devil's

Lake, which entirely fills the valley from side to side. Throughout its whole length the sides of this cleft are precipitous masses of quartzite rising everywhere more than four hundred feet above the bottom, and reaching at the lake an altitude of 501 feet above its level, and of 1,474 feet above the sea. The bottom of the valley is covered with a heavy mass of Drift material, and the lake is held in its position by low Drift hills at its northern and southeastern extremities. The bottom of the lake itself seems to be in a Drift sand, and is over most of its area about thirty feet below the surface of the water. The lake has no outlet; but draining as it does a very small amount of surface, the extraordinary evaporation caused by reflection from the cliffs above, together with the high winds of Wisconsin, is quite sufficient to account for its maintenance of level; whilst the character of the surrounding rock shows readily the reason for its not becoming saline.

The great exposures of cliff at this locality, and the deep rock cuttings on the newly-opened railroad, afford most excellent opportunities for study. The change of direction, too, of the valley, gives facilities for approaching the rocks from different sides, not elsewhere easily obtainable.

The rock here is mainly a hard, dark-colored, very compact quartzite, though the colors vary from a very light grey in places to deep brownish-red. The bedding joints of the quartzite are in some places rather obscure, but the railroad cuttings have so far exposed them, that with a little care I was able readily to ascertain the dip. This on both sides, and throughout the whole length, of the valley, is uniformly about 20 to 25 degrees a little west of north. Some of the writers mentioned, and notably Winchell, have described this valley as corresponding to an old anticlinal axis, but the uniform dip of the strata throughout its length proves, of course, that this is not the case.



SECTION 1.—North and south through the south range on section line 1 of map. A, quartzites; A′, quartzites with some schists; C, conglomerate; S.P., Sauk Prairie; B.V., Baraboo Valley; L, level of lake.

The quartzite, although often looking massive, shows in many places, on weathered surfaces, the lamination and cross-lamination of more modern sandstones. Many of the fallen masses show, too, on exposed surfaces of lamination, the most distinct ripple markings I have ever seen. On the shallow sandy bottom at the north end of the lake below, may be found their very counterparts. Between the beds of quartzite, in many places, are thin layers of a schist principally siliceous, but having always some talcose material. These correspond apparently to the clayey or shaly layers between the beds of sand now represented by the quartzite. In some places these layers seem to be merely a thinly laminated quartzite, with talcose films covering the laminae; in others, the talcose material pervades and gives character to the whole mass, the siliceous material, however, always being present.

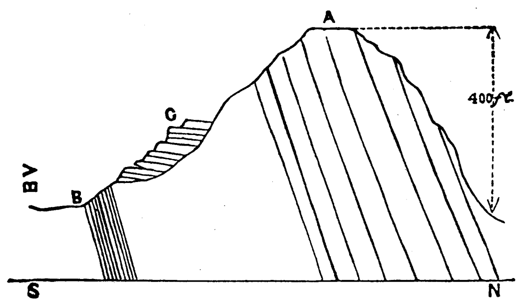
The most remarkable feature of this locality is, however, the very striking system of vertical joints which everywhere intersect the quartzite. The bearing of these joints, taken in some fifty or sixty different localities, I found to be uniformly N.E. and S.W. and S.E. and N.W., the variations in a few places being evidently due to local displacement. On the cliff sides, and more especially about the lake, these joints, together with the bedding joints, have so cut the rock into separate blocks, that these have from time to time been thrown down the bluff by frost and atmospheric agencies in huge rectangular masses, weighing by calculation from seventy-five to two hundred tons apiece.

In many places along the north flank of this ridge and lying always above the quartzite, are outcrops of a conglomerate, containing pebbles unmistakably from the quartzite below, always rounded, and in size varying from a few lines to four or five inches in diameter. In some few places there seems to be a second conglomerate in which the sandy cement itself appears altered to a quartzite. This is a point, however, deserving of further investigation. There are also places where distinct layers of coarse and fine conglomerate occur, the latter always above and graduating into a simple sandstone.

In this conglomerate are found in one locality just northeast of the lake, the Potsdam fossils described by Mr. Winchell in the article referred to, viz: *Scolithus linearis* Hall, *Orthis Barabuensis* Hall, *Delphinocephalus Minnesotensis* Owen, etc. I have examined a collection of these fossils from the above locality, in the possession of Dr. Lapham, of Milwaukee, and have seen the fossils and quartzite pebbles in the same fragments side by side.

II. The observations on the North Range were made about the Lower Narrows of the Baraboo river and westward from there about half a mile. This north range seems to be less continuous both as to elevation and as to the character of its rock material. I am told by

Dr. Lapham that it seems rather to be made up of detached masses of metamorphic rocks. The rising ground, however, never entirely disappears, and the quartzite seems to be found as far to the east and west as in the south range. At the Baraboo Narrows the metamorphic rocks are in great force, the cliffs on either side the river, which here makes a direct cut through the range from south to north, being as much as four hundred feet in height. The body of the bluff on the



SECTION 2.—Through North range at W. Bluff of Baraboo Narrows. A, thick-bedded dark colored quartzites, with some talco siliceous schist; B, siliceous schist; C, horizontal sandstone; B. V., Baraboo Valley.

west side is made up of heavy beds of quartzite, with, in places, intercalated beds of metamorphic conglomerate, and of a talcose schist like that in the south range. These beds all stand at a very high angle, between 75 and 80 degs. from the horizontal, the dip being north, with possibly a slight inclination to the east. At the bottom of the hill on the south side is an exposure of a peculiar light-colored siliceous schist, entirely different from any of the other rocks of the series. An old shaft sunk some thirty feet on the schist, affords most excellent opportunity for examination. The total thickness seen was about twelve feet, the layers varying in thickness from a few lines to four or five inches. Very thin films of a talcose material sometimes appear between the layers. Directly above this schist, I found a horizontal undisturbed sandstone, laid open for some distance by quarrying. The beds are generally a foot or two in thickness. In the loose pieces near by is found *Scolithus linearis*. The sandstone is, of course, the Potsdam of the surrounding valleys. Section 2 will serve to give a clear idea of the structure of this bluff.

The narrow detached ridge just to the westward, represented on the map, is also made up of horizontal Potsdam sandstone. There are many other such detached ridges along the Baraboo valley, bearing the same relation to the quartzite ranges, and showing the same horizontality of strata.

The following arguments in favor of the priority of these rocks to the Potsdam period will, I think, after what has been said, be admitted as valid. I give them in the order in which they became apparent to me.

1st. *The limited area of disturbance*; the undisturbed Potsdam and Calciferous strata being found north, south, and between the ridges, and in close proximity to them.

2d. *The absence of any anticlinal axes.* Dipping as the rocks do uniformly to the north, in order to place them in the Potsdam category, we must imagine a metamorphism of the strata, accompanied by a great fault, having on one side the unchanged sandstones, and on the other the tilted quartzites and schists, an idea new, I think, to geology.

3d. *The occurrence of rounded pebbles of quartzite in the conglomerate on the south side of the south range.* To suppose this conglomerate, which by its fossils is unmistakably Potsdam, to be of the same period as the quartzites below, we must suppose that period to have lasted long enough to cover the deposition of the quartzites as sandstones, their metamorphism, and the rounding of the pebbles by beach action, before the formation of the conglomerate; not to speak of the time sufficient to erase all signs of an anticlinal.

4th. *The occurrence of horizontal sandstones resting unconformably on the flanks of the tilted strata.* This last is, of course, absolutely conclusive as to the *north range*, but lest it might be claimed that the two are independent, I have given the others.

Mr. Winchell argues that, since Mr. Hall states that the fossils I have mentioned as occurring in the conglomerate are restricted to the Middle Potsdam, either this statement must be untrue or the quartzite must be the downward continuation of this formation. This argument, however, loses all force when we regard these ranges as high ridges in the Potsdam seas, never having been entirely covered by these seas, but having merely had the new sandstones and conglomerates deposited about their flanks. The place where these fossils were found must be *at least* 200 feet above the base of the sandstones of the surrounding country. A single glance at Dr. Lapham's geological map of Wisconsin will show this. The conglomerate is by no means necessarily the *base* of the Potsdam because it rests immediately on Huronian or Laurentian rocks.

In the final report of Mr. Hall already referred to, he mentions a low hill north of Baraboo, in which the middle of the hill is quartzite, and the flanks conglomerate and sandstones graduating upward into calcareo-sandy layers, without giving any further explanation. This statement, before somewhat unintelligible to me, now throws further light on my own results.

To my mind these ridges were unquestionably islands in the Potsdam sea, and a more beautiful illustration than is furnished by the sandstones and conglomerates of wave action on a rocky coast, can hardly be imagined.

There are many very interesting details of structure in these ridges which would repay thorough study. The points presented in the present paper are only those necessary to show the age of the rocks.

There are several more of these scattered quartzite ranges in Wisconsin, all but one of them occurring within the Potsdam and Calciferous areas. During the coming season I hope to be able to make a connected study of them.

UNIVERSITY OF WISCONSIN, November 18, 1871.

Courtesy The State Historical Society of Wisconsin WHi(x22)11

Increase Allen Lapham, LL.D.
(1811–1875)

Civil engineer; all-around student of natural science; author of first hardcover book published in Wisconsin, *A Geographic and Topographical Description of Wisconsin, etc.*, 1844; founder of the herbarium at the University of Wisconsin, 1849; founding member and president, State Historical Society of Wisconsin; charter member and first elected secretary of the Wisconsin Academy, and first editor of *Transactions*

OCONOMOWOC LAKE AND OTHER SMALL LAKES OF WISCONSIN, CONSIDERED WITH REFERENCE TO THEIR CAPACITY FOR FISH-PRODUCTION

BY I. A. LAPHAM

The Oconomowoc Lake in Waukesha county, on the line of the Chicago, Milwaukee and St. Paul Railway, is one of those beautiful sheets of clear, cold water that may be taken as a type or representative of hundreds of others within the State of Wisconsin. A few facts and observations in regard to this lake may therefore be of interest to the Fish Commissioners, and to all who desire to encourage the increase of fish-production.

As shown upon the plats of the government land surveys, it has a length of two miles; breadth, three fourths of a mile; a shore-line of six and a half miles; covering an area of 830 acres, or one and three-tenths square miles.

Its elevation above Lake Michigan, as ascertained many years ago, in making the survey of the Milwaukee and Rock River Canal, is two hundred and eighty-two feet. Its irregular form can best be seen by reference to the accompanying chart.

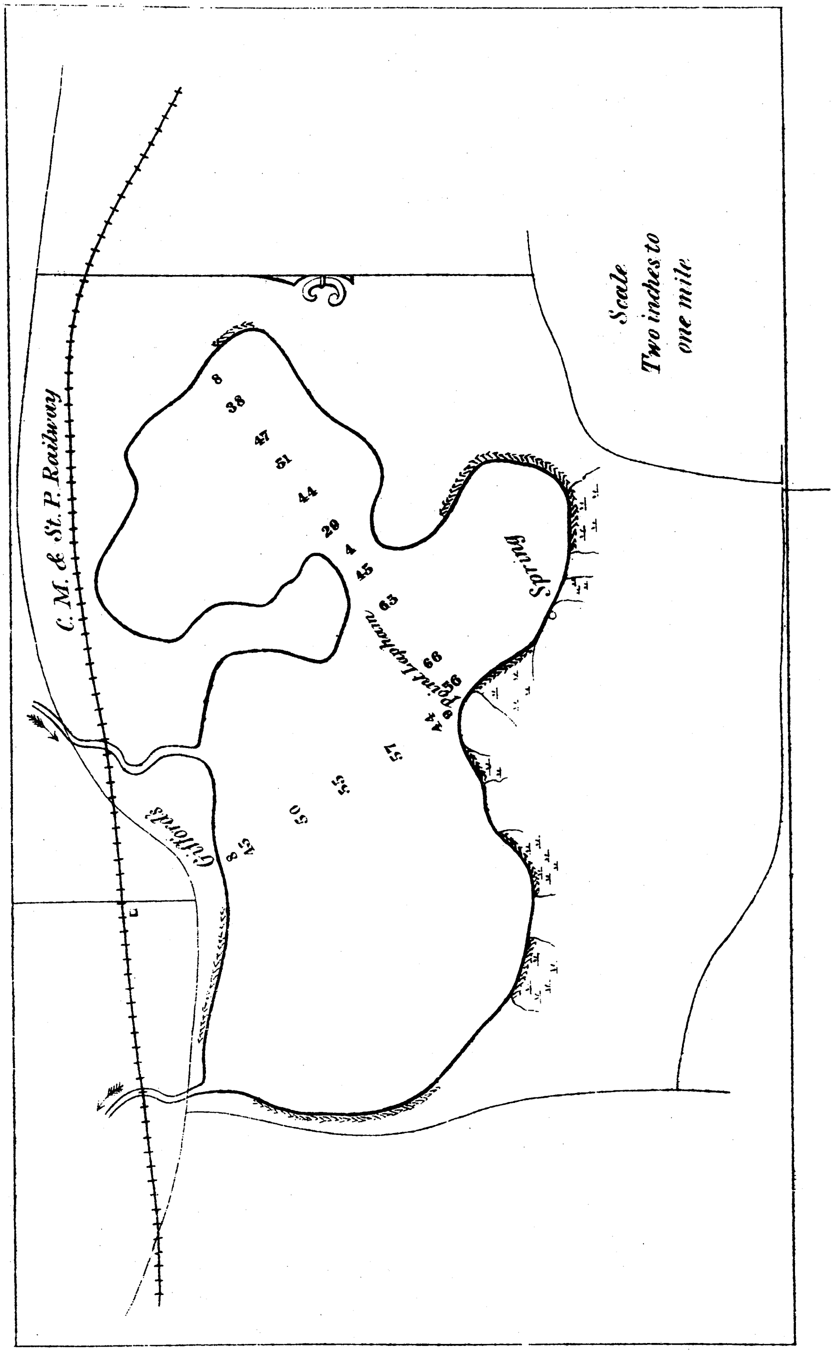
The Oconomowoc River, a small stream which is the outlet of several other lakes, enters it on the north shore and leaves it at the north-west corner. So irregular is the shape of this lake that it might be taken to illustrate geographical terms, as gulf, bay, point, cape, promontory, peninsula; it has also straits, channels, bars, shoals and its coast-line.

The banks of the lake consist mostly of high grounds which are selected as sites of beautiful, often costly residences, which, especially when duplicated by reflection from the smooth surface of the water, form landscapes worthy of the pencil of the painter.

The lines of figures on the accompanying chart show the depth of the water as measured in 1875. They indicate three principal depressions, the deepest being 66 feet,* the mean of all the soundings is 39 feet.

*The greatest depths measured in other lakes in the vicinity were:

	Feet.		Feet.
Nagowicka	100	La Belle	45
Upper Nashotah	55	Silver Lake	40
Lower Nashotah	50	Upper Genesee	39
Pewaukee	50	Lower Namahbin	34


C. M. & St. P. Railway
Scale
Two inches to
one mile
Spring
Point Lapham

There are several shoals with from two to six feet depth of water.

There is no deposit of mud or sand brought into the lake by the river; the water supply both from the river and from the numerous springs on the shore, being always clean and pure. One of these springs on the south shore, known by its Indian name Minnewoc, (place of waters) has been analyzed by Mr. G. Bode, of Milwaukee, Chemist of the Wisconsin Geological Survey, with the following result:

Chloride of sodium	0.129
Sulphate of soda	0.627
Bicarbonate of soda	1.041
Bicarbonate of lime	9.638
Bicarbonate of magnesia	6.138
Bicarbonate of iron	0.129
Alumina	0.067
Silica	0.879
Total (grains in one gallon)	18.648

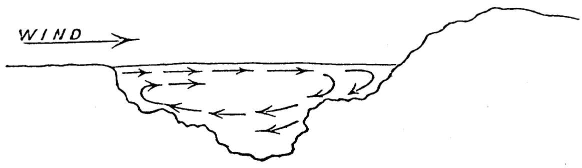
It will be seen that the chief ingredients, as in most Wisconsin waters, are lime or magnesia, derived doubtless directly from the magnesian limestone rocks and pebbles buried beneath the soil. This analysis also shows that the water does not differ essentially from those having great reputation for their medicinal virtues.

The lime from the springs is deposited, under favorable circumstances, upon the bottom of the lake forming beds of pure white marl; a process which is materially assisted by the secretions of mollusks and aquatic plants, especially the chara and algae.

The temperature of the water, being an important item in fish culture, was taken at different times near the surface, where it had considerable depth, with the following result:

In May	41°	Fahr.
In June	63	"
In July	72	"
In August	72	"
In September	72	"
In October, 1874	53	"

An attempt was made to find the temperature at the bottom in deep water and resulted in showing at some times no differences, at other times one or two degrees warmer or colder; though the deep water is popularly believed to be much colder than that at the surface.



The strong wind blowing over the lake causes a surface current which must be balanced by a counter current below, and thus by a constant interchange of water equalizes the temperature. If the day is warm with but little wind, the surface water will become the warmest; at night the surface cools down so that in the early morning it is colder than at the bottom.

The deep-water fishes do not, therefore, seek that locality on account of diminished temperature.

One lake is said to have remained open nearly all winter; the cold weather having been accompanied by high wind, which prevented the water from freezing.

When the surface is once covered with ice the currents cease, and ice is formed of great depth and of crystal transparency and purity.

The temperature of the spring-water along the shores remain [sic] nearly uniform throughout the year, varying from 47 to 49 degrees, which is not far from the mean temperature of this locality.

The currents caused by the wind blowing over the surface of the lake, act upon the bottom and shores, causing abrasions at some places and accumulations at others, very much as by the larger currents of the ocean. This is quite apparent at two points on the channel between the lake and the large bay at the northeast angle. The current flowing into the bay from the lake causes an eddy at these points from which are deposited long narrow bars projecting from the shore. This channel it will be seen is quite narrow and the water in it shallow.

These currents also cause accumulations of beach sand and gravel at certain points along the shore; separating and assorting the material upon a small scale, precisely as is done on a larger scale by the currents in the great lakes, and in the ocean.

While white shell marl is accumulating in some portions of the lake, soft muck resulting from the annual decay of aquatic vegetation is accumulating in others. Some of the lakes, especially those not connected with a stream of running water, are thus becoming rapidly filled with marl and peat, causing changes that become apparent after long intervals of time. Some small shallow lakes have thus been changed to meadows within the recollection of the first settlers of the county only 38 years ago.

The government plats represent some lakes in 1835, which are now only known as marshes or wet meadows. One called "Soft Water Lake," was a clean sheet of water only four years ago, but is now nearly covered with the leaves of the yellow pond lily (Nuphar) and other water plants. Soon it will cease to be known as a lake.

There are also some changes of the level of some of these lakes, indicating a less amount of water than formerly. Sand bars formerly covered with water are now dry, and in one case the bar extends quite across the lake, thus dividing it into two. Another proof of a diminished supply of water is afforded by the occurrence of ancient beaver dams in places where no pond could be formed at the present time, for want of running water.

The time may come when by the use of some simple, easily worked dredge, the marl, and muck may be removed from the bottom of some of the more important of these lakes, to be used as a fertilizer of the neighboring farms; especially as the beauty of the lakes would be increased by deepening the water, and by the consequent removal of the unsightly vegetable growth along their shallow margins.

Ice ridges are formed at certain places around the shore, some of them double, or triple, and varying in height up to ten feet. These ridges are formed by the expansion of the ice during the winter, pushing the materials of the beach in-land. They consist of sand, gravel, or boulders; in the latter case they constitute the so called "walled lakes." If the banks are high and steep at the edge of the water, no ridge can be formed, but wherever low grounds or marshes approach the lake, they may be looked for. Where springs enter the lake, no ridges are formed, the water remaining above the freezing point all winter. Trees are often found with their roots crowded inland by the ice expansion; their tops leaning over the water. These ridges make excellent road-beds, and are often used for that purpose.

The ancient mound-builders, that mysterious people who preceded the present Indian races, once occupied the banks of these lakes as is clearly shown by their numerous works; and they probably derived no inconsiderable portion of their subsistence from fish. No shell-heaps have been found to indicate their use of the abundance of Unio and Anodons found in these lakes. The works of the mound-builders are rapidly disappearing, being levelled by the plow of the farmer.

Besides the Unios, these lakes abound in other bivalve and univalve mollusks; crustaceans and worms, and the larvae of insects appear in wonderful numbers. These, with the innumerable minnows found in shallow waters, afford at all times an abundant supply of food for the larger fishes. Loons, geese, ducks, gulls, plover, and many other birds swim upon the waters or wade along the margin.

Among the fishes to be found are the following:

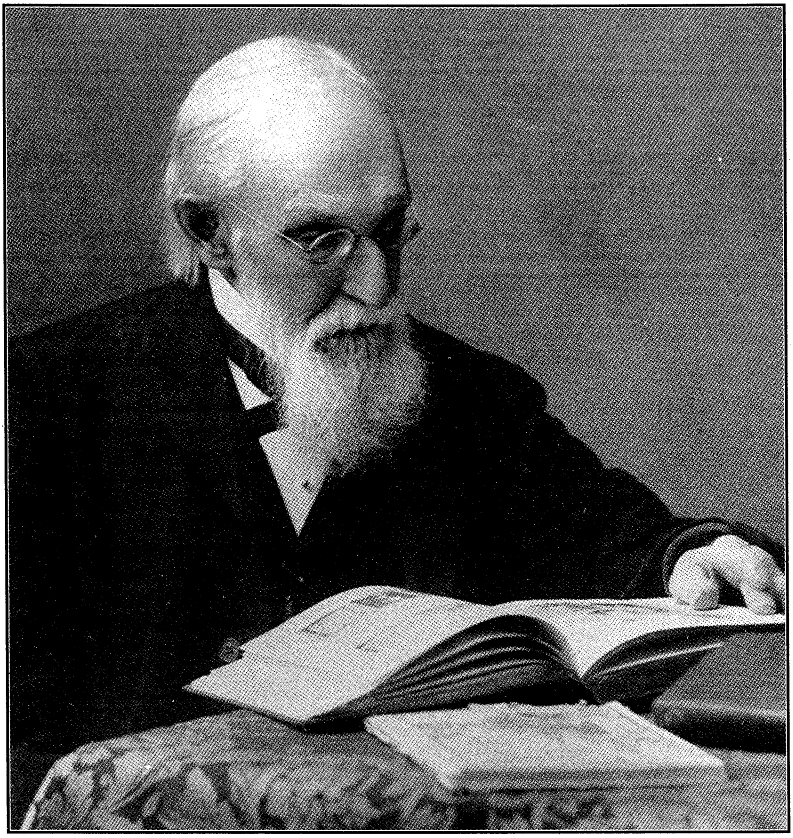
PERCH, Perca flavescens, Cuvier.
WALL-EYED PIKE, Lucoperca americana.
STRIPED BASS, Roccus chrysops, Girary.
ROCK BASS.
STONE-ROLLER, Etheostonia.
BLACK BASS, Micropluas nigricans, Agassiz.
SUN-FISH, Pomotis.
PUMPKINSEED.
SHINER.
SHEEPHEAD, Haploidonotus grunnieus.
STICKLE-BACK, Applissinconstans, Kirtland.
PICKEREL, ESOX, Lesueur.
SISCO, Argysosomus sisco, Jordan Am. Nat., 1875, p. 135, Ind. Geol. rep. 1875, p. 190.
SUCKER, Catastomus.
RED-HORSE, Plychostonus.
CAT-FISH, Amiurus catus, Cuvier.
BULL-HEAD.
BILL-FISH, Lepidosteus oxyurus, Rafinesque.

The Salmon and Brook-trout are reared artificially, and have been introduced into some of the lakes.

Young salmon (Salmo salar) and the brook-trout (S. fontinalis) have been introduced into this lake, but so far as known they have not increased.

From the data given above one will be able to decide whether it would be advisable for the State to attempt to stock this lake with fish; and if so, the kinds best adapted to the conditions named.

The natural supply of fish has been drawn upon so heavily that the present yield is quite small, compared with what it was a dozen or more years ago; and hence the necessity of some effort for the restoration of the supply of the better kinds.



James Davie Butler, LL.D.
(1815–1905)

Student of theology and Congregational minister; seasoned worldwide traveller and popular travel lecturer; professor of Greek at Wabash College; professor of ancient languages and literature at the University of Wisconsin; curator of the Wisconsin Historical Society

COPPER TOOLS FOUND IN THE STATE OF WISCONSIN

BY PROF. J. D. BUTLER, LL.D.

Implements of unalloyed copper are among the most rare and curious of archaeological findings. The exhibit of these articles now made at the Philadelphia Centennial comprises the largest collection ever brought together. The copper age proper, in distinction from the age of bronze, forms a link in the chain of human development which according to Sir John Lubbock, "is scarcely traceable in Europe." The only European museum known to that distinguished archaeologist which contains any copper tools is the royal Academy at Dublin. The number there was thirty till within a year or two, when five were received from Gunjera—a province in India north of Bombay.

The articles now on view at the Centennial are as follows: In the Government building, from the Smithsonian Institution, seventeen real tools, besides casts of several others, and various copper trinkets. In the same building two articles, much corroded, owned in the State of Vermont.

In the mineral annex. From Ohio eight implements; from Michigan nineteen, and from Wisconsin, *one hundred and sixty four.* The whole number from all quarters is two hundred and ten.

I made notes regarding all the exhibits, but having lost them; can only describe the show from Wisconsin. But the coppers from that State are nearly four times as many as all the rest of the world has sent to Philadelphia, and they surpass others in size, variety, and perfection of preservation, as much as in number. The only instrument from any other source, not represented among Wisconsin Coppers, is a crescent about six inches long—perhaps intended for a knife, though it has no handle.

Among the varieties in the Wisconsin exhibit—which is made by the State Historical Society—are the following:

Ninety-five spear-heads. Of these the larger number are what some antiquarians called "winged," that is the sides of the base are rolled up towards each other so as to form a socket to receive a shaft. Some of these sockets are quite perfect, and all are ingeniously swaged. Sixteen of them are punched each with a hole, round, square, or oblong, for a pin to fasten the shaft, and one of the copper pins still sticks fast in its place. Twenty-three of the spear-blades swell on one side something like bayonets, the rest are flat. Three are marked with seven dents apiece, and one with nine; indentations which have been fancied to indicate the number of beasts, or men, the weapons had killed. Nine spear-heads have round tangs which are so long, smooth and sharp, that they may well have been used as awls and gimlets. The blades of these nine spears swell in the middle of each side. Their shape is a beautiful oval. The largest specimen of this class is about a foot in length. In the middle of its blade there is a hole as large as a pipe-stem, which may have been drilled for putting in a cord to recover the spear when it had been thrown into the water. One spear has a unilateral barb. This, meeting with unequal resistance, will not go straight in water, so we think it of an absurd pattern. But the truth is that if aimed at a fish where he looks to be, it will hit him where he is—though, owing to the refraction of light in water, he is not where he looks to be. One barb is then better than two, and we are the fools after all. Spears of a similar pattern, though of other material have been exhumed in France and California, and are still used in Terra del Fuego. Specimens in bone from Santa Barbara may be seen in the Smithsonian exhibit. Thirteen spears have flat tangs to thrust into shafts. Six of these tangs are serrated or notched like the necks of flint weapons for binding about with sinews. They seem to mark the very point of transition from one material to another—from mineral to metal.

There are fifteen knives. Most of these were intended to be stuck in handles, but one of them has a handle rolled out of the same piece of copper with its blade. Another has its copper handle bent into a hook. There are several gads, or wedges, to be driven. There are three adzes—tools beveled only on one side of their edges, and with broad sockets for handles. There are eleven chisels, some as heavy as those we now use. There are twelve axes, one weighing three and three-quarter pounds in exactly the weight of those common among Wisconsin lumbermen to-day. Another, which is a pound heavier, is the largest specimen of wrought copper that has even been brought to light. There is one hook, and a square rod. There are more than half a dozen borers of various sizes. One may be called an auger, being sixteen inches long and three in circumference. There is a dagger ten inches long with a blade an inch wide. These, with various anomalous articles, complete the catalogue.

For the conservation and display of this unique copper treasure the State of Wisconsin has set apart one of the towers of the Capitol in Madison. There they will be daily open for inspection, and will no doubt be a magnet attracting to themselves other curiosities of like nature.

The question is always asked, "Where did these coppers come from?" It cannot be so definitely answered as is to be desired. Nevertheless something is known in respect to the finding of them. They were all discovered within the limits of Wisconsin—while the Smithsonian specimens—less than one eighth as many, were gleaned from eight different States. Nearly all of them have come to light in eleven southeastern counties of Wisconsin. Only in those counties has much search been made.

Most of the Wisconsin coppers were brought together into one collection by the zeal and perseverance of one single man, Frederick S. Perkins of Racine county. Five years ago this gentleman, though he had long been forming a museum of stone implements, had never seen one of copper. On the 25th of November, 1871, he was first shown such an antique. It was a large spear-head that had been exhumed three miles north of his residence in Burlington, Wisconsin. That November date marks the birthday of his interest in copper—or his transition from the stone to the copper age. His enthusiasm which had been great for the former became greater for the latter. He had leisure—or he made it, to ride over county after county on every road, waylaying every pedlar [sic], calling at every school, every store, at almost every house. He advertised in newspapers, he threw tempting baits abroad on all waters. He found what he sought, where no one else would have looked for such a prize, and where many proved to him that it could not be found. He has recorded the name and resident, by county and town, of one hundred and twenty-one persons from whom he obtained pre-historic coppers, as well as of three hundred and twenty-five others who furnished him stone antiques, but had no coppers to furnish. This record shows how thorough and wide-spread were his researches. Indeed, although the Wisconsin Historical Society has bought the bulk of his findings, some of them are scattered far and wide. Five of them are in the Central Park museum, others in the Metropolitan in New York, others I think have enriched the Smithsonian. A further question which must occur to every investigator, is, where were these implements obtained by those from whom Mr. Perkins obtained them? On this point my information is more scanty than it would be were not Mr. Perkins now in Europe, and than it will be on his return. Large numbers of the tools were turned up in plowing or hoeing. Others at greater depth in digging foundations of houses or sinking wells. Not a few have come to light in burial mounds close by skeletons. In one such mound at Prairie du Chien an axe weighing two and seven-sixteenths pounds and eight inches long was discovered lying on a large flint spade, fourteen feet below the top of the mound, and seven feet below the level of the earth around, and among human bones. Another axe, with other coppers, was taken from a similar mound in Barron county. The only socket spear-head which shows its rivet still in place, was found on a knoll in plowed land by James Driscoll in May, 1874, at Lake Five, Waukesha county. One knife was dug out of a mound by a dog while hunting, in 1860, in Troy, Waukesha county. One chisel was met with ten feet below the surface in cutting a road through a bluff at Cedarburg, Ozaukee county, in 1871. One of the most remarkable articles, a sort of copper pike, was dug up three feet under ground on the bank of Pike Lake, Hartford, Washington county, by Samuel Mowry in 1865. One massive celt, at first turned up in Merton, Waukesha county, a pedlar [sic] had preserved for twenty years. Several knives and other implements found near lakes and rivers appear to have been washed out of their banks. A lance-head found at Rubicon, Dodge county, in 1869, has a lump or stud of silver on one side of it.

But we cannot fail to ask, "who made these copper instruments? was it Indians or some pre-Indian race?" It has been argued that they are of pre-Indian origin because the skeletons with which they are discovered in burial mounds are not of the Indian type, but of a very different cranial development. Again, as the mounds, multitudinous and often of vast size, are beyond Indian industry, so the tools seem beyond Indian ingenuity. Most of them indeed, are hammered, and so show copper used rather as a mineral than as a metal. Others of the coppers betray no marks of hammering, no laminations or flaws. Practical foundrymen detect on them mould-marks where the halves of a flask united, and so declare them smelted. Others they hold were run in a sand-mold. These indications of casting are plainest on the largest piercer and on one of the chisels, except perhaps on certain implements which Mr. Perkins has carried abroad for the conversion to his views of trans-Atlantic skeptics regarding our pre-historic metallurgy. All proofs that our coppers were cast, tend to show that they are not the handiwork of Indians.

Our early annals indicate that our copper implements were a pre-Indian manufacture. They testify that the earliest travelers in Wisconsin found the Indians using copper, if at all, only for trinkets and totems, but not for implements either of war or of peace. Thus La Salle on his last expedition through this region, well nigh two centuries ago, says of the Indians: "The extremity of their arrows is armed, instead of iron, with a sharp stone or the tooth of some animal. Their buffalo-arrow is nothing else but a stone or bone, or sometimes a piece of very hard wood" Charlevoix, writing about 1720, mentions Indian "hatchets of flint which take a great deal of time to sharpen, as the only mode of cutting down trees." "To fix them in the handle," says he, "they cut off the head of a young tree, and make a notch in it in which they thrust the head of a young tree, and make a notch in it in which they thrust the head of the hatchet. After some time the tree by growing together keeps the hatchet so fixed that it cannot come out. They then cut the tree to such a length as they would have the handle." "Both their arrows and javelins," he adds, "are armed with a point of bone wrought in different shapes." According to Hennepin about 1680, (2.103) "the Indians, instead of hatchets and knives, made use of sharp stones which they fastened in a cleft piece of wood with leather thongs, and instead of awls they made a certain sharp bone to serve." The Jesuit Father Allouez, writing about 1660, says "I have seen in the hands of the savages, pieces of copper weighing from ten to twenty pounds. They esteem them as divinities or as presents made them by the gods. For this reason they preserve them wrapped up with the most precious things, and have sometimes kept them time out of mind." In none of these or other early chronicles do I find any mention of any copper tool whatever. Pre-historic mines about Lake Superior are a proof that our copper implements are not Indian work. No tradition of such mines was brought to light by early adventurers among Indians. But if excavated by them to such an extent as we see them, and for ages, how could they have been given up and even forgotten? On the whole the evidence now before us tends to show that our copper tools are the work of some pre-Indian race. The success of Mr. Perkins in unearthing coppers in unlooked for numbers should raise up a legion of copper-hunters. For encouraging such investigators still more, my last words shall be regarding the greater harvest than has crowned his labors which seems to me ripe for their sickles.

Indications are not wanting that our past prizes in copper-hunts, are all as nothing to what is in store for us. Pre-historic mining-pits honeycomb Isle Royal all over. Along the south shore of Lake Superior they are frequent for a hundred miles. They were every one rich pockets. Their yield of copper must have been many times enough for sheathing the British navy. What has become of this copper? It cannot have vanished like iron in oxidizing rust. It must still exist, and lurk all around us. At Assouan the quarries prove to a stranger that Egypt must be rich in granitic monoliths, for there we see the rock whence they were hewn. Spanish treasure-ships sunk in the Caribbean ages ago, still teach divers where to ply their sub-marine machinery for richest spoils. In Greece, the Styx, and other catabothra, or lost rivers—emptying into subterranean abysses, suggested to the ancients streams that girdled the whole under world. So our mining shafts sunk time out of mind are a prophecy and an assurance of copper bonanzas for explorers in the future so vast as will make us utterly forget whatever has been discovered. All hail such a ressurrection [sic] of the copper age. The longer it has been lost the more welcome will it be when found again.

William Francis Allen, A.M.
(1830–1889)

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DEPARTMENT

OF SOCIAL AND POLITICAL SCIENCE

UNITED STATES SOVEREIGNTY—WHENCE DERIVED, AND WHERE VESTED

BY W. F. ALLEN, A. M.,

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The late war brought to an end the long and fierce controversy as to the nature of the Federal Union. What argument had not been able to decide, was decided by arms; and the United States are recognized as a Nation, possessed of sovereignty. With the determination of this controversy, however, another question has come into prominence, as to the origin of this sovereignty. Before the war it was commonly held that the act which severed the colonies from the mother country had as its effect the creation of thirteen independent and sovereign States; and that it was not until the formation of the Federal Constitution that sovereignty was conferred upon the central government. This doctrine, however, of the original sovereignty of the States, has been thought to afford some foundation for the doctrine of Secession. Some of the most ardent advocates, therefore, of the national and sovereign character of our Union, have, since the war, brought into great prominence the theory that the Nation was not created by the States, but the States by the Nation; that the States were never, in any true sense of the term, sovereign, but that the act of independence created at once a sovereign Nation. This view has been most fully elaborated in a series of articles in the first volume (1865) of the *Nation*, by Hon. Geo. P. Marsh, United States minister to Italy; it is presented also by Professor Pomeroy in his "Introduction to Constitutional Law." In this work the authority of Hamilton, Jay, Marshall, Story and Webster is claimed for this theory. I do not think, however, that Marshall and Webster can fairly be cited as its adherents. Mr. Pomeroy has given no citations in support of his view, and on the other hand both these jurists have expressed themselves unequivocally in favor of the original sovereignty of the States. Webster says, of the Confederation: "it was a league, and nothing but a league."* Chief Justice Marshall's language is: "it has been said, that they [the States under the Confederation] were sovereign, were completely independent, and were connected with each other only by a league. This is true."†

Admitting, therefore, that the one theory has in its behalf the authority of Jay, Hamilton, Story and Kent, the other has the equally high authority of Marshall, Madison and Webster. We may, therefore, where authorities disagree, proceed to examine the arguments with perfect freedom from bias. The question is eminently an historical one—that is, a question of facts, not of theory. Sovereignty being the supreme power to command, it is simply a question of fact what organization was found in possession of this power, when it ceased to be exercised by Great Britain.

It requires no argument to show that before the Revolution the colonies were absolutely dependent upon Great Britain; whatever powers of government they severally possessed was in virtue purely of sufferance or explicit grant, on the part of the mother country. It is equally clear that the colonies were connected with one another by no organic bond. There was no government of the united colonies; each colony had its own government; and if sometimes, for the convenience of administration, two or more colonies were united under the same royal governor, this was simply an administrative union—one official managing two independent governments at a time, not a single government resulting from the fusion or union of two individual ones. There were thirteen organized communities, standing in a condition of coequal dependence upon the government of Great Britain. This tie of dependence was severed by the Declaration of Independence, July 4, 1776, sustained, as this act was, by armed force.

Two points fall here under consideration: first, the power which severed the tie; second, the logical effects of the act of severance.

First, the power that performed the act of severance was the Continental Congress. But by what authority, and in virtue of what delegation of power did the Continental Congress act? Was the Congress the organ of the several States, or of the "people at large" (to use Mr. Marsh's expression)?‡ To answer this question, which rests at the bottom of the argument, we must trace briefly the history of this Congress.

* Speech on "The Constitution not a Compact," Works, iii. 454.

† Ogden vs. Gibbons, 9 Wheaton, 187.

‡ The Nation, No. 23.

In the year 1764, upon motion of James Otis, the General Court of Massachusetts passed a resolution proposing to the other colonies to form a union for the purpose of resisting the acts of the British government. This proposition was accepted, first by Virginia, then by the other colonies. The Congress met the next year (1765), and shortly afterward, as a result of the spirit thus manifested, the Stamp Act was repealed. The Second Continental Congress met in 1774, called in a precisely similar manner. In both cases the members of the Congress were elected by the several colonies, and in both cases it was only a portion of the colonies—nine the first time, twelve the second—that were represented. Now so long as Georgia staid [sic] away, it is clear that not "the people at large of the United States," but only the people of twelve colonies, were engaged in formal acts of resistance. In the assembly thus composed of delegates from the several colonies, the colonies voted *as such*; no measure was adopted by a majority of votes, as would have been the case if they had been considered to represent the people at large; a majority of the *colonies* must always decide. It was by colonies that the Declaration of Independence was passed, and in this document the several colonies are declared to be "free and independent States."

Let us pause a moment upon this word "State," which thus makes its appearance in our political vocabulary. The great convenience of having a different term to denote the units which compose our federal government from that which designates the federal government itself, has established, in American constitutional law, a fundamental difference in the meaning of the respective terms. By *State* we understand a political organization inferior to the *Nation*. But this distinction is peculiar to American public law. The two terms are originally identical in meaning, or rather in application; being applied indifferently to the same object, but from different points of view. A State is, in public law, a Nation, regarded from the point of view of its organization; a Nation is a State, regarded from the point of view of its individuality. We must not, therefore, suppose that when the colonies, in 1876, declared themselves to be free and independent States, they attributed to the word State the same inferiority which we now associate with the word. They understood by it, a sovereign political organization. That they selected this term, rather than Nation, is no doubt partly due to its expressing more distinctly the idea of organization; partly, I am ready to admit, to the feeling that *Nation* was a larger term, and that a higher organization, which should embrace all these individuals in one whole, was destined to result. Nay, we meet the term Nation very early, as applied to the united body.

That the Congress considered itself as acting as the organ of the colonies or States, and not of the people at large, appears manifest from the language habitually used. On the tenth of May, 1776 Congress resolved to "recommend" to the "respective assemblies and conventions of the United Colonies," to form permanent governments. August 21, of the same year, it made use of the expression: "All persons not members of, nor owing allegiance to any of the United States of America,"—showing that allegiance was regarded as due to the several States. Its constant title for itself was "the United States in Congress assembled"—a term which plainly recognizes that the United States, as an organized body, has no existence except in the Congress, which Congress, as we have seen, acted purely as the organ of the several States.

I pass now to the nature and effect of the act of severance. This act was in the first place purely negative in its intrinsic character. It simply put an end to a certain previously existing relation—that by which the colonies individually depended upon the British sovereignty. The relations of the several colonies to one another could not be affected by it. If before the act they formed a united, organized body, this united body, in virtue of the act of independence, succeeded to the sovereignty surrendered by the mother country; if they were individual and disconnected before, they remained so after the act, and each individual passed into the full enjoyment of sovereignty.

Now I have shown first, that before the revolution the colonies had no organic connection with one another, but only with the mother country; second, that the union which they formed for purposes of resistance professed to be nothing but a voluntary, incomplete and temporary association, with only limited and temporary aims, possessing none of the essentials of a permanent government, capable, it is true, of developing into a complete sovereignty, but in all its acts and words appearing as not itself an organic body, but the representative of certain organic bodies. "The United States in Congress assembled," made no claim to individual or independent existence, but acted avowedly as a mere intermediary or instrument of joint action for organisms which did possess individual existence. And this practical independence accrued to the several colonies simply from the fact that, upon the severance of the tie which connected them severally to the mother country, each was left standing legally alone; and, standing alone, having no legal superior, but possessing a complete and adequate organization of its own, each colony passed into the undisputed enjoyment of sovereignty.

Neither before nor after the commencement of the revolution, therefore, did there exist any united organic body which could supersede the several colonies, and assert a claim to the lapsed sovereignty of Great Britain. And if this is true for the period of inchoate nationality which intervened between the first acts of resistance and the practical establishment of independence, still more is it true for the ensuing period of the Confederation. It needs no argument to show that the States were at this time recognized as fully and exclusively sovereign; its Articles explicitly provide "that each state retains its sovereignty and power which is not by this Confederation expressly delegated to the United States in Congress assembled." All that can be said in opposition to this view is that this was a "palpable usurpation,"* set on foot during this "embryonic or inchoate period"†; and their arguments plainly imply that they understand the Articles of Confederation to represent a different phase of national life from the Declaration of Independence, and as requiring therefore to be construed from a different point of view; they were adopted by Congress sixteen months later than the other act, (Nov. 15, 1777.) and in this period of time, it is hinted, the "flow of enthusiasm," under which the united act of independence had been accomplished, "receded," and selfish and local prejudices took its place. Now, if the Articles of Confederation were really drawn up a year and a half after the Declaration of Independence, this reasoning would have much weight. But the date here given is only that of the *adoption* of the articles by Congress. They were reported to Congress July 12, 1776, just a week after the Declaration—the preliminary steps, indeed, were taken in June, before the passage of the act of independence. It is therefore perfectly legitimate to interpret the act of independence in the light of the government which was established after it. The two acts were to all intents and purposes parts of one and the same act. In the very act of declaring their independence, the States formed themselves into a Federal Union; and in this Union the several States were explicitly declared to be independent and sovereign; from which it necessarily follows that the Union thus formed, was, in Webster's words, "a league and nothing but a league."

It will be seen that the whole controversy turns upon the period between the suspension of the royal authority and the establishment of the confederation. While the royal authority continued to be rec-

* Pomeroy, p. 48.

† Mr. Marsh, in the Nation, No. 1.

ognized, sovereignty of course belonged to Great Britain; after the establishment of the Confederation, it as manifestly belonged to the several States. Was there an interval during which it was possessed by the United Colonies? Mr. Marsh says:* "it was not for a moment imagined that the sovereignty was in the interim lodged anywhere except in the whole people of the United Colonies." But he brings no facts to prove this assertion.

At the beginning of this discussion it was remarked that the question was essentially an historical one, and must find its decision in historical facts—that is, in the series of events by which the sovereignty was transferred from Great Britain to the United States; and I think I have shown that, as a matter of fact, this transfer was not made at one stroke, but that the sovereignty was actually possessed for a while by the several States, before it was transferred by a deliberate act to the nation. There remain, however, some theoretical objections to this view, which it will be necessary to consider.

Mr. Pomeroy states these theoretical objections in the following strong terms: "Grant that in the beginning the several states were, in any true sense independent sovereignties, and I see no escape from the extreme positions reached by Mr. Calhoun."† No arguments are presented in support of this startling assertion, except the doctrine that among the attributes of sovereignty, "the one which underlies all others, and is, in fact, necessarily implied in the very conception of separate nationality, is that of supreme continued self-existence. This inherent right can only be destroyed by overwhelming opposing force; it cannot be permanently parted with by any constitution, treaty, league, or bargain, which shall forever completely resign or essentially limit their sovereignty, and restrain the people from asserting it." There is no attempt made to prove this doctrine; it rests simply upon Mr. Pomeroy's assertion, backed by references to the works of half a dozen European publicsts [sic]. According to this doctrine Texas was never annexed; if the United States had conquered her, and forced her into the Union, her status would have been a legal one; but as she came in voluntarily, surrendering her sovereignty and individual existence, the act was null and void. According to this doctrine the act of union by which, in 1706, England and Scotland surrendered their individual sovereignty, and united into the new sovereignty of Great Britain, was an impossible act; and Scotland might now, if she chose,

* The Nation. No. 21.

† p. 39.

re-establish her Parliament at Edinburgh, and crown a Presbyterian King at Scone. Again; on this theory, what are we to do with Rhode Island and North Carolina in the interval between the establishment of the Federal Government, and their accession to it? They were certainly not members of the new Union; which made no claim to extend its power over them. The Confederation of which they had been members, no longer existed. There is but one answer to this question. They were independent, sovereign States, as independent and as sovereign as Costa Rica, or San Marino, or the Free City of Hamburg.

In arguing for the original sovereignty of the States, I would not be understood to advocate the modern doctrine of State Rights. I hold with Marshall, Webster and Story, with Mr. Marsh and Mr. Pomeroy, that the United States form a nation, and possess full powors [sic] of sovereignty. But I hold that this sovereignty was formally and voluntarily conferred upon them by the States in the act of forming the Federal Constitution. The doctrine advanced by Mr. Pomeroy* as to the relation of the States to the United States, which is essentially that of Mr. Austin, I fully accept. "The people of the United States, as a nation, is the ultimate source of all power, both that conferred upon the General Government, that conferred upon each State as a separate political society, and that retained by themselves." Only, by "ultimate source," I do not understand historical filiation, but legal authority, under the constitution; the States—meaning by that the people of the several States—formed themselves, by this act, into "the People of the United States;" and this sovereign people, as organized in States, exercises its sovereign powers by the two-fold instrumentality of the National Government and the States' Governments, distributing these powers between these two instrumentalities as seems most expedient. Thus the States are as much sovereign as the nation; but in truth neither is sovereign, but each is an organization for the exercise of a certain definite portion of the powers of government. The sovereignty is not divided between States and Nation, because sovereignty is indivisible and absolute; but the functions of government, in which consists the exercise of the powers of sovereignty, can be divided, and are divided between these two organizations.

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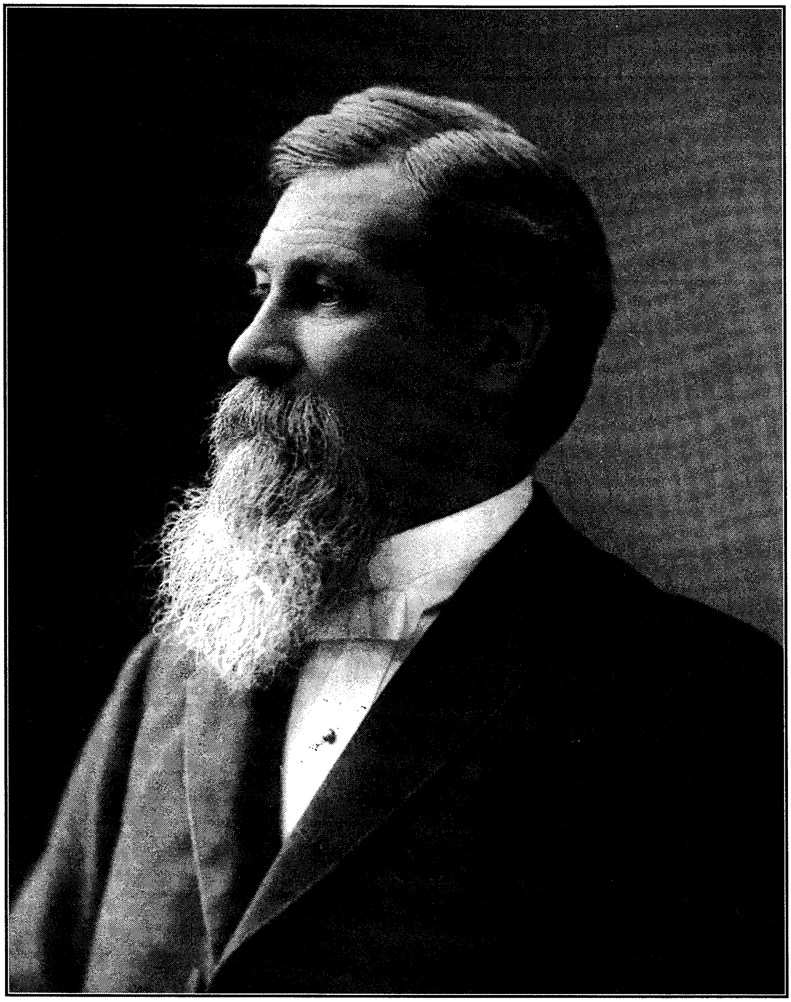


Courtesy The State Historical Society of Wisconsin Whi(x3)33074

Thomas Chrowder Chamberlin, Ph.D., Sc.D., LL.D.
(1843–1928)

Wisconsin State Geologist; professor of geology at Beloit College; charter member and fifth president of the Wisconsin Academy, 1885–87; president of the University of Wisconsin, 1887–92; professor at the University of Chicago

DEPARTMENT

OF THE MATHEMATICAL AND PHYSICAL SCIENCES

ON THE EXTENT AND SIGNIFICANCE OF THE WISCONSIN KETTLE MORAINE

BY T. C. CHAMBERLIN, A.M.,

State Geologist, and Professor of Geology in Beloit College[1]

At the meeting of the Academy, three years since, I took the liberty of occupying the attention of the members by the presentation of some observations and conclusions in reference to a peculiar series of drift hills and ridges in eastern Wisconsin, known as the Kettle range, and the views then advanced afterwards found a place in my report on the geology of eastern Wisconsin.[2] Similar observations were subsequently made by Professor Roland D. Irving, of the Wisconsin survey, and his conclusions are in perfect agreement with my own.[3]

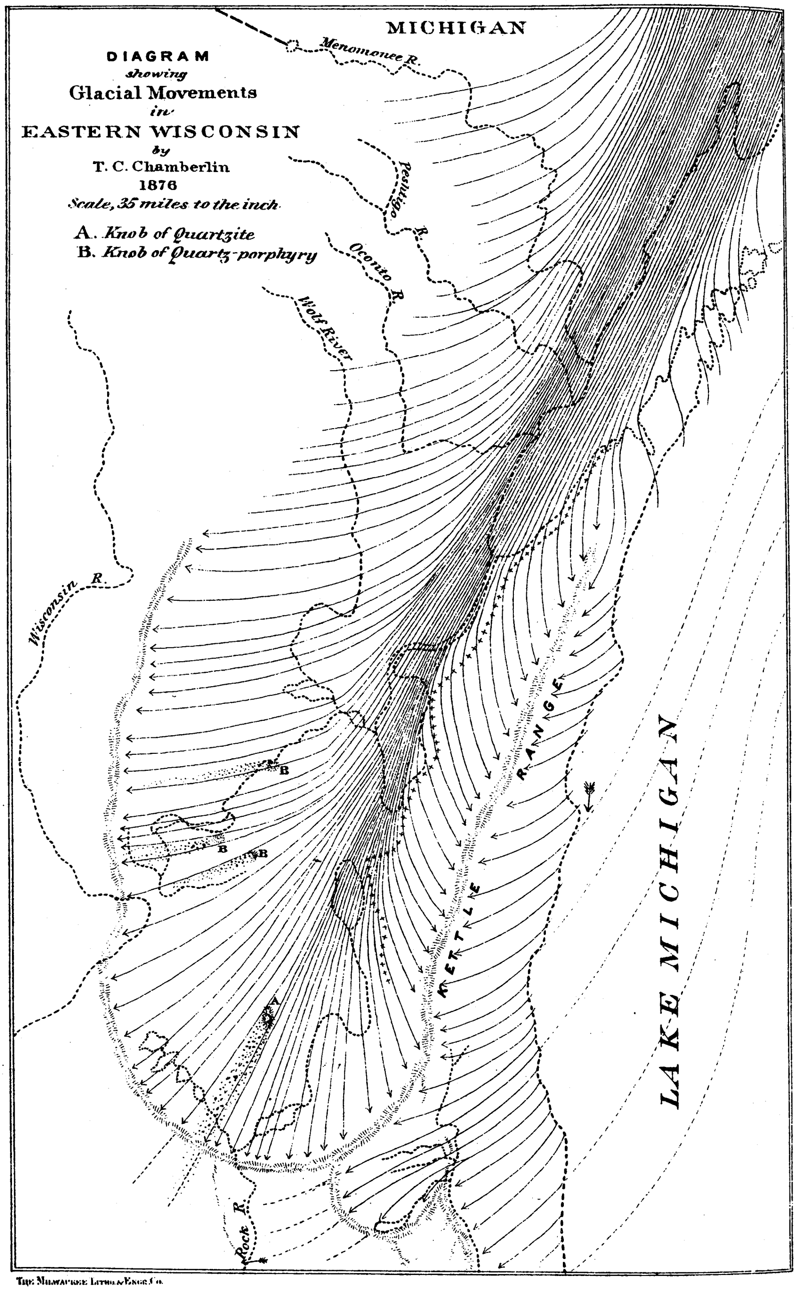
In neither case, however, was any attempt made to show the full extent of the formation outside of the districts reported upon, or to point out its theoretical significance, the chapters being intended only as contributions to local geology, made under somewhat severe limitations as to space.

It is not now possible to map, or even safely conjecture, the complete extent and limitations of the formation; but it is the purpose of this article to add such trustworthy observations as have since been made, and to gather such evidence as may justify a provisional mapping of the range, where it has not been actually traced. A portion of the paper will, therefore, relate to well ascertained facts, while other portions will be in various degrees hypothetical. If care is taken to distinguish between these portions, no harm can arise from their association; while the provisional

[1]I have taken advantage of the interval between the date of reading and the printing to introduce new matter. T.C.C.

[2]Geology of Wis., Vol. II, 1877 (revised edition 1878), pp. 205–215.

[3]Geology of Wis., Vol. II, 1877 (revised edition 1878), pp. 608–635.


MICHIGAN
DIAGRAM
showing
Glacial Movements
in
EASTERN WISCONSIN
by
T. C. Chamberlin
1876
Scale, 35 miles to the inch
A. Knob of Quartzite
B. Knob of Quartz-porphyry
Menomonee R.
Peshtigo R.
Oconto R.
Wolf River
Wisconsin R.
KETTLE RANGE
LAKE MICHIGAN
Rock R.
A
B
B
B

mapping will, it is hoped, prove of service in both stimulating and guiding further investigation. The extent of the range is likely to prove too great for the immediate time and means of a single observer; while the broad and irregular, and sometimes obscure, character of the belt is such that it is likely to be overlooked, as a continuous range, as experience has shown, unless attention be called to it, or the observer be keenly alive to distinctions in drift topography. It is believed, therefore, that the presentation of some things that are only probably, not certain, will not be without value.

It will be advisable to consider first, somewhat critically, the character of the formation. The following description, which is based upon careful observation, relates more specifically to the moraine in Wisconsin, where it is usually well developed, and may require some modification in its application to the range where sub-aqueous deposits overlap or encroach upon it, and in other special situations.

Surface Features.—The superficial aspect of the formation is that of an irregular, intricate series of drift ridges and hills of rapidly, but often very gracefully, undulating contour, consisting of rounded domes, conical peaks, winding and, occasionally, geniculated ridges, short, sharp spurs, mounds, knolls and hummocks, promiscuously arranged, accompanied by corresponding depressions that are even more striking in character. These depressions, which, to casual observation, constitute the most peculiar and obtrusive feature of the range, and give rise to its descriptive name in Wisconsin, are variously known as "Potash kettles," "Pot holes," "Pots and kettles," "Sinks," etc. Those that have most arrested popular attention are circular in outline and symmetrical in form, not unlike the homely utensils that have given them names. But it is important to observe that the most of these depressions are not so symmetrical as to merit the application of these terms. Occasionally, they approach the form of a funnel, or of an inverted bell, while the shallow ones are mere saucer-like hollows, and others are rudely oval, oblong, elliptical, or are extended into trough-like, or even winding hollows, while irregular departures from all these forms are most common. In depth, these cavities vary from the merest indentation of the surface to bowls sixty feet or more deep, while in the irregular forms the descent is not unfrequently one hundred feet or more. The slope of the sides varies greatly, but in the deeper ones it very often reaches an angle of 30° or 35° with the horizon, or, in other words, is about as steep as the material will lie. In horizontal dimensions, those that are popularly recognized as "kettles" seldom exceed 500 feet in diameter, but, structurally considered, they cannot be limited to this dimension, and it may be difficult to assign definite limits to them. One of the peculiarities of the range is the large number of small lakes, without inlet or outlet, that dot its course. Some of these are mere ponds of water at the bottom of typical kettles, and, from this, they graduate by imperceptible degrees into lakes of two or three miles in diameter. These are simply kettles on a large scale.

Next to the depressions themselves, the most striking feature of this singular formation is their counterpart in the form of rounded hills and hillocks that may, not inaptly, be styled inverted kettles. These give to the surface an irregularity sometimes fittingly designated "knobby drift." The trough-like, winding hollows have their correlatives in sharp serpentine ridges. The combined effect of these elevations and depressions is to give to the surface an entirely distinctive character.

These features may be regarded, however, as subordinate elements of the main range, since these hillocks and hollows are variously distributed over its surface. They are usually most abundant upon the more abrupt face of the range, but occur, in greater or less degree, on all sides of it, and in various situations. Not unfrequently, they occur distributed over comparatively level areas, adjacent to the range. Sometimes the kettles prevail in the valleys, the adjacent ridges being free from them; and, again, the reverse is the case, or they are promiscuously distributed over both. These facts are important in considering the question of their origin.

The range itself is of composite character, being made up of a series of rudely parallel ridges, that unite, interlock, separate, appear and disappear in an eccentric and intricate manner. Several of these subordinate ridges are often clearly discernible. It is usually between the component ridges, and occupying depressions, evidently caused by their divergence, that most of the larger lakes associated with the range are found. Ridges, running across the trend of the range, as well as traverse spurs extending out from it, are not uncommon features. The component ridges are themselves exceedingly irregular in height and breadth, being often much broken and interrupted. The united effect of all the foregoing features is to give to the formation a strikingly irregular and complicated aspect.

This peculiar topography, however, finds a miniature representative in the terminal moraines of certain Alpine glaciers. Most of the glaciers of Switzerland, at present, terminate in narrow valleys, on very steep slopes, and leave their debris in the form of lateral ridges, or a torrentially washed valley deposit. A portion of them, however, in their recently advanced state, descended into comparatively open valleys of gentle decline, and left typical, terminal moraines, *formed from the ground moraines of the glaciers*, and only slightly obscured by the medial and lateral morainic products, which have little or no representative in the Quaternary formations. The Rhone glacier has left three such ridges, separated by a few rods interval, that are strikingly similar in topographical eccentricities to the formation under discussion, save in their diminutive size. The two outer ones have been modified by the action of the elements, and covered by grass and shrubs, while the inner one remains still largely bare, and, as they have been cut across by the outflowing glacial streams, they are exceedingly instructive as to glacial action under these circumstances. The inner one graduates in an interesting way into the widespread ground moraine, which occupies the interval between it and the retreating glacier, where not swept by floods, and which presents a different surface contour, illustrative of Till topography. The two Grindelwald glaciers have left similar moraines; those of the upper one, being the more massive, and being driven closer together, present an almost perfect analogy to the Kettle ranges. The Glacier du Bois, the terminal portion of the Mer de Glace, the Argentière, and, less obviously, the Findelen, and others, so far as their situation favored, have developed similar moraines, and indicate that this is the usual method of deposit under these conditions. Reference is here made *only* to the terminal deposit of the *ground moraine*, eliminating, as it is quite possible to do, for the most part, the material borne on the surface of the glacier.

The Material of the Formation. — This topic, which is one of primary importance in determining the origin of the deposit, readily divides itself into three subordinate ones, all of which need discriminative attention; (1) the *form* of the constituents, (2) their *arrangement* as deposited, and (3) their *source*.

(1) Premising that the Kames, and those deposits which have been associated with them in the literature of the subject, are described as composed mainly of sand and gravel, it is to be remarked, in distinction, that *all* the four forms of material common to drift, viz.: clay, sand, gravel, and boulders, enter largely into the constitution of the Kettle range, in its typical development. Of these, gravel is the most conspicuous element, *exposed to observation.* This qualification is an important one in forming an adequate conception of the true structure of the formation. It is to be noticed that the belt, at many points, exhibits two distinct formations. The uppermost—*but not occupying the heights of the range*—consists almost wholly of sand and gravel, and lies, like an irregular, undulating

sheet, over portions of the true original deposit. This superficial formation is confined mainly to the slopes and flanks of the range, and to depressed areas between its constituent ridges; though, when the whole belt is low, it often spreads extensively over it, so as sometimes to be quite deceptive. But, where the range is developed in force, this superficial deposit is so limited and interrupted, as to be quite insignificant, and not at all misleading; and, at some points, where it is more widely developed, excavations reveal unequivocally its relationship to the subjacent accumulations. In such cases, the lower formation shows a more uneven surface than the upper one, indicating that the effect of the latter is to mask the irregular contour of the lower and main formation. Notwithstanding this, the upper sands and gravels are often undulatory, and even strongly billowy, and the bowls and basins in it commonly have more than usual symmetry. A not uncommon arrangement of this stratum is found in an undulating margin on the flank of a ridge of the main formation, from which it stretches away into a sand flat or a gravel plain.

Setting aside this, which is manifestly a secondary formation, it is still true that gravel forms a large constituent of the formation. Some of the minor knolls and ridges are almost wholly composed of sand and gravel, the elements of which are usually very irregular in size, frequently including many boulders. But, notwithstanding these qualifications, *the great core of the range*, as shown by the deeper excavations, and by the prominent hills and ridges, that have not been masked by superficial modifications, *consists of a confused commingling of clay, sand, gravel, and boulders, of the most pronounced type.* There is every gradation of material, from boulders several feet in diameter, down to the finest rock flour. The erratics present all degrees of angularity, from those that are scarcely abraded at all, to thoroughly rounded boulders. The cobble stones are spherically rounded, rather than flat, as is common with beach gravel, where the attrition is produced largely by sliding, rather than rolling.

Stratification. — As indicated above, the heart of the range is essentially unstratified. There is, however, much stratified material intimately associated with it, a part of which, if my discriminations are correct, was formed simultaneously with the production of the unstratified portion, and the rest is due to subsequent modification. The local overlying beds, previously mentioned, are obviously stratified, the bedding lines being often inclined, rather than horizontal, and frequently discordant, undulatory or irregular.

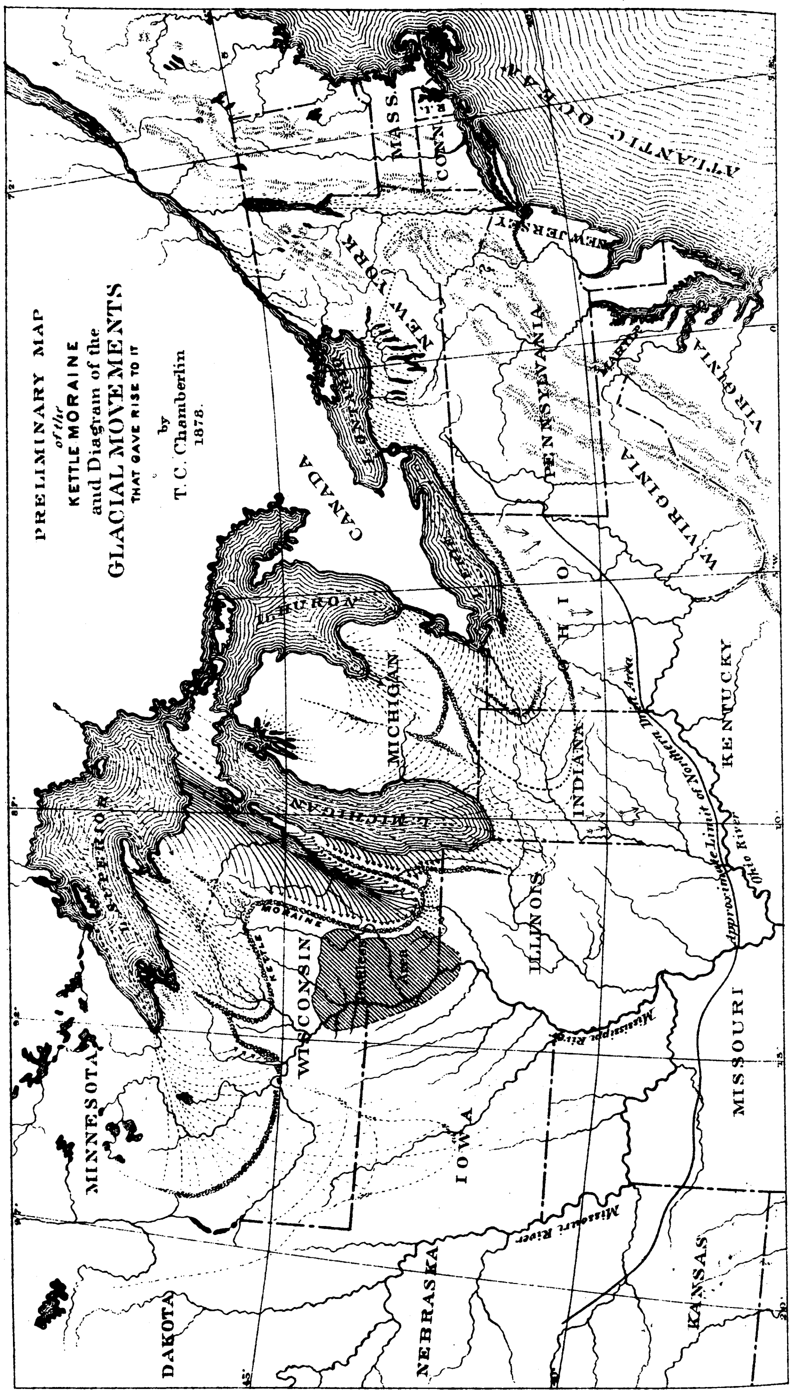
The Source of the Material. — This, so far as the range in Wisconsin is concerned, admits of the most unequivocal demonstration.

The large amount of coarse rock present renders identification easy, and the average abrasion that has been suffered indicates, measurably, the relative distance that has been traveled. The range winds over the rock formations in a peculiar manner, so as to furnish fine opportunities for decisive investigation. Of the many details collected, there is room here for a single illustrative case only. The Green Bay loop of the range surrounds on all sides, save the north, several scattered knobs of quartzite, porphyry and granite, that protrude through the prevailing limestones and sandstones of the region. These make their several contributions to the material of the range, *but only to a limited section of it, and that invariably in the direction of glacial striation.* Any given segment of the range shows a notable proportion of material derived from formation adjacent to it, in the direction of striation; and a less proportion, generally speaking, from the succeeding formations that lie beyond it, backward along the line of glacial movement for three hundred miles or more. It is undeniable, that *the agency, which produced the range, gathered its material all along its course for at least three hundred miles to the northward, and its largest accumulations were in the immediate vicinity of the deposit.* For this reason, as the range is traced along its course, its material is found to change, both lithologically and physically, corresponding to the formation from which it was derived.

These facts find ample parallel in the moraines of Switzerland. The marginal portion of the great moraine of the ancient expanded glaciers, on the flanks of the Juras, is composed, very largely, of boulder clay, derived from the limestones that lie in its vicinity, while the quantity of material derived from the more distant formations of the Alps is quite subordinate. Of the more recently formed moraines, those derived from the Bois, Viesch, Rhone, Aar, and other glaciers, which pass over granitic rocks, consist quite largely of sand, gravel, and boulders, clay being subordinate, while those glaciers of the Zermatt region, that pass mainly over schistose rocks, and the Grindelwald glaciers, that, in the lower part of their course, traverse limestone, give rise to a decided amount of clay. The moraines, previously referred to as miniature kettle ridges, are composed of commingled unstratified debris, in the main, but there are instances of assorted and stratified material. The inner moraine of the upper Grindelwald glacier presents much fine assorted gravel and coarse sand, heaped up, very curiously, into peaks and ridges, in various attitudes on the summit and sides of the moraine.

Relations to Drift Movements. — This is manifestly of most vital consideration. The course of drift movement may be determined, (1) by the grooving of the rock surface, (2) by the direction in which the material has been transported, (3) by the abrasion which rock prominence have suffered, (4) by the trend of elongated domes of polished rock, and, (5) less decisively, by the arrangement of the deposited material and the resulting topography. Recourse has been had to all these means of determination, in that portion of the range that has been carefully investigated, and their individual testimony is entirely harmonious, and their combined force is overwhelming. Exceptional opportunity for positive determination is afforded by the protruding knobs of Archæan rocks before alluded to, from which trains of erratics stretch away in definite lines, continuous with the striation on the parent knobs, and parallel to that of the region, as well as concordant with the general system. The united import of all observations, in eastern Wisconsin, testifies to the following remarkable movements, which may be taken as typical, and which are here given, because they have been determined with much care. Between Lake Michigan and the adjacent Kettle range, the direction was obliquely up the slope, as now situated, southwestward, towards the range. On the opposite side, between the Green Bay valley and the range, the course was, after surmounting the cliff bordering the valley, obliquely down the slope, southeastward, toward the range. In the Green Bay trough, the ice stream moved up the valley to its watershed, and then descended divergingly the Rock River valley. Between the Green Bay valley and the Kettle belt on the west, the course was up the slope, westward, or southwestward, according to position. These movements, which are imperfectly shown on the diagram, exhibit a remarkable divergence from the main channel toward the margin of the striated area, marked by the Kettle range.

Much of the data relating to the movements, outside of Wisconsin, has been derived from a study of publications relating to the geology of the several states, to whose authors I am indebted, but who should not be held responsible for the special collocation presented in the accompanying diagram, which, in some of its details, may prudently be held as somewhat tentative, until more rigorously verified. But the grand features of these movements, which may be confidently accepted, are very striking, and are very singularly related to the great basins of the lake region. The three main channels were the troughs of the great lakes, Superior, Michigan, and the couplet, Erie and Ontario, while between these lay three subordinate ones in the basins of the great bays, Saginaw, Green and Keweenaw.



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The divergence of the striations from the main channels toward the range, in the case of the Green Bay valley, and, so far as the evidence goes, in other troughs, was an unexpected result, developed by combining individual observations; but, when the method of wasting and disappearance of a glacier is studiously considered, appears not only intelligible, but a necessary result, and one which finds partial illustration among existing glaciers.

Topographical Relations and Distribution. — The topographical relations of the formation are an essential consideration, but may be best apprehended in connection with its geographical extension, which now claims our attention. If we start with the northern extremity of the long known Potash Kettle Range, in Wisconsin, we find ourselves about midway between the southern extremity of Green Bay and Lake Michigan, and on an eastward sloping, rocky incline. The base of the range is here less than 200 feet above Lake Michigan, and is flanked on either side by the lacustrine red clays of the region; and seems, in some measure, to be obscured by them. From this point, it stretches away in a general south-southwestward direction, for about 135 miles, ascending gradually, and obliquely, the rocky slope, until it rests directly on its crest.

When within about twenty miles of the Illinois line, *it divides*, one portion passing southward into that state, and the other, which we will follow, curves to the westward, and crosses the Rock river valley. A profile of the rock surface across this valley, beneath the range, would show a downward curve of more than 300 feet. The range should not, perhaps, be regarded as sagging more than half that amount, however, in crossing the valley, as the canon-like channel of the pre-glacial river, seems to have been filled without much affecting the surface contour of the drift. But the fact of undulation to conform to an irregular surface, produced by erosion, and not by flexure of the strata, is a point to be noted, as it is a serious obstacle in the way of any explanation that is only applicable on the supposition that the formation was in a horizontal position when formed, as the view that it was produced by beach action, or the stranding of icebergs.

After crossing Rock river, the range curves gradually to the northward, passing over the watershed between the Rock and Wisconsin rivers, "descends abruptly 200 feet into the low ground of the valley of the Wisconsin,"[1] crosses the great bend of the river, sweeping directly over the quartzite ranges, according to Prof. Irving, with a vertical undulation of

[1] Prof. Irving, Geol. of Wis., Vol. II, 1877, page 616.

over 700 feet, after which it gradually ascends the watershed between the Mississippi and St. Lawrence drainage systems, until its base reaches an estimated elevation of 700 to 800 feet above Lake Michigan. From thence it has been traced across the headwaters of the Wisconsin river, by Mr. A. Clark, under my direction.[1]

Within the Chippewa valley, it has been observed by Prof. F. H. King, of the Wisconsin Survey, and I have observed it in the vicinity of the Wisconsin Central railroad. This region is covered by an immense forest, mainly unsettled and untraversed, even by foot paths, so that geological exploration is difficult and expensive, and, as no industrial importance attaches to it, and the rock below is deeply concealed by it, I have not deemed it sufficiently important to trace the belt continuously to justify the large expenditure of time and means requisite, especially as I entertain no serious doubts as to its continuity and general position. The observations made, indicate that it descends obliquely the eastern slope of the Chippewa valley, and crosses the river below the great bend (T 32, R. 6 and 7), near which the Flambeau, Jump, and several smaller streams gather themselves together, in a manner very similar to that of the branches of the Rock and Upper Wisconsin rivers, just above the point where they are crossed by the range. From this point the belt appears to curve rapidly to the northward, forming the western watershed of the Chippewa. It is joined in eastern Burnett county by a portion of the range coming up from the southwest, the two uniting to form a common range, analogous to that of eastern Wisconsin. The conjoint range thus formed, extends along the watershed of the Chippewa and Nemakagon rivers, to the vicinity of Long and Nemakagon lakes, on the watershed of Lake Superior. This part is given mainly on the authority of Mr. D. A. Caneday, who visited a portion of the formation with me, and whose discrimination can, I think, be trusted. Mr. E. T. Sweet, of the Wisconsin Survey, describes[2] a kettle range as lying along the axis of the

[1] To the eastward of the range, as thus traced, Col. Whittlesey describes (Smithsonian Contributions, 1866) a similar formation in Oconto County. I have observed the same at several points. Mr. E. E. Breed informs me that it occurs on the watershed between the Wolf and Oconto rivers, but it has not yet been traced through the wilderness, to any connection with the main range, and it is uncertain whether it is so connected or constitutes a later formation, as such later moraines have been observed at other points.

[2] Manuscript report on Douglas and Bayfield counties, to form a part of Vol. III, Geol. of Wis.

Bayfield peninsula, but it has not been ascertained that this is connected with the belt under consideration.

Returning to the junction of the two ranges in eastern Burnett county, I have traced the belt thence southwestward through Polk and St. Croix counties to St. Croix lake, on the boundary of the state. The lower portion of this has also been studied by Prof. L. C. Wooster, of the Wisconsin Survey. The southeastern range of the belt may be conveniently seen on the North Wisconsin railroad, near Deer Park, and on the Chicago, St. Paul & Minneapolis line, to the west of the station Turner, but only in moderate force.

If a good surface map of Minnesota be consulted, it will be seen that there lies along the watershed, between the Upper Mississippi and the conjoint valleys of the Minnesota and Red rivers, a remarkable curving belt of small lakes. Along this line, lies a chain of drift hills, known in its northwestern extension as the Leaf hills. In the Sixth Annual Report of the Geological Survey of Minnesota, received just as this article is going to the printer, Prof. N. H. Winchell, speaking of the great moraines of the northwest, says: "There are two such that cross Minnesota, the older being the Coteau and the younger, the Leaf hills. Corresponding to the latter, the Kettle Range in Wisconsin seems a parallel phenomenon."[1] I have seen this belt, west of Minneapolis, and concur in Prof. Winchell's opinion. I have also observed, hastily, what I regard as portions of it—dissevered by the river channels—on the peninsula formed by the bend of the Mississippi and the Minnesota, south of St. Paul, and on the similar peninsula between the Mississippi and Lake St. Croix; and this seems to be the line of connection between the Wisconsin and Minnesota ranges. It appears to me, therefore, well nigh certain, that the Leaf hills of Minnesota are not only analogous to the Wisconsin Kettle range, but are portions of the same linear formation.

The multitude of small lakes, found in Wisconsin, lie almost exclusively either along the Kettle belt itself, or in the area within, or north of it. The surface outside has a much more perfect system of drainage, and is almost entirely free from lakelets. The Kettle range constitutes the margin of the lake district. But in Minnesota, south of the Leaf hills, there is an extensive lake region stretching southward in a broad tongue, nearly to the center of Iowa, though the lakes are

[1] Sixth Annual Rept. Geol. & Nat. Hist. Sur. Minn., p. 106. The R. R. profiles crossing this belt furnish valuable data. See Ann. Rept. for 1872, pp. 53 and 57, and Sixth Ann. Rept., pp. 47 and 156.

not very numerous in the latter state. The question naturally arises, whether this lake district is likewise bordered by similar drift accumulations, and this question, though not essential to the present discussion, has much interest in connection with it. In respect to this, I can only give some detached observations and quotations. As already stated, accumulations of this character occur south of St. Paul. Still further to the southward, in the town of Aurora, Steel county, there is a moderate exhibition of gravelly boulder-bearing hillocks and ridges, accompanied by shallow basins and irregular marshes, much after the manner of the formation in question. From the descriptions of Prof. Harrington,[1] these features appear to characterize the county somewhat widely, especially in the southern part. Near Albert Lea, in the adjoining county, on the south, and only a few miles from the Iowa line, there is a more prominent development of similar features, the ridges having a southwestward trend. Dr. C. A. White, in the Geology of Iowa, describes a terrace in the northern part of the state, which, in its eastern extension, "becomes broken up into a well marked strip of 'knobby country.' Here it consists of elevated knobs and short ridges, wholly composed of drift, and usually containing more than an average proportion of gravel and boulders. Interspersed among these knobs and ridges, are many of the peat marshes of the region."[2] One knob he estimates as rising 300 feet above the stream at its base. This area lies in the line of the preceding localities, and near the Minnesota border. Between the "knobby country" and the Algoma branch of the C., M. & St. P. R. R., and stretching southwestward from the latter, there is a broad belt of low mounds and ridges, some of which show the structure and composition common to the Kettle moraine, while others present externally only a pebble clay, similar to that which characterizes the level country to the west of it. The whole presents the appearance of a low range modified by lacustrine deposits.

Near the center of the state, Dr. White describes a second range under the name of "Mineral Ridge,"[3] as consisting, "to a considerable extent, of a collection of slightly raised ridges and knolls, sometimes interspersed with small, shallow ponds, the whole having an elevation, probably, nowhere exceeding 50 feet above the general surface, but, being in an open prairie region, it attracts attention at a considerable distance." Both of these ridges, Dr. White classes as probable moraines.

[1] Geol. and Nat. Hist. Sur. Minn., Ann. Rept. 1875, pp. 108 *et seq.*

[2] Geol. of Iowa, 1870, p. 99.

[3] Loc. cit.

This Mineral ridge lies south of the lake district, and may be regarded as forming its margin in that direction. On the western border, Dr. White describes "knobby drift," in Dickinson county, which, however, is "without perceptible order or system of arrangement."[1] To the northwest from this, we soon encounter the morainic accumulations of the "Coteac de Prairie,"[2] and the "Cobble Knolls" and "Antelope Hills."

These observations do not indicate a continuous, well defined range, but seem rather to point to a half-buried moraine, that only here and there, along its course, protrudes conspicuously, and this is the impression gained from an inspection of the formation. It is to be noted, as supporting this view, that, at least so far as the eastern side is concerned, this supposed moraine is flanked on the *exterior* by level plains, of smooth surface, often underlaid by sand and gravel, that seemingly owe their origin to broad rivers or lakes that fringed the border of the glacier, in its advanced state, when it probably discharged its waters over the moraine at numerous points, rather than at one, or a few, selected points, as would more likely be the case during its retreat, when accumulations of water could gather along its foot, within the moraine, and large areas be discharged at some single favorable point. But on the inner side of the moraine, the surface, although nearly level, in its general aspect, undulates in minor swells and sags, and the drainage is imperfect. The substratum, instead of being gravel, sand, or laminated clay, is generally a pebble or boulder clay. *Outside* of the moraine, the existing surface contour was formed in the presence, and, to some extent, under the modifying influence, of a fairly established drainage system. But on the *interior*, the drainage system has not, even yet, become fully established, much less impressed itself upon the surface configuration, except in the vicinity of the main rivers.

The terrace-like ridge mentioned by Dr. White, and some of the lines of hills described by Prof. Winchell in Minnesota, as running in a similar direction, may be perhaps regarded as minor morainic lines, stretching across the glacial pathway and marking oscillations in its retreat, analogous to some quite clearly made out in Wisconsin.[3]

[1] Geol. of Iowa, Vol. II, p. 221.

[2] See note of Prof. Mather, Nat. Hist. Sur. 1st Dist., N.Y., p. 193. See also 2d Annual Report Geol. and Nat. His. Sur. Minnesota, by N. H. Winchell, pp. 193 to 195; also *loc cit., ante.*

[3] Geol. of Wis., Col. II, 1876, p. 215 *et seq.*

This southern morainic loop is, of course, presumed to be older than the Kettle range, and is here discussed because of the interesting way in which it is associated with the latter formation, and the suggestions it may contribute to the final solution of the main problem, to which the special one under discussion is only a tributary, viz.: the definite history of the Quatenary formations.

Returning to the branching of the range in southeastern Wisconsin, we find the left arm, or that nearest Lake Michigan, striking southward into Illinois. If we lay before us Prof. Worthen's geological map of that state, and attentively observe its topographical features and its drainage systems, it will be observed that nearly all the lakelets, the greater part of the marshes, and most of the region of abnormal drainage may be included in a curving line, rudely concentric with the shore of Lake Michigan, starting near the center of McHenry county, on the Wisconsin line, and ending in Vermillion county, on the Indiana border. It may also be observed, on a similar inspection of Indiana, that nearly all the lake district lies north of the Wabash.

In Wisconsin, as already stated, we have found this area bordered by the Kettle range, which is itself notably lake-bearing. The range continues to sustain this relationship in Illinois, so far as I know it to be directly continuous. It exhibits a progressive broadening, and flattening, as it enters upon the level county that encompasses the head of Lake Michigan. The pebble clay deposit—not coarse boulder clay—that characterizes the flat country, and which, to the north, has been separated from the range by a belt of coarse boulder clay, here approaches, and appears, to some extent, to overlap the range, and to be one cause of its less conspicuous character. From what I have seen of the region south of Lake Michigan, and from all I can find in geological reports relating to the region, I gather that the range, so far as it escaped the destructive action of the floods issuing from the Lake Michigan basin, both while occupied by ice, and subsequently, is, to a large extent, buried beneath later deposits, or so modified as to be inconspicuous. Whatever the correct interpretation, it remains a fact beyond question, that the belt becomes very obscure, compared with its development to the northward. Dr. E. Andrews says: "As we trace it southward, the material becomes finer, and the hills lower, until they shade off imperceptibly into the drift clay, of the Illinois prairies."[1] The members of the geological corps of Illinois did not recognize it distinctively, in the sense in which it is now considered, but Dr. Ban-

[1]On Western Boulder Drift, Am. Jour. Sci., Sept. 1869, p. 176.

nister, in his report on Lake county, says: "In the western part of the county, near the Fox river, we find the ridges, in some places, to be largely composed of rolled limestone boulders. The same character has been observed further south along the same stream and remarked upon in the chapter on Cook county."[1] In respect to McHenry county he says: "In the vicinity of the Fox river, the same kind of gravel ridges are met with as those which have been described as occurring in the western part of Lake county."[2] This lies in the belt identified by me, from personal observation, as belonging to the Kettle range.

Concerning the district farther south, he says: "Boulders of granite, quartzite, greenstone, and various other rocks are abundant in various localities on the surface of the ground, and are frequently met with in excavations for wells, etc., and large deposits of rolled boulders, chiefly of limestone from the underlying Niagara beds, similar to those already described in the report on Cook county, occur in the drift deposits of the adjoining portions of Kane and Du Page counties."[3] Concerning the topography, the same writer says: "Along some of the principal streams, and especially the Fox river in Kane county, the country is more roughly broken, and can, in some parts, even be called hilly, although the more abrupt elevations seldom exceed eighty or one hundred feet above their immediate base."[4] This broken country, if we may judge from what is true of the rough country along the same river to the north of this, is not due so much to the drainage erosion of the river as to the original deposition of the drift. The same features are said to continue into Kendall county, next south, which brings us to the vicinity of the ancient outlet of Lake Michigan, where, of course, the moraine is locally swept away. Still farther south, in Livingston county, Mr. H. C. Freeman mentions a ridge running southeasterly from a point in La Salle county, to near Chatsworth, a distance of about forty miles. "This is gravelly and sandy, giving it a distinctive character as compared with the adjacent prairie."[5] This is quite too meager to base an identification upon, but I have thought it worthy of quotation here. At Odell, which lies near this ridge, the drift is said to be 350 feet deep.[6]

[1] Geol. Sur. of Ill., Vol.I V, p. 130.

[2] Loc. cit., p. 131.

[3] Geol. Surv. of Ill., Part IV, p.113.

[4] Geol. Surv. of Ill., Part IV, p. 113.

[5] Geol. Surv. of Ill.,Vol. IV, p. 227.

[6] Geol. Surv.of Ill., Vol. VI, p. 237.

On the railroad line from Chicago to Kankakee, there is no recognizable indication of the formation under consideration. Southwestward from Kankakee, on the line to La Fayette, Ind., there are a few mounds and ridges that bear a somewhat morainic aspect, but they are isolated in a generally level tract of lacustrine, rather than glacial, topography. They are, perhaps, remnants of a formation that has been largely eroded or buried. Near Fowler, in Benton county, Indiana, there is a belt of low mounds and ridges, accompanied by shallow depressions, that quite closely resemble the Kettle range in its more modified phases. Boulders appear upon the surface, and, in the more immediate vicinity of the village, are large and numerous. This is probably a portion of the "stream of boulders two miles wide," which Mr. F. H. Bradley mentions as extending through the eastern part of Iroquois county, Illinois, and the central part of Benton county, Indiana,[1] and which he attributes to floating ice. He does not, however, mention the associated topography or underlying drift formation. South of this low range, the country again becomes level, or gently undulating, as far as the Wabash.

The Indiana geologists have not yet critically examined the heavy drift region in the northern part of the state, through which the moraine might be supposed to pass, but in such preliminary inspection as has been made, they have not recognized any prominent moraine-like accumulation. The superficial expression of the region is quite monotonous, and presents to view deposits of sand, gravel, lacustrine or pebble clays, but more rarely the coarse boulder clay or mixed material, that I regard as the unmodified ground moraine. The modifying agencies which produced this phase of the deposits, would be antagonistic to ridge-like morainic accumulations, and their presence, in sharp outline, is not to be expected. In the vicinity of Ligonier, in Noble county, there is a feeble, but somewhat characteristic development of some of the features of the formation. So also, in the vicinity of Rome and La Grange to the northeast. Between La Port and Otis there is a kindred, though somewhat peculiar formation, but I am in doubt as to its true character.

On entering Michigan, we find the formation more unequivocally developed. Just north of Sturgis, which is near the southern line of the state, the formation appears in marked development. It does not attain a great altitude, but presents the peculiar strongly undulating and hummocky contour, and the coarse, mingled material, character-

[1] Geol. Surv. of Ill., Vol. VI, p. 236.

istic of the deposit. It may be seen to advantage on the line of the Grand Rapids & Indiana R. R. To the northeast in the vicinity of Albion, it may be seen from Springport on the north, to Condit on the south. It is here broad and flat, and superficially composed of gravel, for the greater part, but some of the deeper excavations reveal the characteristic coarser material. On the Michigan Central R. R., the formation may be observed between Jackson and Dexter, the most prominent portion being between the stations Francisco and Chelsea. It is not very prominent on the immediate line of the road, which was doubtless selected to avoid it, but in the vicinity it rises into prominent hills and ridges. Some of these, on the north, are conspicuous objects at considerable distances. Still farther to the northeast, my friend, Dr. D. F. Boughton, whose identifications I have elsewhere verified, informs me that the range is well developed in Oakland county, and is finely exhibited near the line of the Flint & Pere Marquette R. R., between Plymouth and Holly. Still farther to the northeast, it may be seen at great convenience and advantage, along the Detroit & Milwaukee R. R. from Birmingham, below Pontiac, to Holly. On the flanks, its features are subdued, the hills and ridges being rather low, with more or less level surface between them, and the superficial sands and gravels are prevalent; but from Waterford to beyond Clarkston, the range has a fine, though irregular development. The hills rise with characteristic contours, to an estimated altitude of 200 feet or more above the surface of the beautiful lakelets embosomed at their base. The deep cuts near the latter station, amply exhibit the coarse, commingled material, characteristic of the core of the range.

Putting the foregoing observations together, they seem to establish beyond reasonable doubt the existence of a broad, massive belt stretching northeastward on the highland between the Saginaw and Erie basins.

If we return again to the southwestern part of the state, we are informed by Dr. Boughton that we shall find a similar accumulation at, and in the vicinity of, Kalamazoo. To the north-northeast, in Barry county, the Thorn Apple river cuts across this range between Sheridan and Middleville. This belt here, though broad, presents a more prominent and ridge-like aspect, with better defined limits than elsewhere observed in Michigan. To the north of this, opposite Saginaw bay, there occurs, near Farwell, broken, rough country and abundant coarse drift, that probably belongs to the belt in question, but my opportunity for observation was unsatisfactory. Beyond this point, I have no definite information, but I deem it highly probable that the moraine will be found extending some distance farther, on the highlands of the Peninsula.

The lake survey charts show that Grand Traverse bay has the remarkable depth of over 600 feet. This great depth, together with its linear character, and the form and arrangement of the associated inlets and lakes, has suggested that it may have been the channel of a separate minor glacier, analogous to that of Green Bay on the opposite side of the great lake, but I have no direct evidence that such was the fact.

In the reports of the geological survey of Ohio, a formation of nearly, or quite, identical characteristics is carefully described by the several writers whose districts embraced it. In the second volume,[1] Dr. Newberry gives, under the name of "Kames," an excellent summary of its leading features. These harmonize very nearly with those of the Kettle belt. The main points of difference are the less conspicuous character and massiveness of the Ohio range, and the greater prevalence of assorted and stratified material; in other words, its features are the same that the Kettle range presents in its more subdued aspects, especially where it is formed in a comparatively smooth country, and is flanked by pebble clays, with level surface, instead of coarse boulder clay, with ridged, or mammillary, contour. I cannot turn aside, here, to define, with sufficient circumspection, the distinction between these clays, further than to indicate my belief that the former are sub-aqueous, and the latter sub-aerial, or, if you please, sub-glacial, deposits.[2]

Where I have seen the Ohio formation, it presents almost precisely the characteristics that are exhibited by the Kettle range in northern Illinois, where it is similarly related to plane topography and pebble clays, and it is also very similar to the same formation opposite Green Bay, where it is bordered on both sides by red lacustrine clays of later date. Dr. Newberry quite clearly recognizes the parallelism, but perhaps not the identity, of the formations.[3] Col. C. Whittlesey, in his

[1] Pages 41–47. See also "Surface Geology of Northwestern Ohio," Proc. Am. Assoc. Ad. Sci. 1872, by Prof. N. H. Winchell, under heads of St.Johns and Wabash Ridges.

[2] I have mapped these formations separately in eastern Wisconsin. See Atlas accompanying Vol. II, Geol. of Wis. 1877, Plate III, Map of Quaternary formations. See also, p. 225 of the volume.

[3] Geol. Surv. of Ohio, Vol. II, pp. 4, 5, and 453. Dr. Newberry's views as to the origin of the Ohio "Kame" belt are at variance with those here presented.

article on the "Fresh Water Glacial Drift of the Northwestern States,"[1] classes the formations together as identical in character, though he does not seem to have considered them members of a continuous formation, and could not well do so with the prevalent view, which he somewhat emphasizes, that it is peculiarly a *summit* formation. It very often does occupy the summit of a rock terrane, and it sometimes *forms* a watershed by its own massiveness, but it likewise occupies slopes and crosses valleys, as shown in detail in the Wisconsin report. Prof. Andrews of the Ohio survey, in a personal communication, adds his conviction that the Ohio and Wisconsin deposits are parallel formations. It would seem, then, that the only question relates to the *continuity* of the belts. Unfortunately there intervenes the Wabash valley, the ancient drainage channel of the Erie basin. Absolute continuity undoubtedly does not exist. If my views are correct, this was the great—not exclusive—channel of discharge of the glacial floods, at the very time the moraine was being formed, where it could be formed, and, for that reason, the debris was swept away or leveled. In addition to this, the region has been subjected to the vicissitudes of erosion, of a reversal of drainage systems, and of lacustrine and fluviatile accumulation. It is to be presumed, therefore, that a portion of the range, where once formed, has been lost, leveled, or buried. Some remnant indications of the range, on the upper slopes, might, however, rationally be presumed to exist. But, awaiting a critical examination of the region, we must confess a want of direct evidence. The belt stretches entirely across Ohio and enters Indiana, but has not been traced farther.

In the line of indirect testimony, however, some facts may be noticed. Prof. N. H. Winchell describes in the Ohio reports[2] six ridges running parallel to Lake Erie, and Mr. G. K. Gilbert has described that portion of these which lie in the more immediate Maumee valley.[3] Two of the inner ones are conceded to be lake beaches. The two outer ones are members of the "Kame," or Kettle belt, according to Dr. Newberry.[4] The one next within, the St. Mary's ridge, Prof. Newberry distinguishes, apparently, with justness, from both the other classes. Mr. Gilbert gives a clear and discriminating description of this, and expresses the conviction that it is "the superficial represen-

[1] Smithsonian Contributions, 1866.

[2] See also Proc. Am. Assoc. Ad. Sci., 1872.

[3] Geol. Sur. Ohio, Vol. II, pp. 56 and 57.

[4] Geol. Surv. Ohio, Vol. I, pp. 537 *et seq.*

tation of a terminal glacial moraine, that rests directly on the rock bed and is covered by a heavy sheet of Erie clay, a subsequent aqueous and iceberg deposit."[1] The views of Professors Newberry and Winchell, while they each differ somewhat, agree with this in the only point essential to the present discussion, viz: *that this ridge represents the margin of the glacier at the time it was formed.* This shows the glacier to have been a tongue or lobe of ice, differentiated from the supposed continental glacier, and having its axis coincident with the Maumee valley, and, withal, capable of forming a morainic accumulation on both sides. The St. Mary's ridge crosses the Maumee-Wabash valley—the glacial trough—and, recurving upon itself, bears away to the northeast, approximately parallel to the Kettle belt already described in southeastern Michigan. This wing of the St. Mary's ridge bears the same relation to the Kettle belt bordering the Erie basin on the Michigan side, that the opposite wing does to the "Kame" belt on the south side. The force of this relationship is not easily escaped.

If my views are correct, that this Michigan belt was formed along the right hand margin of the Erie glacier (conjointly with the Saginaw glacier), just as the "Kame" belt was formed on the left hand margin, then its composition should give evidence of the fact. In the case of the Green Bay glacier, I have shown that the lines of striation and transportation diverge from the main axis toward the margin,[2] and, so far as the paths of other glaciers lie within Wisconsin, the observations made upon them, imply the same method of movement, and this habit finds partial exemplification among the glaciers of the Alps — partial, because their contracted valleys and steep slopes afford little opportunity to deploy in this fashion. If this manner of movement holds true with the Erie glacier, material from its trough will be found to have been transported westward and northwestward toward the moraine. Thirteen years ago, in an article in the American Journal of Science, entitled, "Some Indications of a Northward Transportation of Drift Material in the Lower Peninsular of Michigan,"[3] Professor Alexander Winchell called attention, with much detail and precision, to a large mass of evidence, which finds, for the first time, so far as I am aware, satisfactory explanation in the view now presented, and, in return, has the force of confirmatory evidence. It appears that immense, and often but slightly eroded masses of Corniferous limestone,

[1] Loc. cit.

[2] Geol. of Wis., Vol. II, pp. 199 *et seq.*

[3] Am. Jour. of Sci.,Vol. XL, Nov., 1865.

have been borne in the direction indicated, and scattered over the areas of the Hamilton group, the Marshall sandstone, and the Subcarboniferous limestone; that similar blocks of Hamilton rock have been deposited over the two last named formations and even beyond; that the Marshall sandstone has likewise been borne on to the Carboniferous limestone, and that this transportation has been from lower to higher levels, as the strata now lie, and are presumed to have lain, since the basin is one of excavation and not of flexure. These phenomena, in all their details, are precisely what we should expect from the action of a glacier advancing through the Erie valley, and moving in a manner analogous to that of the Green Bay glacier. That a glacier moved through this valley has been abundantly shown by the Ohio geologists. The only labor of this article is to show that it was an individualized stream, forming the Ohio "Kame" belt on one side, and the Michigan on the other, simultaneously, and that they are collateral members of a common moraine.

Eastward from Ohio, there has been, so far as I am aware, no definite attempt to trace out the extent of the belt. In western New York, Prof. Hall mentions, as one of the three general aspects of the superficial deposits, a surface "broken into irregular hills or ridges, with deep bowl-shaped depressions, or long valleys, which often communicate in more extensive ones, or are enclosed on all sides by drift,"[1] but he does not definitely locate the formation, or indicate whether it assumes the form of a belt, or otherwise. In central New York, Prof. Vanuxem says: "There is another class of deposits, well defined as to position, but irregular as to composition, which are worthy of note. They occur in the north and south valleys, which are on the south of the Mohawk river, or the great level." "The whole of these deposits have a common character. They are in short hills, quite high for their base and are usually in considerable numbers." "They consist of gravel, stones, of stones also of greater size, sand and earth."[2] These, he says, greatly resemble the "deluvial elevations" noticed in the survey of Massachusetts,[3] the description of which is perfectly applicable to the formation under consideration. Furthermore, Prof. F. H. King, of the Wisconsin survey, has examined the same deposits in the vicinity of Ithaca, and recognizes their identity in kind. Neither of these observers, however, discern a definite belt, although Prof. Vanuxem destroys the force of his apparent limitation of the formation

[1] Nat. Hist. Surv. 4th Dist., Geol., Pt. IV, pp. 320, 321.

[2] Nat. Hist. Surv. N.Y., 3d Dist., p. 218.

[3] Geol. of Mass., E. Hitchcock, 1833, p. 144.

to the valleys, by stating that there are numerous points where it has formed over the hill sides, and by associating in mention with it accumulations on the "heights, apparently in no regular order."[1] As these are deep, canon-like valleys, they would probably modify in some degree, the comparatively thin margin of the glacier, giving it a somewhat digitate outline, and the greatest accumulations would take place near the extremities of the tongues, in the valleys, so far as drainage permitted; while the connecting chains would form retreating lines, and be less conspicuous, and might, therefore, escape observation not definitely turned to the subject. This, at least, is suggested by some observations of my own in similar situations. Such valley accumulations, however, do occur at the extremities of linear glacial lakes that are unconnected with a definite belt, as in the case of Green Lake, Wisconsin.[2]

On the line of the Erie R. R., along the small tributary of the Delaware river that is followed up, westward, from Deposit, I have observed winding Osar-like ridges, parallel to the valley, and Kame-like hills upon the slope, up to the watershed of the Delaware and Susquehanna; likewise in the valley of the latter, at and near the village of Susquehanna, but I have no knowledge of their intimate structure, extent or relations.

In the southeastern district of New York, Prof. Mather recognizes the distinctive aspect of this class of accumulations.[3] He cites several instances of its occurrence on the east side of the Hudson, leaving the impression that they are local features. But on Long Island, it forms "an elevated ridge, called by some 'Green Mountains,' and by others, the 'Backbone' of the island.[4]

This he describes in detail and maps, showing that it branches at the east, one chain extending along the southern peninsula to Montauk Point, and the other, along the northern to its extremity, and, theoretically, to the islands beyond.

Professors Cook and Smock have recently examined this, and have shown its connection with a similar moraine, that stretches across the northern part of New Jersey, from Perth Amboy to the Delaware river, below Belvidere.[5] The descriptions of this range tally quite perfectly with that of the Kettle moraine. This range, however, lies on the mar-

[1] Loc. cit., p. 219.

[2] Nat. Hist. Surv. N.Y. 1st Dist., Pt. IV, p. 212.

[3] Geol. of Wis., 1877, Vol. II, p. 138.

[4] Loc. cit., p. 161.

[5] Ann. Rept. of State Geologist, N.J., 1877, pp. 9 *et seq.*

gin of the area of northern drift, while the western one is medial in position, and at some points is quite distant from the margin. It will be observed, nevertheless, that this distance is greatest, in general, at the west, and that in Ohio it becomes very greatly reduced, so that the fact of coincidence on the Atlantic coast, presents no reason for supposing the ranges to be distinct. But, whether distinct or not, is a matter to be settled by observation, and it is to be hoped that it will not long remain undecided for want of it. The extension of the New Jersey moraine westward has not, so far as I can learn, yet been traced, but the survey of Pennsylvania, in progress, will, doubtless, soon leave nothing to be desired, so far as that State is involved.

To the eastward, Mr. Warren Upham has recently been engaged in studying its probable continuation in southeastern Massachusetts. In a personal communication he writes: "A very clear line of terminal moraine extends along the chain of the Elizabeth islands southeast of Buzzard's Bay; thence it bends to the northeast and north as far as to North Sandwich, when *it turns at a right angle* to the east, and extends through Barnstable and other towns to Orleans, running along the east and west portion of Cape Cod, and terminating at its east shore." "This terminal moraine, like the 'Kettle moraine', is not at the outmost limit reached by the ice-sheet; for hills, in series nearly parallel to the moraine already described, and similarly composed of glacial drift with many boulders, occur on Martha's Vineyard and Nantucket islands, corresponding, perhaps, to the terminal moraine which forms the 'backbone' of Long Island. * * The moraine of the Elizabeth islands and Cape Cod has a length of about 65 miles." It may be suggested that the range along the Elizabeth islands may correspond to the northern branch of the Long Island moraine described by Prof. Mather, and that, as Mr. Upham suggests, that of Martha's Vineyard and Nantucket corresponds to the southern.

Dr. E. Hitchcock refers to these accumulations in his report on the geology of Massachusetts,[1] and classes with them "diluvial elevations and depressions," occurring at other points in that and adjoining States. It would appear, from the geological reports of the Eastern States that analogous, though not certainly identical formations, occur locally, more frequently than in the interior, and this, from the mountainous nature of the country, is not strange; but no continuous massive range seems to have been discerned, except the southern one already described.

[1] Geol. of Mass., 1883, pp. 144 *et seq.*

In the interior, so far as yet ascertained, the drift limit is not marked by any such persistent ridge-like accumulation, but gradually dies away or is buried by later deposits, so that the precise limit of glacial advance is not easily determined. The only approach to an exception to this, known to me, is the case of the Kettle moraine in Central Wisconsin, where it lies near the border of the driftless area. Elsewhere around that area, the drift thins out very gradually, so as to render the mapping of its margin a work of close inspection; and, as the region presents no evidence of subsequent submersion, or any other special modifying agency, except the usual meteorological forces, this would seem to represent approximately the original form of deposit.

It is evident from the foregoing sketch that much observation remains to be made before the complete geography of this formation is determined. The conjectural lines on the map are only theoretical suggestions, preliminary to observation.

Summary. — It may be helpful at this point to summarize, and bring into close juxtaposition, in thought, the leading characteristics of this remarkable formation.

1. Its linear extent is very great, whatever its final limits may be found to be.

2. It has a width of from one to thirty miles.

3. Its average vertical thickness can only be very roughly estimated, but may, very prudently, be placed at 200 or 300 feet.

4. Its surface configuration is peculiarly irregular, and denotes an extraordinary origin.

5. It is a complex range, the component ridges being often arranged in rude parallelism.

6. A distinction is usually to be observed between the superficial and lateral portions of the deposit on the one hand, and the central, underlying one on the other, the former being chiefly sand and gravel, the latter complex commingled debris.

7. The superficial sands and gravels are usually stratified in various attitudes, but the core of the range is mainly unstratified.

8. The irregularities of the range are most conspicuous where the superficial sands and gravels are least abundant.

9. The material was derived, in part, conspicuously so, from the vicinity of the range, and, in part, from the formations lying backward along the line of drift movement for at least 300 miles.

10. A portion of the material is spherically rounded, a part is scratched and polished, and some is little affected, though sometimes soft or friable, the latter being usually from adjacent formations.

11. The range is tortuous in its course, but sustains a remarkable and significant relationship to the great lake basins.

12. It undulates over the face of the country, varying at least 800 feet in its vertical oscillations.

13. It does not sustain any uniform relation to present, or what are presumed to have been, preglacial drainage systems in their details. In some portions, it occupies water-partings; in others, lies on slopes; and in still others, stretches across valleys.

14. It crosses, in its course, all the indurated formations, from the Laurentian to the Coal measures, but exhibits no specific relation to their strike or dip.

15. It sustains a definite and most important relationship to the lines of general drift movement.

16. The range is frequently flanked on its southern, or outer edge, by level areas of sand and gravel, of greater or less extent. These also occur between the component ridges of the belt, and on the inner flank, but less frequently.

17. The surface contour of the adjacent region within, or north of, the belt, usually, though not invariably, has a less perfect drainage system, and exhibits less noticeably the effects of superficial modification, than the outer side.

Origin. — Waiving, for the present, some further generalizations, it is thought that the foregoing phenomena present a *specific combination* which points unequivocally to a morainic origin. To the writer, familiar with the multitudinous details, that cannot here find a place, and having studied recent moraines with special reference to this formation, they have a force little less than demonstrative. The range is confidently regarded as a moraine formed at the margin of a group of glaciers—which may be regarded as a single lobate one—and marking a definite stage of their history. A more vivid and graphic view of the outline and movements of these glaciers, than can be given in words, may be obtained from the accompanying map, from which it will appear that through each of the great lake troughs there poured an ice stream, attended by minor currents through the lesser channels.

Its Medial Position. — It has already been remarked that, in the interior, this moraine does not mark the extreme limit of glacial advance. Numerous striations, and other evidence of glaciation, occur on the south side of it. A line has been drawn on the map intended to indicate the approximate limit of northern drift, based on several authorities.[1] How

[1] Tesley, Newberry, Cox, and assistants, Worthen, Swallow, and Mudge.

nearly this shows the limit of actual glacial progress, in distinction from other means of transportation, is not, I think, as yet definitely ascertained, but the general fact of progress, to a considerable distance beyond the Kettle moraine, is sufficiently established. The moraine was, therefore, formed *after the retreat of the glacier had commenced, and marks a certain stage of its subsequent history.*

Glacial Movements before the Formation of the Moraine. — It becomes an interesting question to ascertain whether the glacial movements were the same before the formation of the moraine, as afterwards. Fortunately, in southern Wisconsin, we have very definite and specific evidence bearing on this question. In the towns of Portland and Waterloo, which lie within the area of the Green Bay glacier, and from twenty-five to thirty miles distant from the moraine, there are several domes of quartzite that rise through the horizontal sandstones and limestones, which occupy the surrounding region. These domes are glacially abraded and grooved in a direction S. 30° W., and trains of quartzite boulders stretch away in that direction to the moraine, and, mingling with it, pass onward to an equal distance beyond. At the same time there is abundant evidence from the material of the drift, from the surface contour and from striation, recently observed by Mr. I. M. Buell, that the westerly movement of the Lake Michigan glacier, near the Illinois line, extended to the west side of Rock River, and that the line of junction of the two glaciers was on the west side of that stream. It appears then, that in this region, the movements were in the same general direction before and after the formation of the moraine, but that there were changes in the details, and that the relative size and position of the glaciers were somewhat different, the Green Bay glacier being relatively smaller in the earlier epoch. Testimony of similar general import, but less specific, may be gleamed [sic] from the reports of the other states involved.

Method of Formation. — If, then, the glacial movements were the same, in general, before and after the formation of the moraine, and yet the minor movements and relative size of the glaciers somewhat different, how was the moraine formed? A halt in the retreat of the glaciers, by which their confluent margin should remain stationary for a period, would doubtless cause an unusual accumulation of debris, but this would fail to account for the varying width or irregularities of the moraine. The structure of the range seems to indicate an alternating retreat and advance of the ice mass. During the former, debris was thrust out at the foot of the melting mass, which, when the glacier advanced, was plowed up into immense ridges. If this process be repeated several times parallel ranges will be accounted for, and the irregularities incident to such advance and retreat will explain the complexity of the range. Where the later advances were equal to the earlier ones, the accumulation of drift material would be forced into a single massive ridge. Where any advance failed to equal a former one, an interval between the accumulations of the two would result, giving rise to a depression whose form would depend upon the relations of the two accumulations, but would in general be more or less trough-like in character. Where tongues of ice were thrust into the accumulated material an irregular or broken outline would be the result. If masses of the ice became incorporated in the drift, as has been suggested, their melting would give rise to depressions, constituting one form of the kettles that characterize the range. The suggestion just made, with reference to the irregular advance of the ice mass, accounts for other forms, and, at the same time, for the irregular hills, mounds, and hillocks. Certain of the kettles may be due to underdrainage, through the action of strong underground streams that occasionally flow, as full brooklets, from its base. The drainage of the glacier, while it was advancing and pushing the debris before it, was probably quite general and promiscuous *over* the moraine, and this would give rise to the stratified sands or gravels, and other evidences of the action of water, among which may perhaps, be reckoned some of the minor mounds, ridges and depressions. The changing attitudes, which the debris would be likely to assume, as it was forced along, would, perhaps, give peculiar force to torrential effects.

The gaps in the range, attended by plains, or long streams of gravel and sand, appear to represent the more considerable points of discharge of the glacial floods. When the surface about the margin of the glacier permitted the accumulation of water, the moraine would doubtless be much modified by it and present a subdued aspect.

The Alpine moraines, above referred to, are regarded as miniature exemplifications of the process by which the Kettle moraine was formed.

But, in addition to the structure of the range, the change in the relative position of the Green Bay and Lake Michigan glaciers, already alluded to, affords evidence of an exceedingly interesting character, which has a significance much beyond what can be here indicated. It appears that the junction between the Green Bay and Lake Michigan glaciers at the last observable stage, preceding the formation of the Kettle moraine, was about twenty-five miles farther west, than at the time of the latter's formation, or in other words, there is an abrubt easterly shift of the line of junction. It appears, also, that the width of the ante-morainic Green Bay glacier, measured just south of the Kettle moraine, was only half that of the post-morainic glacier, north of it, measured at a distance just far enough to escape the terminal curvature. An inspection of the outline of the Green Bay glacier shows that this eastward shift of the junction of the two glaciers was not due simply to encroachment on the Lake Michigan stream, nor to a common movement of both in that direction, for the opposite margin of the Green Bay glacier lay close upon the borders of the driftless region, demonstrating that there was no eastward swaying on that side. Indeed, the indenture of the outline of the driftless area strongly suggests actual encroachment on that side also, and this view is not without independent support.

In harmony with these phenomena are the fiords of the Green Bay peninsula, which indicate that the Green Bay ice stream overflowed into the basin of Lake Michigan. These facts, taken altogether, seem to warrant the belief that both glaciers retreated sufficiently far to the northward, and within their respective basins, to allow time and opportunity for the change in the relative size and position of the two ice streams, and that, under slightly changed conditions that favored the Green Bay glacier, they advanced to the position of the Kettle moraine, and, after a series of oscillations, retreated permanently. This view seems also to be demanded by certain details in the distribution of the drift material that are otherwise enigmatical, but whose discussion would too much extend this article.

Significance. — As forty-five years have passed since Dr. Hitchcock called attention to some of the phenomena under consideration, or, at least, to some distinctly related to it, and yet, the matter has received so little consideration, that our present knowledge is limited to such a degree, that I lay myself liable to the charge of undue temerity in attempting to correlate the observations, I may be pardoned in attempting to indicate, briefly, something of the significance and importance the foregoing conclusions, if sustained, have in relation to the Quaternary history of the region involved. The moraine constitutes *a definite historical datum line*, in the midst of the glacial epoch, and becomes a basis of reference and correlation for adjacent formations. It is an historical rampart, outlining the great dynamic agency of the period, at an important stage of its activity, and separating the formations on either hand by a chronological barrier. It is manifest that the true Boulder Clay, or ground moraine, south of the belt, must have been formed earlier than that north of it, and that the two portions are not at all synchronous. In sedimentary formations synchronism is found in horizontal strata, but in glacial deposits it is to be sought in linear belts, concentric with the margin of the glacier. This fact finds illustration, and emphasis, in the demarcation introduced by this singular corrugation of the wide-spread glacial sheet. It is difficult to limit the value of such a determinate line, in the midst of the complex drift formations, if fully established, and should similar belts be found to mark other stages of glaciation, there would be opened a definite line of investigation that promises much assistance in unraveling the gnarled skein of Quaternary history.

While it does not follow, necessarily, that all formations overlaying the true glacial clay, south of the Kettle moraine, are older than those occupying similar relations to the newer Till, north of it, it is clear, that similarity of stratigraphical sequence is not, by any means, sufficient ground for assuming chronological equivalence. It is evident, that all endeavors at correlation between the superficial deposits, on the opposite sides of the moraine, should be attempted with much circumspection.

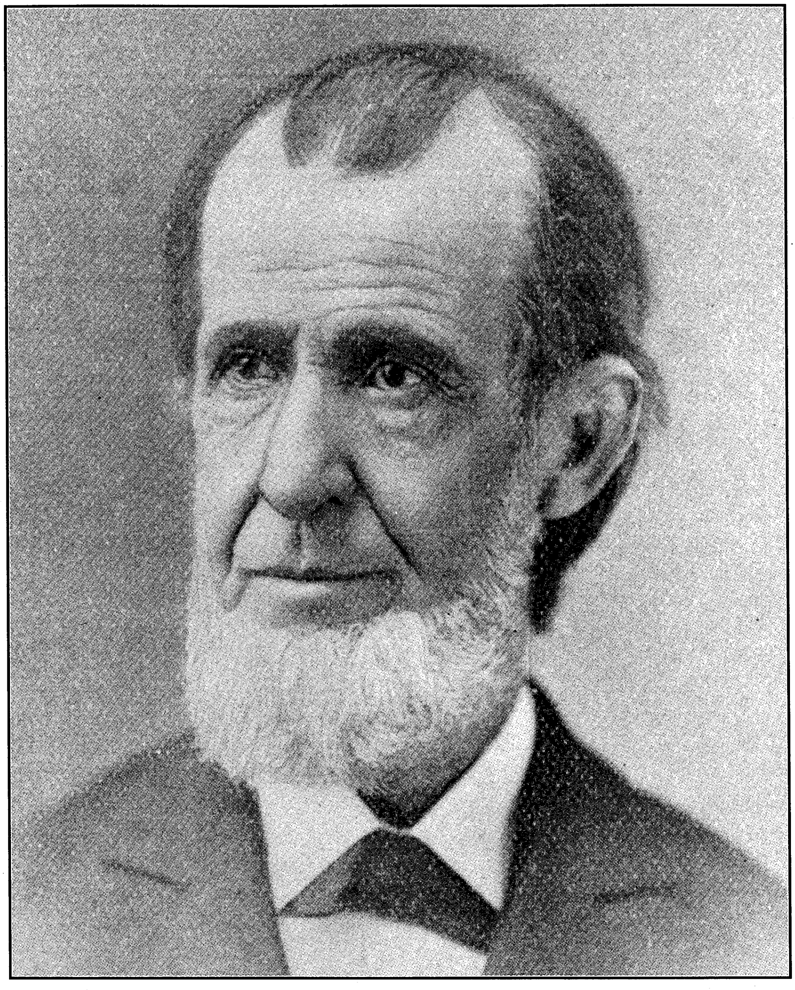
These suggestions have especial application to the discussion of the vegetal deposits, so frequently found in the later Quaternary formations. By many writers, the various deposits of this kind, in the Mississippi basin, have been, very naturally, in the present state of our knowledge, grouped together without reference to the necessary discriminations above indicated, and, as a result, beds of diverse age are referred to a common stratum. A general discussion of these deposits is not sufficiently germane to our subject to be fittingly introduced here, but it is appropriate to point out the fact that some of the vegetal strata sustain such a relation to the Kettle moraine, that they must be widely separated from others, in the date of their accumulation and burial. Some of these organic strata lie at the immediate foot of the moraine, beneath fluviatile and lacustrine deposits that, I am confident, began to be accumulated during the accumulation of the moraine, and through the agency of glacial floods; while it is even more certain, that other vegetal deposits accumulated much subsequently, as those found in the red clays of Wisconsin, which are lacustrine deposits of the great lakes formed after the recession of the glacier. It would be too much to assume that all plant remains, found south of the moraine, antedate its formation, but it is safe to affirm that, with only phenomenal exceptions, e.g., such as escaped glacial abrasion, all north of it are more recent.

The bearing of these definite determinations of the glacial outlines and movements upon the question of the origin of the remarkable driftless area of Wisconsin, Minnesota, Iowa and Illinois (see map) was early perceived, and it was clearly foreseen that this line of investigation promised a *demonstrative* solution of the problem. The driftless area manifestly owes its origin to the divergence of the glaciers through the Lake Superior channel, on the one hand, and that of Green Bay and Lake Michigan, on the other, and to the obstacle presented by the highlands of northern Wisconsin and Michigan. This obstacle the glacier surmounted, and passed some distance down the southern slope, but apparently not in sufficient thickness to overcome the melting and wasting to which it was subjected, and so it terminated midway the slope. But the deep, massive ice currents of the great channels pushed far on to the south, converging toward each other; and, if they did not actually unite, at least commingled their debris south of the driftless area.[1] An instance closely similar to this, considered from a dynamical point of view, may be seen, at the present termination of the Viesch glacier, and illustrations of the general principles involved in the explanation may be seen in connection with several other Alpine glaciers.

If the evidence adduced to show that the Kettle moraine was due to an advance of the glaciers be trustworthy, then, to the extent of that advance, whether much or little, the moraine marks a secondary period of glaciation, with an interval of deglaciation between it and the epoch of extreme advance. Its great extent indicates that whatever agency caused the advance was very wide spread, if not continental in its influence. The moraine, therefore, may be worthy of study in its bearings upon the interesting question of glacial and interglacial periods.

It will also furnish definite data bearing upon the somewhat mooted question of the origin of the Great Lakes, as well as other questions involving both perglacial [sic] and postglacial topography.

[1] Compare N. H. Winchell in An. Rep., Geol. of Minn., 1876, and R. D. Irving, Geol. of Wis., Vol. II, 1877, whose views are closely analogous to the above and each to the other but are not strictly identical. See, also, J. D. Dana, Am. Jour. Sci., April 1878.



Philo Romayne Hoy, M.D.
(1816–1892)

Physician, surgeon, and scientist; collector of plants, fossils, and relics of aboriginal life; charter member and second president of the Wisconsin Academy, 1876–78

THE LARGER WILD ANIMALS THAT HAVE BECOME EXTINCT IN WISCONSIN

(Read at the Racine meeting)

BY DR. P. R. HOY

A record of the date and order in which native animals become extinct within the bounds of any country is of present interest, and in the future may be perused with redoubled satisfaction.

Fifty years ago the territory now included in the state of Wisconsin was nearly in its primitive condition. Then many of the larger wild animals were abundant. Now all has changed; the ax and plow, gun and dog, railway and telegraph, have completely metamorphosed the face of nature. Not a few of the large quadrupeds and birds have been exterminated or have hid themselves away in the wilderness of northern Wisconsin.

There was a time, away back in the dim past, when the mastodon, ox, elephant, tapir, peccary, and musk-ox roamed over the ancient prairies of Wisconsin, but now only their bones, from time to time, are exhumed and thus exposed to the wondering gaze of the ignorant many and the trained eye of the wiser few. We shall at this time, however, confine our attention to the historic period.

The antelope, *Antilocarpa Americana*, now found only on the western plains, did, two hundred years ago, inhabit Wisconsin as far east as Lake Michigan. In October, 1679, Father Hennepin, with La Salle and party, in four canoes, coasted along the western shore of Lake Michigan. In Hennepin's narrative he says: "The oldest of them" [the Indians] "came to us the next morning, with their calumets of peace, and brought some *wild goats*." This was at or near Milwaukee. "Being in sore distress, we saw upon the coast a great many ravens and eagles, from whence we conjectured there was some prey, and having landed on that spot we found above the half of a fat wild goat which the wolves had strangled. This provision was very acceptable to us, and the rudest of our men could not but praise the Divine Providence which took so particular care of them." This was, undoubtedly, near Racine. "On the 16th" [October 16, 1679] "we met with abundance of game; a savage we had with us killed several stags and *wild goats*, and our men a great many turkey, very fat and big." This last point was between Kenosha and Racine. Hennepin's goats were without doubt antelopes. Father Joliet, a little earlier, mentions that "on the Wisconsin there are plenty of turkey cocks, parrots, quails, wild oxen, stags and wild goats." All species of the deer family were called stags by the early travelers. Schoolcraft mentions antelopes as occurring in the Northwestern Territory, and as late as 1850. Antelopes were not uncommon in southern Minnesota, only forty miles west of the Mississippi river. It is evident, then, that antelopes have retired quite leisurely.

When the last buffalo, *Bos. Americana*, crossed the Mississippi is not precisely known. Governor Dodge told me that buffalo were killed on the Wisconsin side of the St. Croix river the next year after the close of the Blackhawk war, which would be 1833. So Wisconsin had the last buffaloes east of the Mississippi river.

The Woodland Caribon, *Rangifer Caribou*, were probably never numerous within the limits of the state. A few, however, were seen near La Point in 1840; none since.

Elk, *Cervus Canadensis*, were on Hay river in 1863, and I have but little doubt that a few still linger with us. The next to follow the buffalo, antelope and reindeer.

Moose, *Alce Americanus*, continue to inhabit the northern part of the state, where they still range in spite of persecution. A fine cow moose was shot near the line of the Wisconsin Central Railway in December, 1877.

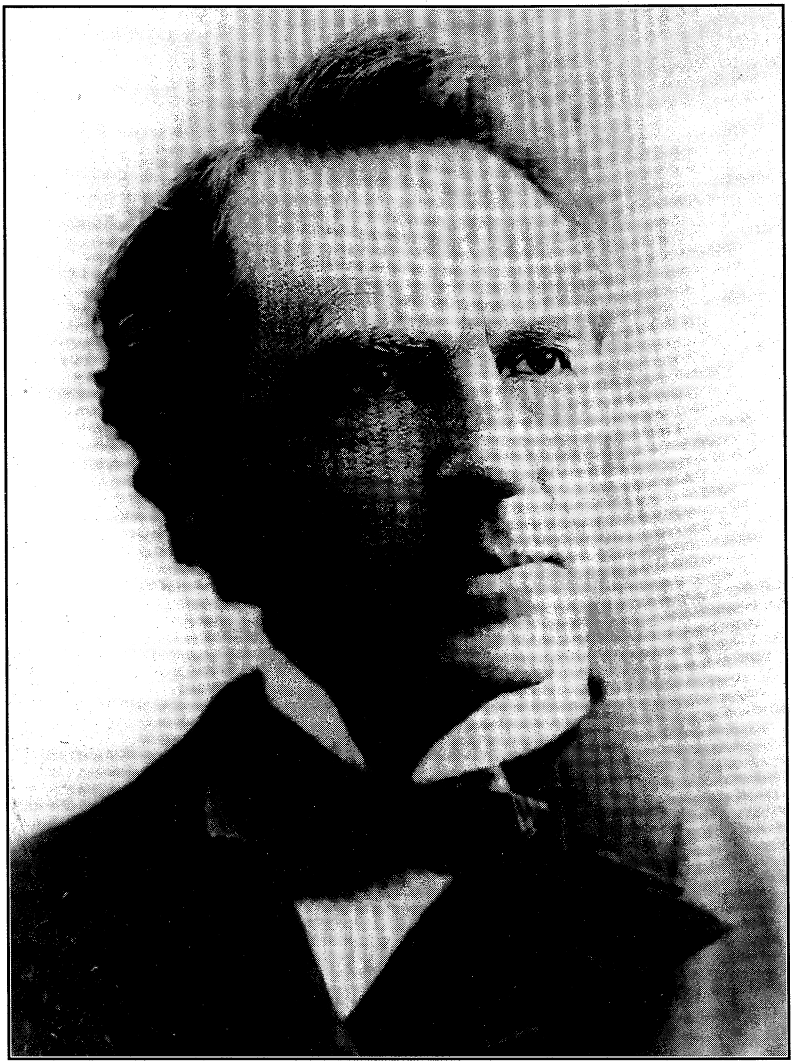
A few panthers, *Felis Concolor*, are yet with us; a straggler is occasionally seen. Benjamin Bones of Racine shot one on the head-waters of Black river, December, 1863.

Wolverines, *Gulo luscus*, are occasionally taken in the timber; one was taken in La Crosse County in 1870.

Of beaver, *Castor Canadensis*, a few still continue to inhabit some of the small lakes situated in Lincoln and adjacent counties.

The badger, *Taxidea Americana*, is now nearly extinct in Wisconsin. In a few years the only badger found in the state will be the one on the coat of arms.

The opossum, *Didelphis Virginiana*, were not uncommon in Racine and Walworth counties as late as 1848. They have been caught as far north as Waukesha, and one near Madison in 1872, since which time I have not heard of any being taken. I am told that a few are still found in Grant county. They will soon be exterminated, no doubt. The last wild turkeys, *Meleagris Gallopavo*, in the eastern part of the state, was [sic] in the fall of 1846, at which time a few were discovered near Racine. They were hunted with such vigor that the entire number were shot, "The last of the Mohicans." I am told, by Dr. E. B. Wolcott, that turkeys were abundant in Wisconsin previous to the hard winter of 1842–3, when snow was yet two feet deep in March, with a firm crust, so that the turkeys could not get to the ground; they hence became so poor and weak that they could not fly and so were an easy prey for the wolves, wildcats, foxes and minks. The Doctor further stated that he saw but one single turkey the next winter, and none since. One was shot in Grant county in the fall of 1872. Possibly there are a few yet to be found in this large southwestern county; if not, then wild turkeys are exterminated in the state of Wisconsin.



Courtesy The State Historical Society of Wisconsin WHi(x3)1759

John Wesley Hoyt, M.D., LL.D.
(1831–1912)

Professor of chemistry and natural history at Antioch College; secretary of the Wisconsin State Agricultural Society; editor of the *Wisconsin Farmer*; charter member and first president of the Wisconsin Academy, 1870–75; governor of the Wyoming Territory and first president of the University of Wyoming

SOME PERSONAL RECOLLECTIONS OF ABRAHAM LINCOLN

BY JOHN WESLEY HOYT

My deep interest in Mr. Lincoln came, first, of his manifestations of opposition to any further extension of slavery over the territories of the United States—an opposition in which I believe I shared as sincerely as any American; for, while a student and medical professor in Cincinnati, in the early fifties of the last century, I had ofttimes looked across the Ohio River to the shadows of the Kentucky side, and now and then, by sympathy, felt the smart of a driver's lash on Freedom's shore; there, too, had earnest part in forming the great political party solemnly sworn to resist extension of the damning curse of human bondage, and thence had gone out, as one of Freedom's advocates on more than a hundred 'stumps,' in Ohio, Indiana, Illinois, and Wisconsin.

Meanwhile, I had, with profound interest, so watched the masterly discussions of Mr. Lincoln with Douglas, in northern Illinois, and so marked him for his destiny, that, in the winter of 1858–9, being then in command of agricultural affairs in Wisconsin, I went down to Chicago to congratulate him and, if possible, secure him for delivery of the annual address at the next state fair, to be held at Milwaukee in September, 1859.

We spent half the night together, in his chamber, reviewing the past and outlining a possible, even probable future—an evening so deeply interesting that, after fifty years, the discussions and incidents are still almost fresh enough for recital in detail. Even then the dark clouds of a coming conflict hovered near enough to make one anxious; but in the minds of both, even civil war, with carnage widespread and fearful, seemed not so dreadful as a further extension of human slavery over half a continent by consent of possessors whose immediate ancestors had themselves been freed from British oppression, not half so terrible, at great cost of blood and treasure. There was yet hope that the resolute champions of the curse would stay their demands, but the prospect was sadly faint, for even then the need of preparing for the worst was painfully felt.

I need hardly say that my conviction of the greatness of Mr. Lincoln, already gained by a reading of his discussions of the all-engrossing questions of the time, was yet further deepened by that night's experience and study of the homely, robust statesman before me, and that, with a glad heart I bore away, at midnight, his promise to be with us, in Milwaukee, at the appointed time.

When, at the moment of departure, he was asked to let me know the time of his leaving Chicago, so that I could meet him on his arrival in Milwaukee, he merely said, with his characteristic simplicity: "Oh, don't trouble yourself on my account; I'll be at the Newhall in good time, all right." And so he was, some eight months later.

But it so happened that his actual arrival was at midnight, and that the room intended to be reserved for him had, by the blunder of a clerk, been given to a man and his wife who were already in bed and asleep. There was no remaining vacant room in the house, and the clerk, having been stoutly arraigned by the landlord, was in distress of mind; seeing which, Mr. Lincoln, with a smiling countenance and comforting words, said: "Oh, my dear sir, don't be unhappy on my account. I see there is vacant space enough right here, at the end of the counter. Just bring a cot and clothes-rack, with sheet for a screen, and I'll sleep like a top." The thing was done, and the distinguished guest, after a cheerful and hearty "Goodnight, gentlemen," handsomely retired.

Of course I was prompt to fulfill my promise to come down in good time to breakfast with him, but he was a little tardy, so that when, having heard a little stir behind the screen, I ventured to tap gently on the frame, word came out at once, "Come in!" But, on passing 'round, I found him not only half dressed, but shaving himself, and so encumbered that, instead of moving his chair for a greeting of his visitor, having recognized my voice, he turned his head squarely back and saw me, with his lathered face inverted and considerably broadened by a smile. Of course I was quick to retire and wait.

The breakfast disposed of, we were soon on our way to the Fair grounds, for Mr. Lincoln said he wanted to see what sort of farmers, gardeners, and mechanics the Badgers made.

The address was to be at 11:00, and meanwhile we made ourselves very busy, going the rounds of all the departments. It soon became apparent that, notwithstanding his modest disclaimer of knowing much of practical affairs beside wood-chopping and rail-splitting, he did know much of many things in country life; that he was in fact capable of critical judgment of horses, cattle, sheep, and other domestic animals, as well as of most products of the soil.

The address was listened to by many thousands, some say thirty thousand, not a few of whom had made special efforts and sacrifices that they might see and hear the man who, from the depths of poverty and laborious service in wood and field, had risen to a foremost place in the legal profession and in statesmanship. Perhaps no address more practical, useful, and entertaining was ever delivered on any such occasion. It dealt with the necessary relation between education and labor, as well as with the economy of thorough work in farming especially, and was so enlivened by humorous hits that it was at once highly entertaining and of enduring value. It was in fact so admirable, and so deepened my conviction of his eminent fitness for leadership, that then and there I began to speak of him as the man for the next President of the United States—fit for a superior service in statesmanship at any time, but pre-eminently fit for such a crisis as then seemed surely very near—in due time I went to Chicago, to help nominate him, and thereafter gave myself to platform service in many of the Northern states, and to the end of the campaign.

How nobly, now grandly he transcended the highest expectations of his most sanguine admirers is too well known for historic proof. No greater demand for a national guide and guardian was ever made, or more nobly and wonderfully met in any part of the world. It is certain that, for measure of endowment and balance of powers, the supreme founder and father of the Republic alone can be compared with Lincoln, its preserver and the emancipator of millions of a downtrodden and most wretched race.

Intellectually, Mr. Lincoln was remarkable for the habit of close and critical attention to whatever engaged his thought; for such power of discrimination and comparison as made him clear-headed; such power of logical analysis as made him quick to detect a flaw and expose a fallacy, on which account his opponent in debate ofttimes found himself floundering ere he knew he was on the wrong side, and painfully subject to such withering sarcasm, if he deserved it, as Mr. Lincoln knew so well how to use; remarkable also for such readiness to discover the relations of things as made him far-sighted and hence either courageous, even bold and daring, or prudent, as the occasion might justify or demand.

On the side of the sensibilities I was happy to find, after a further acquaintance, that I had myself underrated him. His rugged, stalwart frame was at first suggestive of a probable sternness of spirit and manner. But, as I came nearer, I was charmed by the delicacy, even tenderness, and all-abounding sympathy of a great and beautiful soul—qualities that made him a lover of the beautiful in nature; that prompted him, on entering the great round rent at the Wisconsin State Fair, with its magnificent display of fruits and flowers, to take off his hat, for a salute, with a grace that won the hearts of all who were present, saying: "How beautiful! Eden transferred!;" that made him too glad for utterance when he signed the immortal Emancipation Proclamation and saw the shackles fall from millions of his fellow-men, and again when, after one of the most fearful conflicts in human history, he knew the Republic saved and foresaw a Union grander and more glorious than had been dreamed of in all the past, a thing of destiny; qualities, too, that made him so impressionable by others, so sensitive in soul, that he almost never failed to judge rightly the men with whom he had to do, and enabled him to draw into the service of his country so great a galaxy of men of genius, devotion, and heroic virtue.

Morally, Mr. Lincoln was nothing less than an embodiment of virtue, truth, and justice. Those who knew him best believed him incapable of wilful wrong. He so loved truth that he was ever in earnest search of it, and anxious to make it known; and it was the cherishing of a profound love of justice, and his exalted aims and aspirations that made him every ready, even glad, to do and die for his country.

As for the will, he was resolution itself—never halting or hesitating in his course. Because he felt himself right, and knew the right must win, there was fixedness of purpose. He never just hoped for a final victory; he saw it coming, and though deeply sad over the dreadful fate of so many martyrs, yet, after all, whenever the future of the Republic was referred to, his noble face was illumined. It was this high assurance of a determined soul that made it easy for him to say to me, one dark morning, when I had gone to the White House, with anxious sympathy, because great armies of Confederate troops had boldly crowded into Pennsylvania and were threatening both Harrisburg and Philadelphia, "Never mind, Dr. Hoyt, you may be sure we'll trot them out of there very soon and make them glad to get home again."

It was this fixedness of purpose and his unfailing confidence that enabled him to preserve his calmness, so that he was rarely disturbed in spirit and never really agitated. His face and voice and daily life were ever giving expression to an unwavering trust in God.

And thus it is that we are amply justified in pronouncing Abraham Lincoln one of the very noblest and grandest of men in all human history.

WASHINGTON, D.C.

Part Two:
Current Articles

John A. Cross

Dairying in an urban environment: The Milwaukee metropolitan area

Abstract *Urban expansion in the greater Milwaukee area has displaced dairy farming. Southeast Wisconsin now accounts for only three percent of the state's milk production. The spatial pattern of decline in dairy production in southeastern Wisconsin between 1989 and 1994 is examined at the civil town level, considering farm entry and exit. Farm relocation from the region is also explored, and the stress experienced by the region's farmers is surveyed.*

Urban expansion in the greater Milwaukee metropolitan area has significantly altered the pattern of dairy farming in the southeastern Wisconsin agricultural reporting district, whose boundaries roughly coincide with the Census Bureau-defined Milwaukee, Racine, and Kenosha metropolitan areas. Early this century Waukesha County was considered one of the state's leading milk producers, having more pure blood dairy cows than any other similar area in the nation (Whitbeck 1921). Half a century ago 50 percent of Milwaukee County was in agricultural production, with 440 dairy farms in operation (Durand 1962). Durand (1962, 1963) has described in detail the steep decline of dairying in Milwaukee County in the two decades following the outbreak of World War II. By the beginning of the 1960s approximately 50 dairy farms remained in Milwaukee County and dairying had retreated in Waukesha and Ozaukee Counties. The zone of agricultural demise that Durand described is now overwhelming the surrounding counties. Four dairy herds remain in Milwaukee County, and only two are on commercial farms. One of the other two herds is at the Milwaukee County Zoo Heritage Farm, while the second is at the Wisconsin State Fair Park. These herds are but small reminders of dairying in a county that once had been "near the top of the leading dairy counties of the nation" (Durand 1962).

This paper explores the spatial pattern of decline in dairy production in the metropolitan counties of southeastern Wisconsin. By spring 1994 the region had only 925 herds (Table 1), with a total of 63,100 cows counted the previous year (Wisconsin Agricultural Statistics Service 1994a). Twenty years earlier Milwaukee County already had dropped to 14 dairy herds, but southeastern Wisconsin still had 2,050 herds, with a total of 89,400 cows (Wisconsin Statistical Reporting Service 1975). The entire region lost 41.3 percent of its herds over the past decade, with a decline of 23.7 percent between 1989 and 1994.

The decline in number of milk cows in southeastern Wisconsin has only slightly trailed the shrinkage in number of dairy farm herds. While the region lost 21.1 percent of its milk cows since 1983, most of the loss was in the past half decade, inasmuch as the number of cows within the area fell by only 2,700 between 1983 and 1988. Between 1988 and 1993 the region lost 9,300 dairy cows, a loss of 18.4 percent, and milk production decreased by 14.2 percent (Wisconsin Agriculture Reporting Service, 1984; Wisconsin Agricultural Statistics Service 1989, 1994a).

Spatial Patterns of Decline

Over the past half decade, at the county level the greatest proportional declines in dairying in southeastern Wisconsin occurred in Waukesha and Kenosha Counties, both of which lost more than one quarter of their herds (Table 1). Wisconsin Department of Agriculture lists of dairy herds that have undergone the Brucellosis Ring Test (required for commercial milk sales) reveal changes in dairy operations at the civil town (Table 2) and section level (see Cross 1994a). The entry and exit behavior of dairy farmers at the civil town level provides a clearer picture of the expanding ring of dairy abandonment, a ring corresponding to the perimetropolitan bow wave that Hart (1991) has so eloquently described. Dairy farming, of all types of agriculture, is among the most vulnerable to urban development, because of a variety of conflicts that arise with non-farm neighbors (Hirschl and Long 1993). Such conflicts include vandalism and trespassing, complaints about farm odors and farm equipment moving over suburban roads, and inevitable increases in taxes and land use controls.

Only four towns in the southeast Wiscon-

Table 1. Decline in number of dairy herds in southeast Wisconsin

	Dairy Farms			Dairy Herds		
County	*Number in 1940*	*Number in 1990*	*% decline 1940–1990*	*Number in 1984*	*Number in 1994*	*% change 1984–1994*
Kenosha	1,166	98	91.6	131	75	-42.7
Milwaukee	992	4	99.6	3	4	+33.3
Ozaukee	1,361	157	88.5	214	122	-43.0
Racine	1,650	106	93.6	146	88	-39.7
Walworth	2,287	270	88.2	359	219	-39.0
Washington	2,452	384	84.3	511	310	-39.3
Waukesha	2,711	155	94.3	213	107	-49.8
WISCONSIN	167,407	33,805	79.8	43,508	28,641	-34.2

Data sources: U.S. Census of Agriculture, 1947 (number of farms reporting milk cows in 1940), Wisconsin Agriculture Reporting Service 1984; Wisconsin Agricultural Statistics Service 1994 (number of herds in late March or early April of each year tested for Brucellosis—required for milk sales).

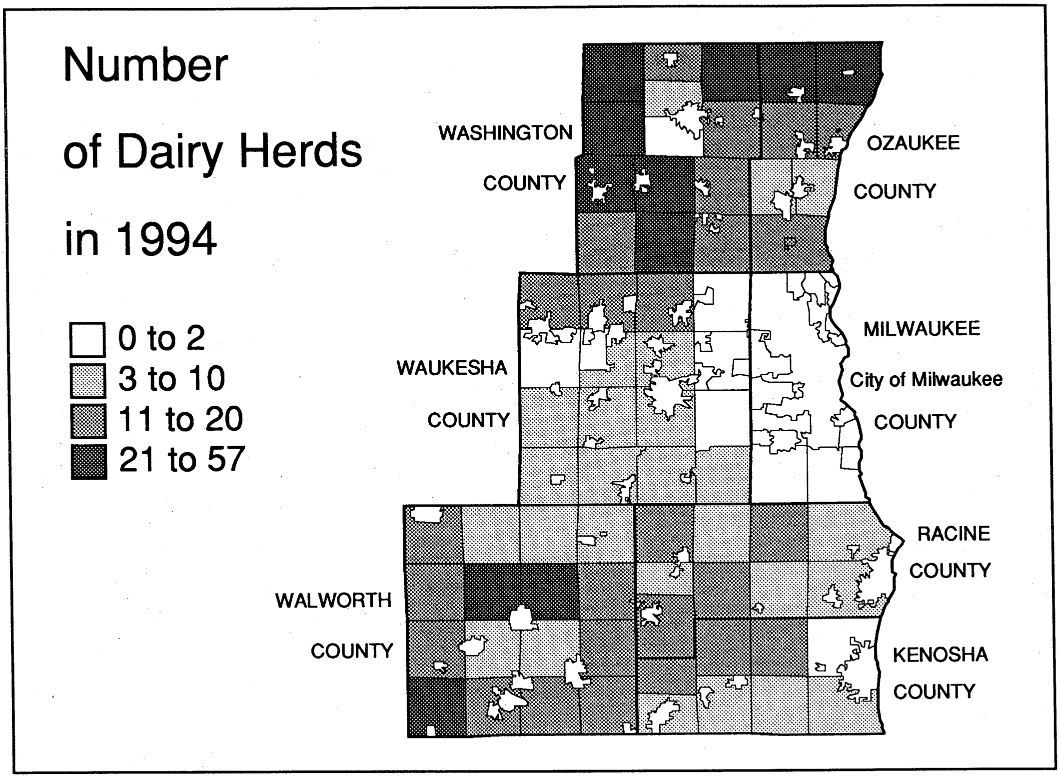


Fig. 1. Number of dairy herds is greatest in towns most distant from Milwaukee. Data source: See Table 2.

sin agricultural reporting district had as many as one dairy herd per square mile by early 1994 (Figure 1). One of these was in northern Ozaukee County, and the other three were in western Washington County. Closer to Milwaukee County, three towns within eastern Waukesha County (Brookfield, Menomonee Falls, and New Berlin) had two or fewer herds. Brookfield had none. None of the towns along Lake Michigan south of Milwaukee to the Illinois state line had more than five herds. The greatest proportional decreases in dairy herds since 1989 were in a swath of towns extending from Menomonee Falls in northeast Waukesha County southwest to Mukwonago in Waukesha County and three towns in northern Walworth County. All lost at least ten percent of their herds annually since 1989 (Figure 2). Because many of these towns already had relatively few surviving dairy farms, the greatest numerical losses were in towns that were farther from Milwaukee (Figure 3). For example, four towns north and west of the Menomonee Falls-Pewaukee areas all lost more than six herds. Four towns in northern Ozaukee and Washington Counties and several towns within Walworth County had similar losses.

Entry and Exit Activity

One measure of the declining viability of dairying is the ratio of new dairy operators to farmers leaving. The number of farmers quitting dairying outnumbered the number

Table 2. Farmers entering and exiting dairy operations by civil town between 1989 and 1994

County/ Town	*Dairy Herds 1989*	*Dairy Herds 1994*	*Net Change 1989–94*	*Farmers Entering Dairying*	*Farmers Exiting Dairying*	*Farmers Moving in Town*
Kenosha						
Brighton	25	20	-5	1	6	0
Bristol	8	4	-4	2	6	0
Paris	20	18	-2	1	3	0
Pleasant Prairie	5	4	-1	0	1	0
Randall	11	5	-6	1	7	0
Salem	5	4	-1	1	2	0
Somers	4	2	-2	1	3	0
Wheatland	25	18	-7	2	9	0
Milwaukee						
Franklin	1	1	0	0	0	0
Granville	0	0	0	0	0	0
Greenfield	0	0	0	0	0	0
Lake	0	0	0	0	0	0
Milwaukee	0	1	+1	1	0	0
Oak Creek	2	1	-1	0	1	0
Wauwatosa	1	1	0	0	0	0
Ozaukee						
Belgium	40	34	-6	3	9	1
Cedarburg	12	9	-3	1	4	0
Fredonia	42	29	-13	1	14	0
Grafton	6	4	-2	0	2	0
Mequon	14	11	-3	1	4	0
Port Washington	23	16	-7	1	8	0
Saukville	22	19	-3	1	4	0
Racine						
Burlington	18	13	-5	0	5	0
Caledonia	3	3	0	0	0	0
Dover	17	15	-2	3	5	0
Mt. Pleasant	4	4	0	0	0	0
Norway	14	10	-4	0	4	0
Raymond	21	15	-6	1	7	0
Rochester	7	4	-3	0	3	0
Waterford	21	16	-5	1	6	0
Yorkville	9	8	-1	0	1	0
Walworth						
Bloomfield	14	13	-1	5	6	0
Darien	19	15	-4	1	5	0
Delavan	10	9	-1	1	2	0
East Troy	9	4	-5	0	5	0
Geneva	13	10	-3	0	3	0
Lafayette	25	21	-4	4	8	1
La Grange	13	6	-7	2	9	0
Linn	11	13	+2	4	2	0
Lyons	17	15	-2	3	5	0
Richmond	14	13	-1	3	4	0
Sharon	37	28	-9	4	13	1

County/ Town	Dairy Herds 1989	Dairy Herds 1994	Net Change 1989-94	Farmers Entering Dairying	Farmers Exiting Dairying	Farmers Moving in Town
Spring Prairie	23	16	-7	6	13	1
Sugar Creek	22	21	-1	3	4	0
Troy	14	5	-9	1	10	1
Walworth	14	11	-3	0	3	0
Whitewater	21	19	-2	7	9	2
Washington						
Addison	68	57	-11	5	16	0
Barton	11	9	-2	0	2	0
Erin	17	11	-6	2	8	0
Farmington	32	30	-2	8	10	0
Germantown	19	13	-6	1	7	0
Hartford	47	38	-9	6	15	0
Jackson	26	20	-6	3	9	0
Kewaskum	24	17	-7	2	9	0
Polk	41	34	-7	5	12	0
Richfield	31	23	-8	2	10	0
Trenton	29	20	-9	2	11	0
Wayne	45	37	-8	3	11	0
West Bend	5	1	-4	0	4	0
Waukesha						
Brookfield	0	0	0	0	0	0
Delafield	10	9	-1	1	2	0
Eagle	14	9	-5	2	7	0
Genesee	7	4	-3	2	5	0
Lisbon	22	16	-6	0	6	1
Menomonee Falls	2	1	-1	0	1	0
Merton	21	15	-6	0	6	0
Mukwonago	11	5	-6	0	6	0
Muskego	11	6	-5	0	5	0
New Berlin	2	2	0	0	0	0
Oconomowoc	25	15	-10	1	11	0
Ottawa	12	9	-3	0	3	0
Pewaukee	6	3	-3	0	3	0
Summit	3	1	-2	0	2	0
Vernon	10	9	-1	1	2	0
Waukesha	6	3	-3	1	4	0

Data sources: Computer tapes listing dairy farms having had the Brucellosis Ring Test (required of all commercial dairy herds), which provided the dairy farmers' names, mailing addresses, grade and farm location (by county, civil town, and section). These tapes, produced in early April 1989, early April 1990, early April 1991, late March 1992, late March 1993, and April 4, 1994 (the last four dates coordinated with the published statistics of the Wisconsin Agricultural Statistics Service) were obtained from the Wisconsin Department of Agriculture, Trade, and Consumer Protection, Madison.

NOTE: Farmers who had ceased operations within any given civil town between any two consecutive years were considered to have exited. Farmers who had begun operations within any given civil town between any two consecutive years were considered to have entered. Because many farmers moved their operations during a year, these figures will overestimate the actual number of farmers who have abandoned dairy operations entirely, regardless of location. Farmers moving within a town had moved their operations within the same civil town to a noncontiguous section, thus a distance of at least one mile, and are listed separately, but not included within the totals of farmers entering and exiting dairying.

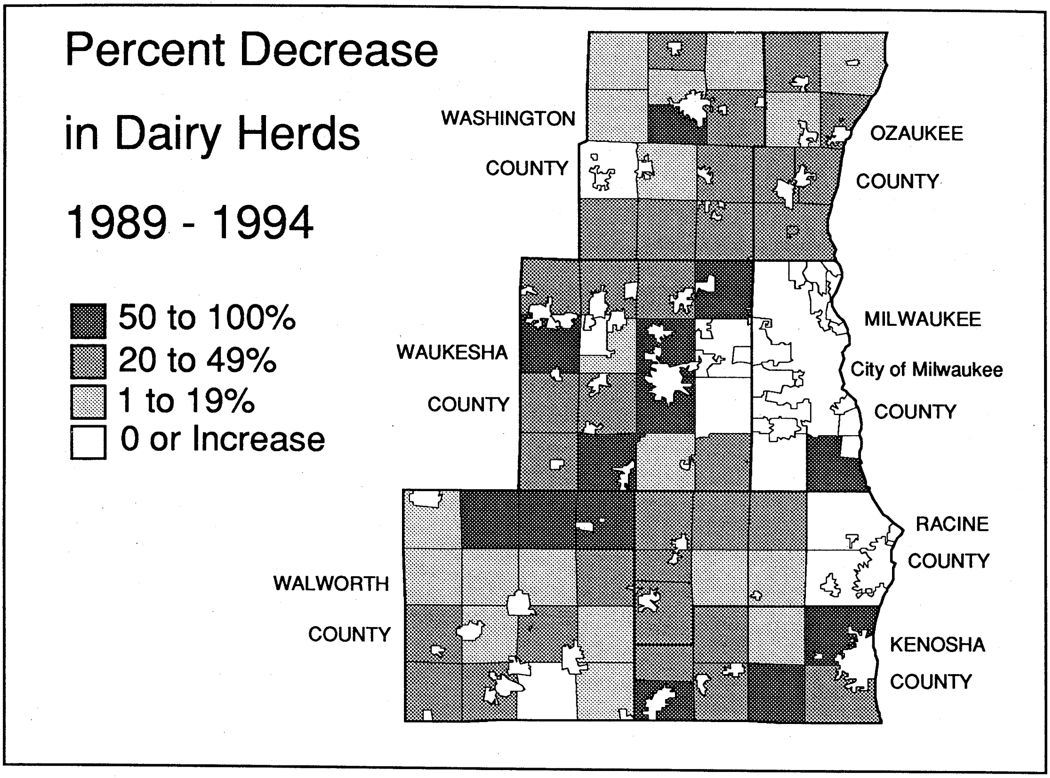


Fig. 2. Percentage decrease in dairy herds is typically greatest in towns experiencing urban expansion, as in Waukesha County. Data source: See Table 2.

of farmers entering in the metropolitan counties of southeastern Wisconsin (excluding Walworth County) by a ratio of 4.2 to 1.0, far surpassing the overall statewide ratio of 2.0 to 1.0. Although dairying is still viewed as viable within some towns, such as Farmington in northeastern Washington County, where eight new operators replaced ten who ceased operations between 1989 and 1994, only a few other towns have ratios close to the state average. These towns are around the northern and western perimeter of the southeast Wisconsin agricultural reporting district. Many towns have no entering dairy farmers, and former dairy farms are becoming the sites of shopping centers and residential subdivisions.

Farmers exiting dairying in southeastern Wisconsin are not necessarily leaving agriculture. Over half of the land area in five of the region's seven counties is still classified as "land in farms" (Table 3), and 63.1 percent of Racine County is considered agricultural. Conversely, farmland now comprises less than ten percent of Milwaukee County, but the 130 remaining farmers received average earnings of $1,727 per acre in 1992, a figure far higher than the statewide average of $318 (calculated from Wisconsin Agricultural Statistics Service 1994b). Wisconsin farmers as a whole rely on dairying to produce over half of their cash receipts, but farmers in several metropolitan counties have concentrated upon other agricultural

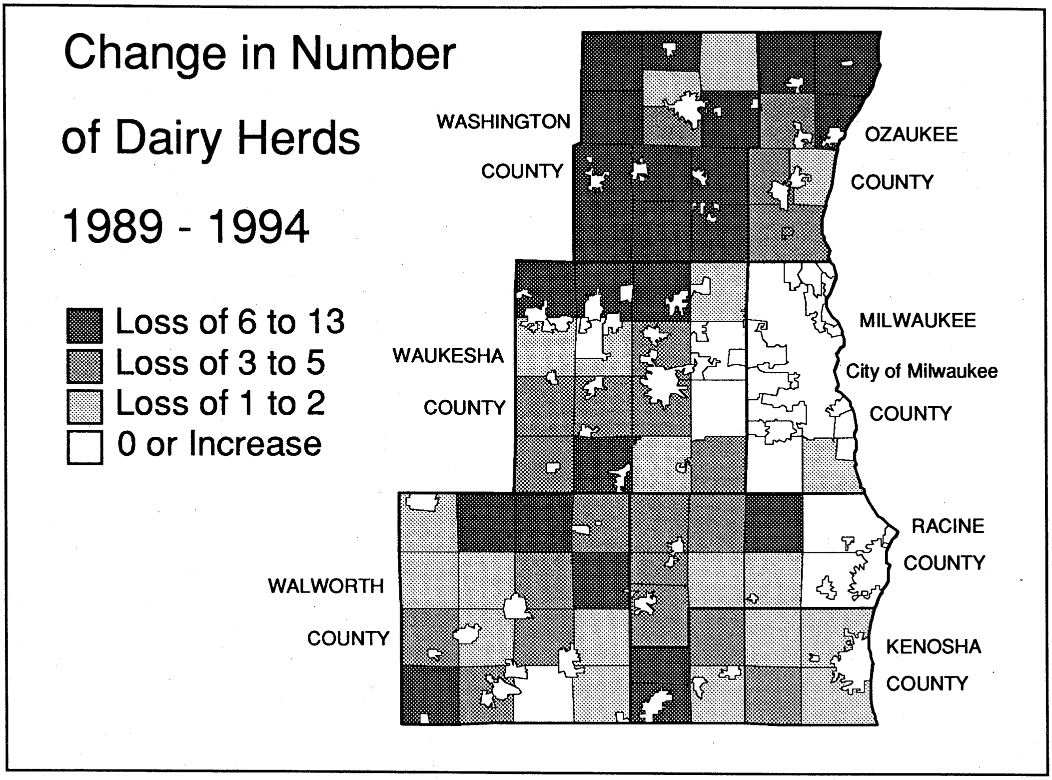


Fig. 3. Largest losses in number of dairy herds often occur in towns with the largest number of herds. Data source: See Table 2.

Table 3. Agricultural production in southeastern Wisconsin

County	*Number of all farms (1993)*	*Land in farms (acres) (1993)*	*% Area in farms (1993)*	*% Farms in dairying (1993)*	*% Earnings from dairying (1992)*	*Total cash receipts per acre (1992)*
Kenosha	550	99,000	56.9	14.5	33.7	$300.02
Milwaukee	130	14,000	9.2	3.1	0.7	$1,727.36
Ozaukee	530	87,000	58.2	24.9	53.1	$400.07
Racine	780	136,000	63.1	11.9	16.5	$515.40
Walworth	1,050	247,000	69.2	21.5	37.9	$333.77
Washington	1,070	159,000	58.0	31.4	57.0	$455.30
Waukesha	890	138,000	38.8	13.4	37.0	$319.38

Data source: Wisconsin Agricultural Statistics Service 1993a and 1994b activities. Milwaukee County leads the state in its cash receipts for "other crops," a category that includes greenhouse and nursery crops together with fruit and miscellaneous specialty crops. Racine County is the state's second largest producer of eggs and poultry (Wisconsin Agricultural Statistics Service 1993). Moreover, as Hart (1991) notes in his discussion of the bow-wave process, "[s]ome . . . keep their land and continue to farm it less intensively." The low cash receipts per acre for Kenosha and Waukesha Counties, where only one in seven farmers have dairy herds, lend credence to such arguments.

Emigration of Dairy Farmers

Some farmers remain in dairying by fleeing the advance of urbanization. Undoubtedly, some dairy farmers may have moved to locations in northwestern Illinois, eastern Iowa or southern Minnesota, although the available data does not permit those movements to be traced. Statistics do show that between 1989 and 1994 fifty-two southeastern Wisconsin dairy farmers moved their operations to other locations in the state. Some of these moves were local: thirteen were to another town within the same county, eight others were to non-contiguous sections within the same town, and two were to another county within southeastern Wisconsin. However, 29 dairy farmers moved from southeast Wisconsin to other areas of the state (Figure 4). For example, dairy farmers moved from Racine County to Lafayette, Sauk, Buffalo, Manitowoc, and Sheboygan Counties. Waukesha County lost dairy farmers to Dodge, Jefferson, Waupaca, Green, and Richland Counties.

Neighbors or kin sometimes move in unison. Clark County received three incoming operators from a small area of far western Kenosha and adjacent Walworth Counties. Two farmers living six miles apart in Washington County relocated to towns in eastern Taylor County. Eight of the 29 farmers relocating from southeastern Wisconsin moved more than 100 miles.

Stresses of Urbanization

Stresses of urbanization are clearly recognized by dairy farmers in southeastern Wisconsin (Table 4). Although survey respondents (Cross 1994b) in southeastern Wisconsin did not differ significantly from dairy farmers elsewhere in the state in their evaluation of a variety of potential problems facing them—including wholesale milk prices, hay and feed prices and shortages, labor availability, farm debt and interest rates, various climatic hazards, and government regulations—their evaluations of property taxes and local urban expansion were significantly different statistically. Indeed, half of the surveyed dairy farmers in southeastern Wisconsin (55 percent, excluding Walworth County) ranked "local urban expansion" as a "major problem," compared with just 6.1 percent of dairy farmers elsewhere in the state. Nevertheless, only 13.2 percent of the farmers in this region wish to sell their farms, compared with 26.8 percent of the farmers elsewhere in the state, a statistical difference significant at the 0.10 level.

Ties to the land are strong, with dairy farms in southeastern Wisconsin more likely to have been owned by a family member since the 1800s than in any other region of the state. Twenty-four percent of the dairy farmers surveyed by the author in the region indicate that their family had operated their farm since the last century, compared with 14 percent elsewhere in Wisconsin. Southeastern Wisconsin dairy farmers were less likely to submit bids to participate in the

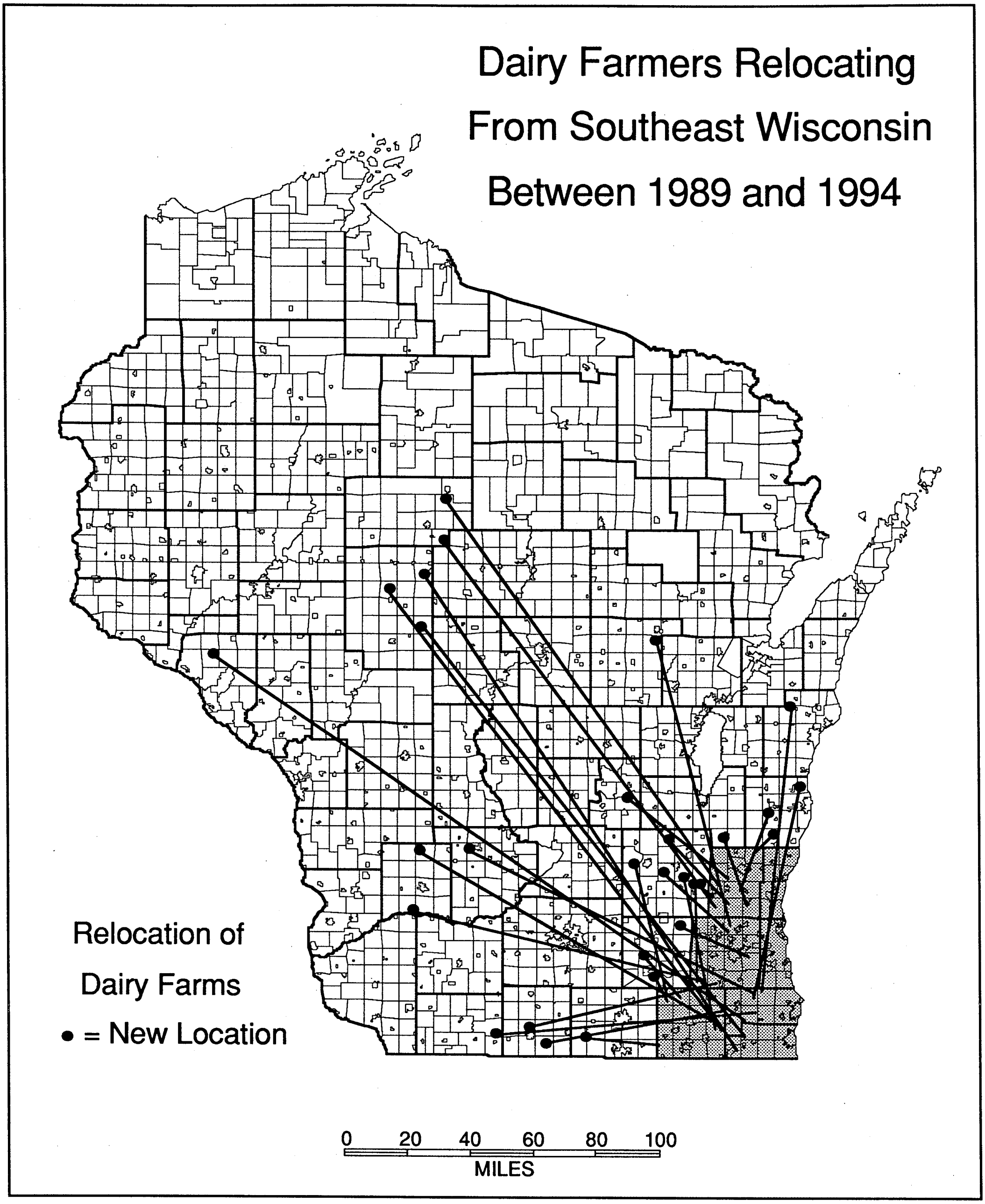


Fig. 4. Twenty-nine dairy farmers moved their herds from southeastern Wisconsin to other parts of the state between 1989 and 1994. Data source: See Table 2.

Table 4. Perception of problems facing dairy farmers: southeast Wisconsin versus other Wisconsin farmers

	Percent of farmers ranking item as:			
Factor considered:	*Major Problem*	*Somewhat a Problem*	*Minor Problem*	*Not a Problem*
Milk support prices				
Southeast Wisconsin	26.3	50.0	13.2	10.5
Other Wisconsin Farmers	52.4	29.6	11.3	6.8
Prices of Hay and Feed				
Southeast Wisconsin	24.3	32.4	27.0	16.2
Other Wisconsin Farmers	19.8	36.5	27.0	16.7
Shortages of Hay and Feed				
Southeast Wisconsin	23.7	18.4	31.6	26.3
Other Wisconsin Farmers	21.7	31.0	27.8	19.6
Shortage of Farm Labor				
Southeast Wisconsin	23.7	36.8	21.1	18.4
Other Wisconsin Farmers	21.9	27.2	26.9	24.0
Excessive Debt				
Southeast Wisconsin	21.1	42.1	15.8	21.1
Other Wisconsin Farmers	30.8	33.4	18.9	16.8
Flood Possibilities				
Southeast Wisconsin	7.9	23.7	28.9	39.5
Other Wisconsin Farmers	3.7	13.9	34.9	47.5
Government Regulations				
Southeast Wisconsin	34.2	39.5	15.8	10.5
Other Wisconsin Farmers	45.5	37.4	12.1	5.0
Property Taxes				
Southeast Wisconsin	73.7	15.8	0.0	10.5
Other Wisconsin Farmers	68.1	24.5	4.7	2.6
Local Urban Expansion				
Southeast Wisconsin	50.0	15.8	23.7	10.5
Other Wisconsin Farmers	6.1	16.1	20.6	57.3

Data source: Survey of Wisconsin dairy farmers conducted spring 1993. See Cross 1994b.

Dairy Termination Program in 1986 than elsewhere in the state, although their bid acceptance rates exceeded the state average (Cross 1989). On the other hand, southeastern Wisconsin dairy farmers are slightly less likely (36.8 versus 42.7 percent, not statistically significant) to "expect that a son, a daughter, or another relative will operate their dairy farm after [they] retire."

Agricultural land sales prices in southeast Wisconsin are the highest in the state, averaging $1,929 per acre if the land remained in agriculture and $3,679 if the land was diverted to other uses. These 1992 figures were actual decreases from 1991 values (Wisconsin Agricultural Statistics Service 1994b). Prices averaged $3,539 and $3,348 per acre for land remaining in agriculture in Milwaukee and Waukesha Counties. Such high land prices burden farmers with high taxes, make farm expansion prohibitively expensive, and provide strong incentives for farmers wishing to sell. In contrast, agricultural land sales averaged less than $1,000 per acre in 54 of

Wisconsin's 72 counties and below $750 in 38 of the state's counties.

The median acreage owned by southeastern Wisconsin dairy farmers responding to the 1993 survey was 130 acres, contrasting with a statewide median of 180 acres. (Actual median farm size was 255 acres, because many farmers rented additional acreage.) Furthermore, land fragmentation is a problem. In no other region of Wisconsin did a smaller proportion (13 percent) of dairy farmers report that their "farm fields were located all together," not even separated by a road. One third of the southeastern Wisconsin dairy farmers, the highest proportion in the state, reported that their fields were separated by at least two miles.

The average dairy farmer in southeastern Wisconsin grows over 95 percent of the hay and feed grains fed to his herd, the highest average among the state's nine agricultural reporting districts. Nearly three-quarters of the dairy farmers in this area report that they normally grow all of the feedstuffs for their cows. Unlike their counterparts in other urbanizing areas, whose dairy farms survive by importing large quantities of feed, the southeastern Wisconsin dairy farmer relies upon production from his increasingly expensive farmlands. Nevertheless, average herd size in southeastern Wisconsin exceeds that of all the state's other agricultural districts.

Conclusions

Three broad dairying zones can be identified in southeastern Wisconsin: (1) a zone in which dairying has ceased to be important, with only a few solitary holdouts who have resisted the pressures to sell-out; (2) a zone of rapid decline, in which large numbers of farmers are abandoning dairying at rates considerably in excess of average rates statewide; and (3) a peripheral zone in which dairying remains important. Although the impacts of urban expansion upon dairying may be most conspicuous in the greater Milwaukee metropolitan area, fingers of decline have spread towards other areas of Wisconsin, including a zone extending west to Madison and north along the Fox River Valley, particularly between Fond du Lac and Green Bay. What we have seen surrounding Milwaukee is not unique. The same process has been documented around Chicago (Berry 1979), but it is radically different from the process in southern California (Gilbert and Akor 1988), which has resulted in highly capitalized corporate dairy farms that took away Wisconsin's number one rank as a milk producing state during August 1993. Wisconsin remains a state of family farms, but dairy farmers are rapidly leaving the southeastern metropolitan area of the state.

Acknowledgments

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Eric E. Jorgensen and Lyle E. Nauman

Small mammal distribution associated with commercial cranberry production

Abstract *We documented the distribution of small mammals in association with commercial cranberry production in south-central Wisconsin. Small mammals were captured with snap traps, in and adjacent to cranberry beds. Fewer small mammals were present in cranberry beds compared to habitat directly adjacent them ($\underline{P}$ < 0.0214, 2 df). This may have been due to cultural influences, structural diversity, or predation. A range extension for the arctic shrew* (Sorex arcticus) *was documented.*

Commercial cranberries are extensively cultivated in Wisconsin. Cultivation is typified by intensive management of discrete crop producing complexes within a wetland matrix (U.S. Army Corps of Engineers 1991). Cranberry growing is unique, compared to other agricultural practices, because it is practiced in modified wetlands. Only one study has investigated small mammals in this unique setting. IEP (1990) studied three cranberry production facilities. They used snap traps but only had five captures (three meadow voles [*Microtus pennsylvanicus*], and one each of white-footed mouse [*Peromyscus leucopus*] and meadow jumping mouse [*Zapus hudsonius*], with about 1% trap success.

Small mammal distributions in association with agricultural practices have seldom been the subject of research. This research documented the distribution and diversity of mammals near commercial cranberry beds.

Description of the Study Areas

Five commercial cranberry production facilities in Wood County (Township of Babcock Sec. 32, T22N, R4E; Township of Vesper Sec. 13, T22N, R4E; Township of City Point Sec. 19, T21N, R2E), Juneau County (Township of Shennington

Sec. 17, T18N, R2E), and Portage County (Township of Dancy Sec. 17, T25N, R7E) were studied in south-central Wisconsin. Different wetland habitat types were associated with these facilities including shallow open water communities, sedge (*Carex* spp.) meadows, and sphagnum (*Sphagnum* spp.) bogs. All of the commercial cranberry wetlands studied in this research were classified as palustrine (Cowardin et al. 1979).

Trapping was conducted in commercial cranberry beds and adjacent wetlands. Adjacent wetlands were composed of sedge meadows and mats, sphagnum communities, wet meadows, and lowland forest. A detailed description of the study areas is found in Jorgensen (1992).

Methods

Each of the five facilities was sampled over two periods of two nights each from May through August, 1991. Each day, 100 snap traps baited with peanut butter were placed in 25 identical clusters of four traps consisting of two Museum Special and two Victor mouse traps (Call 1986). Clusters were located using a stratified random sampling method. Stratification was in three distance classes, relative to the cranberry bed matrix: clusters were placed in the cranberry beds, within 50 m of the cranberry beds and greater than 100 m from the cranberry bed matrix. The response variable was the number of small mammals caught per cluster per night. Data were analyzed with a Friedman Test because of non-normality and heteroscedasticity (unequal variances). Facilities were blocks and distance classes were treatments. There were 40 cluster nights in the 50 m treatment and 30 cluster nights in each of the other treatments per facility. Because each cluster night was a sample and not an experimental unit, this imbalance only affected the results to the extent that experimental error was increased, biasing our results toward nonsignificance. Means of ranked data within blocks were separated by the Tukey-Kramer method (Sokal and Rohlf 1981) for unequal sample sizes when treatment effects were observed.

Results

Eight species were trapped, and each facility's (block) small mammal assemblage appeared unique (Table 1). Species level comparisons were not made because sample sizes were too small to detect differences.

Table 1. Small mammals snap-trapped in and adjacent to commercial cranberry production beds in south-central Wisconsin during 500 trap cluster nights, 1991

Species	*Wood County no. 1*	*Wood County no. 2*	*Wood County no. 3*	*Juneau County no. 1*	*Portage County no. 1*
Microtus pennsylvanicus	22	31	1	9	6
Zapus hudsonius	3	5	–	2	3
Peromyscus leucopus	4	–	–	1	4
Peromyscus maniculatus	–	10	–	–	–
Blarina brevicauda	–	–	–	7	1
Sorex arcticus	–	–	1	5	–
Sorex cinereus	1	–	2	1	–
Eutamias striatus	–	–	–	–	1

Table 2. Catches of small mammals snap-trapped in and adjacent to commercial cranberry beds in south-central Wisconsin, 1991

Distance Class	*Cluster Nights N*	*Average Catch (Catches/cluster night)*[a]	*Std. Error*
Cranberry Beds	150	0.06	0.092
< 50 m	200	0.27	0.213
> 100 m	150	0.22	0.242

[a]Mean separation ($\alpha = 0.05$, Tukey-Kramer test) on ranks indicates that the number of small mammals captured was unique at each distance class.

The meadow vole (*M. pennsylvanicus*) was the most frequently caught and observed small mammal. At Wood County no. 2 the prairie deer mice (*P. maniculatus*) were of the subspecies *P. m. bairdii*. Small mammal populations were nonrandomly distributed with respect to distance class ($\underline{P} = 0.0214$, Friedman's Test, 2 df). Subsequent mean separation ($\alpha = 0.05$) indicated that the number of small mammals caught at each distance class was distinct, with the fewest animals captured in the cranberry beds (0.06 catches/cluster night) and the most captured (0.27 catches/cluster night) within 50 m of the beds (Table 2). The mean separation test was exceptionally powerful because of consistent results in the ranked data across treatments, though large differences in the unranked data were observable only with respect to the cranberry beds themselves (Table 2).

Catches within the beds totaled six *M. pennsylvanicus*, three *P. maniculatus*, and two masked shrews (*Sorex cinereus*). We consider the number of captures too few to allow accurate analyses of diversity.

Arctic shrews (*S. arcticus*) were caught at Juneau County no. 1 (Township of Shennington, Sec. 17, T18N, R2E) and Wood County no. 3 (Township of City Point, Sec. 19, T21N, R2E). These records are outside of the previously documented range for the arctic shrew in Wisconsin (Jackson 1961; C. A. Long, pers. comm.), and two specimens have been placed in the mammal collection of the Museum of Natural History at the University of Wisconsin–Stevens Point (catalogue numbers 7100 and 7101).

Discussion

Small mammals were present in greater numbers ($\underline{P} = 0.0214$) in the semi-natural habitat outside of the cranberry beds compared to the beds themselves (Table 2). We call these areas semi-natural because although they are not directly modified to cranberry beds, their close proximity probably affects plant distribution (Jorgensen 1992; Jorgensen and Nauman 1994) and bird distribution (Jorgensen and Nauman 1993).

There were three factors that could contribute to the distribution of small mammals we measured. The first factor was the continual disturbance that is present in the beds. Disturbance included various human intrusions and pesticide applications. The second factor may have been a relative lack of cover (Wrigley et al. 1979; Reich 1981). There appeared to be less vertical cover in the beds, which were maintained as monocultures, than in the adjacent habitat. Harriers (*Circus cyaneus*) hunt over the beds. A lack of cover might have contributed to increased predation, or otherwise caused a lack of suitable habitat. The third factor might have been a lack of diversity in both vegetative structure and plant species within the beds. The vegetation is essentially monotypic, and the insect populations, when they were not being controlled, were probably monotypic also and present in low numbers. Interspecific competition has also been implicated as a factor affecting small mammal distribution (Buckner 1966) in wetlands. This study was not designed to detect this type of interaction.

Acknowledgments

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Ken Parejko and Douglas Wikum

The effect of manure management on phosphorus and suspended solids in the Lake Tainter, Wisconsin, watershed

Abstract *Phosphorus, suspended solids, and conductivity were measured during the spring of 1993 at five sites in the Lake Tainter (Dunn County, Wisconsin) watershed upstream and downstream from fields spread with turkey litter. Three sites were spread with litter during the winter, and two sites were spread in the spring after the ground was thawed. There was no significant difference in most sites in the phosphorus, suspended solids, and conductivity upstream versus downstream. Increased solids were detected downstream from two sites during spring-spreading and spring tillage. Phosphorus concentration showed a highly significant relationship to suspended solids but was inversely related to conductivity.*

Human effects on aquatic ecosystems stem primarily from point-source and nonpoint-source effluents. Point sources such as industries and municipal wastewater facilities are regulated through the permitting process. Nonpoint inputs are more difficult to regulate or control. Yet in 75% of the nation's lakes, measureable improvement in water quality will only come with control of nonpoint-source impacts (Committee on Restoration et al. 1992.)

Tainter Lake, in Dunn County, Wisconsin, is an impoundment of the Red Cedar and Hay Rivers, with a large, predominately agricultural watershed of over one million acres. This lake is experiencing significant cultural eutrophication, primarily due to phosphorus inputs that contribute to nuisance algal blooms and consequent undesireable effects. With relatively large watersheds and a high potential for nutrient loading in comparison to natural lakes, reservoirs such as Tainter Lake are considered especially susceptible to cultural eutrophication (Baxter 1977; Thornton 1984). Schreiber (1992) estimated that at least 90% of the phosphorus entering Tainter Lake is nonpoint source in origin. More than half of the total annual phosphorus loading into Tainter Lake arises during spring snowmelt runoff (U.S. Geological Survey 1990). Spring snowmelt also contributes more than half the total suspended solids loading into the lake.

Runoff from agricultural sources is suspected as the major source of phosphorus loading into the Tainter Lake watershed (Mechelke et al. 1992). Phosphorus enters the watershed from barnyard runoff, decaying vegetation, and runoff of commercial and manure fertilizers. Although considerable interannual variation may occur due to the amount of precipitation, the variation in frost depth, and the timing of manure application relative to snow and rain events, nutrient runoff studies indicate that total phosphorus runoff is significantly affected by several factors: the amount of phosphorus applied as fertilizer (Coote et al. 1979), the presence or absence of vegetated buffers between the field and the waterway (Thompson et al. 1979), soil texture and type, slope (Magette 1988), and winter-spreading versus spring-spreading manures (Khaleel et al. 1980.) Though there is little information on actual nutrient inputs into streams from individual fields, studies of intercepted runoff from experimental plots suggest that manure applied to frozen ground may have much more runoff potential than manure spread on thawed ground and incorporated in a timely manner (Converse et al. 1975; Klausner et al. 1976; Minshall et al. 1970; Mueller et al. 1984; Young and Mutchler 1976.)

Best management agricultural practices, based on these experimental studies, call for soil testing for phosphorus and limiting application to necessary amounts; applying manures in the spring after thaw and incorporating them as soon as possible; and restricting application of manures to fields with minimal slopes (Magette 1988). For example, the spreading of turkey litter from large turkey farms in the Tainter Lake watershed falls under Wisconsin Pollutant Discharge Elimination System (WPDES) permits that use these best management practices as guidelines for spreading. In a recently granted permit for one large turkey farm, farmers who purchase turkey litter from Jerome Foods of Barron, Wisconsin, are prohibited from winter-spreading that litter in several townships in the Tainter Lake watershed.

This study had two purposes. The first was to test the ability to detect phosphorus and erosional sediment inputs into waterways from individual fields that have been winter-spread and spring-spread with turkey litter. The second was to test for significant differences in phosphorus and sediment inputs into the rivers, comparing the two manure management strategies.

Study Sites and Methods

With the cooperation of Jerome Foods, Barron, Wisconsin, two fields adjacent to streams within the watershed that were spring-spread with turkey litter (sites A and B) and three fields that had been winter-spread (sites C, D and E) were selected (Fig. 1). Turkey litter applied at spring-spread sites was incorporated within three days of spreading. Sites are characterized as to runoff potential in Table 1. Sampling locations were established just upstream and just downstream from the field sites. Sampling began on March 13 and ended on May 6, 1993. During snowmelt runoff and for

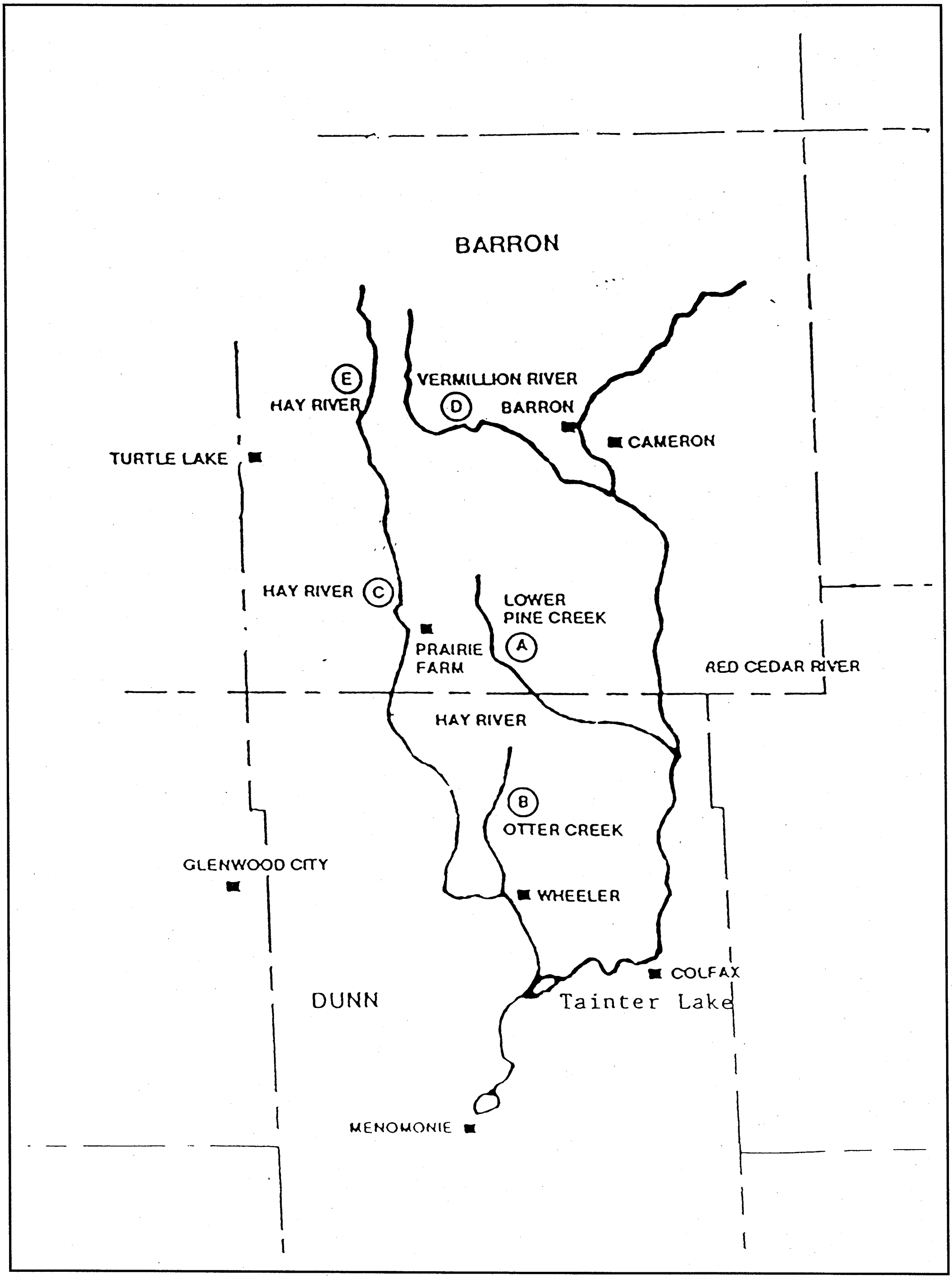

Fig. 1. Sampling sites for manure management study

Table 1. Study site characterization

	Site				
Parameter	*A*	*B*	*C*	*D*	*E*
Total hectares	18.2	10.1	8.9	2.4	4.0
Metric tons turkey litter applied	211	61	55	44	73
Kg phosphorus applied	4590	1330	1190	950	1580
Kg phosphorus applied per hectare	252	132	134	396	395
Date of application	4/21/93	4/20/93	2/24/93	11/5/92	12/2/92
Average slope	2%	< 2%	2%	2%	4-6%
Soil type[a]	1	2	3	3	4
Streambank, ft[b]	1000	900	1400	2400	800
Vegetated buffer, % of streambank	100%	100%	100%	100%	100%
Vegetated buffer, average width (m)	5 m	5 m	8 m	8 m	12 m
Crop, fall 1992	Corn	Soybeans	Corn	Hay	Corn
Tillage, fall 1993	none	Chisel plow	none	none	none
Phosphorus Runoff Potential[c]	84	4.0	23	64	94

[a]Soil types: I = Urne Silt Loam; 2 = Plainfield Sandy Loam and Brems Sandy Loam; 3 = Antigo Silt Loam; 4 = Otterholt Silt Loam.
[b]Streambank = approximate footage of streambank along the field.
[c]for Phosphorus Runoff Potential calculation, see text, pp. 95–96.

about one week bracketing the spreading and incorporation of litter at spring-spread sites, sampling was done on an approximately daily basis. At other times sampling was done approximately two to three times per week. For technical reasons, we were unable to coordinate sampling dates with precipitation events. Precipitation amounts at Cedar Falls Dam on the Red Cedar River, supplied by the Wisconsin State Climatologist, and snow depth (measured at each site on each sampling date and averaged over all sites) are shown in Figure 2. Dates are converted to consecutive numerals: March 1 = 1 and May 6 = 67.

At each upstream or downstream location for each site, samples were taken as a single grab, about six feet from the stream bank and just beneath the water's surface. Aliquots (100 ml) were acidified, refrigerated up to 28 days, and analyzed for total phosphorus by the Colfax Commercial Testing Lab, Colfax, Wisconsin. Phosphorus concentrations are means of duplicate analyses. The limit of detection was 0.04 mg/liter total phosphorus. Suspended solids were determined from a one liter sample taken in the same manner as the phosphorus sample. Solids were filtered through a preweighed Gelman type A/E membrane, dried to constant weight and reweighed, according to Standard Methods (APHA 1985). In-lab measurement of conductivity (umhos/cm) was performed using a YSI model 33 con-

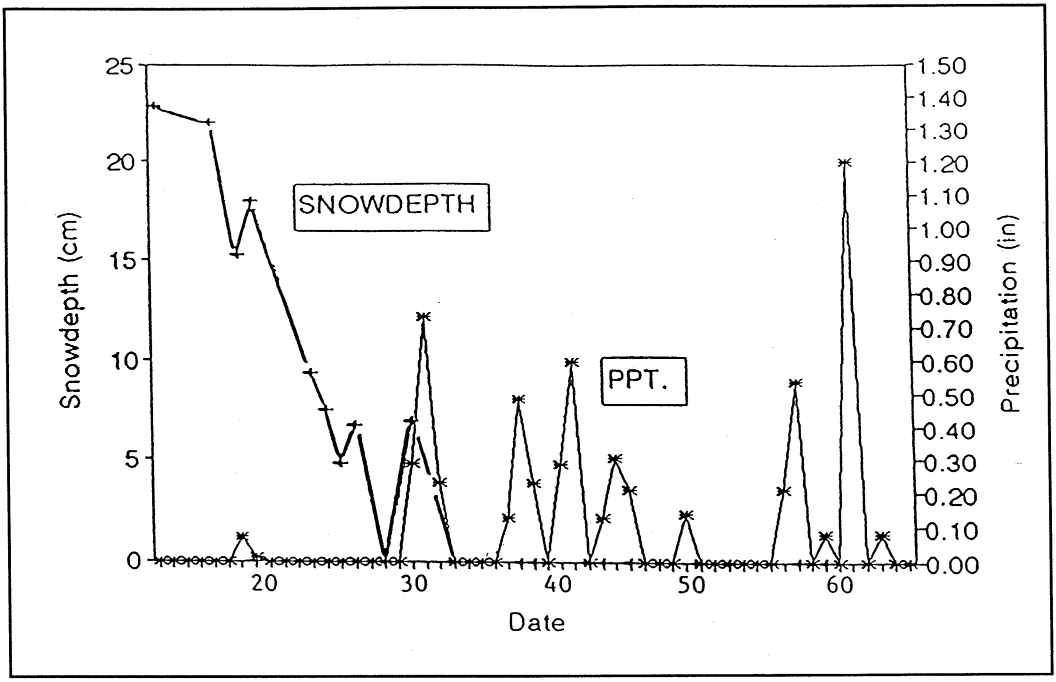

Fig. 2. Snowdepth (cm) and precipitation (in.) vs date

ductivity meter on samples refrigerated at 4°C. All conductivity values were standardized to 25°C.

Staff gages were installed in the rivers at downstream sampling locations before the study. Discharge at staff gages was measured on four to seven dates during the study with use of a Marsh McBurney Model 201 flowmeter. Stream cross-section was determined by measuring stream depth at 1 m intervals. Flow was measured at 0.6 x depth at midpoint of the 1 m intervals, and total discharge summed over the entire stream cross-section. A gage versus discharge curve was developed by plotting log gage depth versus. log discharge (Chow 1964). Discharges for dates on which flows were not measured were interpolated from the gage/ discharge curve. For sites B, C, D, and E there were several dates when staff gages had been uprooted by ice or high water and not yet replaced. For those dates, flags on the streambank were used to measure stream height. For a few dates, it was necessary to interpolate river depths from data from other sites. Stream discharges are shown in Figure 3.

To compare sites in their potential for phosphorus loading, we created a Phosphorus Runoff Potential (PRP). This parameter for sample sites was calculated as follows:

PRP = kilograms phosphorus applied x application date factor x slope factor x streambank factor x vegetative buffer factor x crop factor x tillage factor, where

Application date factor = 1 for manure applied under snow, 0.5 for manure applied on top of snow, and 0.25 for spring-spread manure (see Thompson et al. 1979);

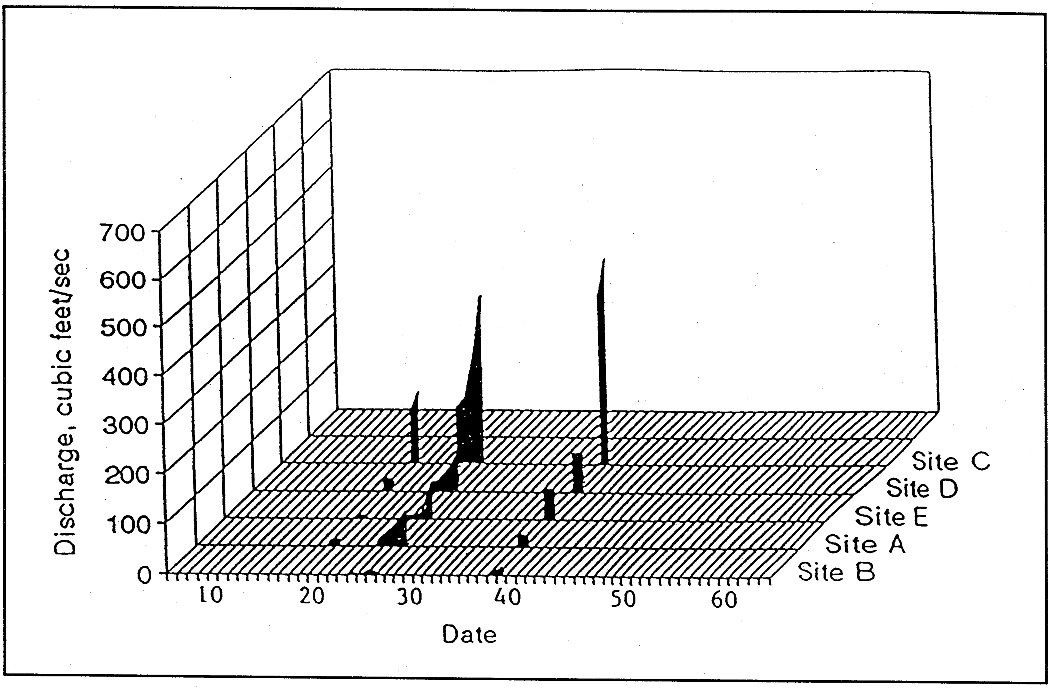

Fig. 3. Stream discharge vs date

Slope factor = 0.25 for slope < 2%, 0.5 for slope 2%, 0.75 for slope 2–4%, 1 for slope 4–6%;

Soil factor, all = 1 for soils encountered in this study;

Streambank factor = number of feet of streambank/2400;

Vegetative buffer factor is an estimate, interpolated from Thompson et al. 1979, of the percent of phosphorus reaching the streambank with various widths of vegetative buffers. For 5 meters, buffer = 35%, for 8 m = 27%, for 12 m = 18%;

Crop factor estimates runoff potential from different crops onto which manure is applied (Thompson et al. 1979). For corn or soybeans, = 1; for non-alfalfa hay = 0.5;

Tillage factor estimates the effect of tillage on runoff (from Mueller et al. 1984). For no tillage = 1; for chisel plow = 0.5.

For example, for site A, PRP = 4590 x 0.25 x 0.5 x 1 x 0.42 x 0.35 x 1 x 1 = 84.

The Phosphorus Runoff Potential should not be viewed as a quantitative estimate of the amount of phosphorus potentially entering the stream. It is instead a numerical method of comparing the study sites A through E. Sites with higher PRPs would be expected to have more nutrient runoff potential than sites with lower PRPs. Mean PRP for spring-spread sites is 44; for winter-spread sites it is 69. These can be considered approximately equivalent.

Most-probable-number fecal coliform analyses were done in the UW–Stout microbiology lab on stream samples taken on one date during snowmelt runoff and one date during spring-spread runoff, for all sites. To estimate what portion of total phosphorus was attached to particulates, on several dates total phosphorus analyses were done on samples of unfiltered stream water and on filtrates of the same sample that had passed through a Gelman A/E 1 micron cutoff membrane.

Statistical analyses were done with Minitab release 7.1. Data were checked for normality by correlating n scores with raw data. Correlations routinely fell below critical values due to a few very high values (phosphorus, suspended solids) or low values (conductivity) during runoff events. Log transformation of data gave very high n score correlations, indicating normality. Thus, we normalized data using log transformation.

Results

Data for suspended solids, conductivity, phosphorus, and flow discharge are shown in Appendices 1–4. In general, we found no obvious water quality patterns as a result of runoff from winter-spread versus spring-spread fields. Using paired t-tests, sites A through E were tested for a significant difference in suspended solids at upstream versus downstream locations. Over all 22 sampling dates, suspended solids were significantly higher downstream than upstream only at site B ($p < .01$) and higher downstream at both sites B and E for dates corresponding to spring-spreading (April 20–May 6). For all other dates and sites, there was no significant difference ($p > .10$) in suspended solids upstream versus downstream of each field.

Conductivity was lower downstream than upstream at site B ($p <. 001$) and higher downstream than upstream at site E ($.01 < p < .05$), over all dates. For dates corresponding to snowmelt runoff (March 26–April 17), site B showed lower conductivity downstream than upstream ($.02 < p < .05$), and site E showed higher conductivity downstream than upstream ($.05 < p < .10$). For dates corresponding to spring-spreading, only site B showed a significant difference in conductivity, with downstream sites lower than upstream ($p < .01$).

Phosphorus concentrations at all sites except site E were not significantly different between downstream and upstream sampling locations for all dates, whether winter-spread dates or spring-spread dates. Site E had significantly lower phosphorus downstream than upstream ($.02 < p < .05$), for snowmelt runoff dates only.

Separate single-factor regressions relating log-transformed phosphorus concentrations, conductivity and levels of suspended solids for each site/sampling location (five sites x two sampling locations per site) indicated a significant ($p < .01$) positive relationship between phosphorus concentration and suspended solids for all ten site locations. Phosphorus was significantly negatively related to conductivity for site A only ($p < .01$.) Conductivity was significantly negatively related to suspended solids at all sites except site D, downstream data (all $p < .10$).

When all sites were regressed together, phosphorus was significantly positively correlated with suspended solids ($p < .001$) and negatively correlated with conductivity ($p < .001$.) Conductivity was negatively related to suspended solids ($p < .001$.)

Table 2 shows the results from two sites, on two dates, of phosphorus analyses on filtered and unfiltered samples. Total soluble phosphorus in these samples accounted for 44–100% of the total phosphorus in the sample.

Fecal coliform analysis of stream samples taken on March 31 (during snowmelt runoff) resulted in all ten samples having 100 or more bacteria per ml, with site D, upstream, showing highest coliform levels (14,000/ml) and site B showing lowest

Table 2. Phosphorus analyses of filtrates of selected samples

Date	*Sampling Location*	*Total P mg/l*	*Filtrate P mg/l*	*Filtrate P/ Total P*
3/25	Site A, upstream	0.28	0.26	0.93
	A, downstream	0.27	0.27	1.00
	C, upstream	0.44	0.21	0.48
	C, downstream	0.55	0.32	0.58
3/27	Site A, upstream	.87	0.38	0.44
	A, downstream	0.86	0.36	0.42
	C, upstream	1.30	0.85	0.65
	C, downstream	1.18	0.83	0.70

coliform (100 and 200 per ml, downstream and upstream.) Coliform estimates on samples taken on April 27 (spring-spread) resulted in site A, upstream, having 100 bacteria/ml; all other sites had less than 100/ml.

Discussion

Highest stream discharges coincided with the period of most rapid snow melt, with peak discharges occurring around March 26 (see Figs. 2 and 3). A second discharge peak occurred on April 8, at a time of relatively heavy rains. A heavy rainfall on April 30, however, did not result in significant increases in stream discharge. Snow depth and frost depths for the 1992-93 winter were below normal compared to averages for the past 20 years, as was precipitation for March (pers. comm., Wisconsin State Climatologist). Precipitation for April and May were above normal. Total runoff potential for the spring of 1993, which is directly related to snow depth and precipitation and inversely related to frost depth, should therefore be considered about normal compared to the past 20 years.

A single sample of surface water runoff, taken in a part of the field containing turkey litter at site C during snowmelt, was measured for total phosphorus as 32 mg/l (data not shown). However, these very high nutrient levels on-site do not translate into statistically detectable solids or phosphorus inputs from individual fields during spring snowmelt runoff. Snowmelt is a period of very high discharge and relatively high phosphorus concentrations and levels of suspended solids. These high levels within the streams result from the cumulative contributions of many fields, barnyards, and forests within the watershed. The incremental load from an individual field appears to represent too small an input, under these conditions, to be detectable. Fields used in this study had phosphorus and sediment runoff ameliorated by relatively gentle slopes, sandy soils, and the presence of vegetative buffers. It is possible that under conditions of more potential runoff, such as fields with higher slope, more clay, and no buffers, or during years of abnormally high runoff, increments from individual fields may be detectable.

During spring-spreading of litter, and during spring tillage, sediment inputs were detected at two of the sites. At this time, while fields were being tilled, streams had low discharge and low sediment loads. Under these conditions, it was possible to detect sediment loading from some of the fields.

Conductivity (dissolved ions) was generally not significantly different upstream from downstream. One site (site B) showed lower conductivity downstream than upstream, and one site (site E) showed higher conductivity downstream than upstream, during snowmelt runoff.

Janzen et al. (1974) measured nutrient concentrations in small streams in South Carolina, adjacent to fields spread with dairy manure. They noted somewhat higher phosphorus concentrations in the streams directly adjacent to but not 50–600 meters downstream from the fields. In our study, it was generally not possible to detect phosphorus inputs from individual fields. At site E and site C during snowmelt runoff, phosphorus concentrations were significantly lower downstream than upstream.

In addition to nutrient input into streams, animal manure has the potential to degrade water quality from the input of coliform bacteria. Robbins et al. (1971) noted a significant increase in the numbers of coliforms in water adjacent to fields spread with animal manure. Janzen et al. (1974) found similar results. Although we were not able to detect significant increments of bacteria from individual fields, our results indicate that bacteria from the manure are in fact making their way into the streams. This was especially notable during snowmelt runoff. Numbers of coliform dropped below limits of detection after snowmelt runoff, when suspended solids and phosphorus concentrations also declined.

Phosphorus entered the study streams in both the soluble and insoluble forms. An average of 65% of measured phosphorus remained in the filtrate as soluble phosphorus for two dates, shown in Table 2. The portion of phosphorus as soluble phosphorus appears, from these results, to vary from site to site and date to date. The significant positive regression between phosphorus and suspended solids for all sites over all dates suggests that in general increased erosional input into streams will increase the input of phosphorus. Conductivity is determined by the concentration of total cations and anions in the stream, which may show a different mobility in the soil, compared to phosphorus itself (Rodhe 1949). Previous studies have also demonstrated a negative relationship between phosphorus and conductivity (Mueller et al. 1984).

Although this study was not able to pinpoint phosphorus loading from particular fields into nearby streams, levels of this nutrient and of erosional sediments within the streams were seen to increase drastically during snowmelt runoff. The incremental loading of nutrients from various sources into the nation's waterways provides an input into lakes and reservoirs that causes a significant impact on water quality. Monitoring streams during snowmelt runoff and during low-flow, background loading both for total phosphorus and total dissolved phosphorus has the potential to provide information useful in improving nutrient management. In addition, monitoring phosphorus concentrations in streams during snowmelt can help identify those subwatersheds that contribute the most phosphorus to particular lakes or reservoirs.

Appendix 1. Suspended solids, mg/l at upstream (u) and downstream (d) sampling sites

Date	*A,u*	*A,d*	*B,u*	*B,d*	*C,u*	*C,d*	*D,u*	*D,d*	*E,u*	*E,d*
6			3.2	5.1		3.1	3.4			
13			6.9	6.6	3.8	3.8	5.5	4.2	5.3	4.2
17			2.7	5.1	2.1	3.1	4.1	4.6	4.7	5.2
19	1.4	1.4	1.5	2.6	1.9	1.4	4.4	2.7	1.9	2.4
20	0.9	0.9	1.8	3	1.6	2.2	3.1	3.2	3.3	3.6
24	3.8	7.8	25.8	26.3	6.7	4.1	4	3.5	5.8	4.8
25	11	10.9	16.7	16	8.6	11.1	4.2	6.5	6.2	5
26	24.9	16.8	70.7	74.4	60.6	41.4	9.6	9.2	36.6	12
27	13.4	11.2	42.2	34.6	55	45.5	95	44.5	24.8	25.4
29	6.9	6.4	14.4	18.9	26.4	27.4	19.2	24.6	12.6	14
31	4.7	5	8.6	6.1	11.4	11.6	10.4	10.7	6.8	8.1
34	4.4	4.3	3.7	5.9	7.8	7.7	5.2	5.6	5.1	5.2
39	3.9	9.1	14.2	8.3	26.3	29.9	12.4	13.9	13.3	14.8
40	3.8	5.3	6.5	5.8	15	16.6	7.5	7.1	8.5	8.6
44	1.7	1.8			9.3	9.9				
45	1.7	1.7	3.3	9.1	7.7	7.5	11.5	10.8	5.5	6.3
48	1.9	1.5	4.5	5.4	6.7	6.8	4.6	4.6	5.1	6.2
53	3.1	3.1	3	9.2	5.1	5.8	5.7	5.3	7.6	9.2
55	1	0.8	2.4	4.7	5.8	7.3	4.4	4.6	5.7	7.1
58	2.3	1.8	10.9	11.1	4.4	4.6	4	4.9	4.9	6.9
60	1.3	3.6	3.7	7.5	7.8	11	4.7	4.7	6.7	8.3
62	1.9	2.7	4.5	4.5	6.1	7	5.3	4.9	5.3	5.4
67	3	4.2	4	6.6	15.8	17.8	9.4	8.5	22.8	28.8

For dates, 1 = March 1; 32 = April 1; 62 = May 1.

Appendix 2. Conductivity, umhos/cm^2, at 25°C at upstream (u) and downstream (d) sampling sites

Date	*A,u*	*A,d*	*B,u*	*B,d*	*C,u*	*C,d*	*D,u*	*D,d*	*E,u*	*E,d*
17			277	269	237	202	205	196	221	224
19	344	371	261	258	234	234	213	221	234	237
20	363	376	261	252	229	229	202	212	228	231
24	338	335	224	224	142	142	198	194	215	213
25	300	300	218	212	245	272	207	205	224	224
26	205	198	174	164	229	220	202	196	210	223
27	130	130	174	177	172	175	144	174	152	155
29	101	99	125	126	114	114	150	164	114	11
31	194	191	207	202	137	133	166	167	144	145
34	270	272	224	224	160	161	153	153	153	158
39	224	235	190	175	139	126	123	131	155	153
40	204	204	201	190	156	149	115	120		
45	237	237	142	128	160	160	114	114	139	139
48	256	261	234	221	167	174	142	142	141	142
53	299	297	239	235	191	191	158	160	174	174
55	307	307	245	237	207	205	163	166	212	220
58	300	300	213	205	221	221	169	172	218	220
60	272	269	237	221	205	209	172	169	207	207
62	299	288	251	237	219	223	167	163	220	216
67	269	283	251	234	172	177	175	174	136	142

For dates, 1 = March 1; 32 = April 1; 62 = May 1.

Appendix 3. Phosphorous,mg/l at upstream (u) and downstream (d) sampling sites

Date	*A,u*	*A,d*	*B,u*	*B,d*	*C,u*	*C,d*	*D,u*	*D,d*	*E,u*	*E,d*
13			0.100	0.090	0.080	0.110	0.130	0.060	0.090	0.130
17			0.210	0.130	<.04	<.04	0.120	0.090	0.050	0.040
19	<.04	0.040	0.040	<.04	<.04	<.04	0.070	0.050	0.050	0.050
20	0.040	<.04	0.060	0.120	<.04	<.04	0.040	0.050	0.040	0.040
24	0.200	0.300	0.200	0.200	0.200	0.200	0.200	0.090	0.120	0.090
25	0.280	0.270	0.130	0.120	0.440	0.550	0.190	0.190	0.220	0.210
26	0.630	0.580	0.260	0.250	1.190	0.790	0.300	0.300	0.480	0.460
27	0.870	0.860	0.490	0.290	1.300	1.180	0.730	0.620	0.750	0.720
29	0.260	0.290	0.080	0.170	0.850	0.770	0.540	0.570	0.420	0.420
31	0.140	0.140	<.04	<.04	0.370	0.370	0.400	0.410	0.170	0.160
34	<.04	<.04	<.04	<.04	0.130	0.110	0.250	0.240	<.04	<.04
39	0.130	0.120	<.04	<.04	0.330	0.270	0.250	0.240	0.220	0.190
40	0.130	0.130	<.04	<.04	0.280	0.270	0.190	0.190	0.130	0.130
44	<.04	<.04			0.130	0.150				
45	<.04	<.04	<.04	<.04	0.140	0.120	0.140	0.140	<.04	<.04
48	<.04	<.04	<.04	<.04	0.110	0.130	0.140	0.180	<.04	<.04
53	<.04	<.04	<.04	<.04	<.04	<.04	<.04	0.110	0.150	<.04
55	<.04	<.04	<.04	<.04	0.120	0.100	<.04	0.120	0.120	0.100
58	<.04	<.04	<.04	<.04	<.04	<.04	<.04	<.04	<.04	<.04
60	<.04	<.04	<.04	<.04	<.04	<.04	<.04	<.04	0.130	0.140
62	<.04	<.04	<.04	<.04	0.110	0.120	0.110	0.100	0.120	0.130
67	<.04	0.100	<.04	<.04	0.130	0.210	0.220	0.370	0.190	0.160

For dates, 1 = March 1; 32 = April 1; 62 = May 1.

Appendix 4. Manure management study, spring 1993, water discharge, ft³/sec

Date	Site A	Site B	Site C	Site D	Site E
6	*	0.1	140	32	12
13	*	0.1	160	32	13
17	*	0.2	190	35	15
19	11	0.1	110	27	4.6
20	14	0.1	140	23	4.6
24	12	3.0	120	20	5.1
25	29	0.6	140	22	6.0
26	41	8.0	220	42	11
27	72	1.7	350	79	74
29	44	2.8	600	140	81
31	27	1.1	430	110	65
34	13	0.1	140	81	62
39	25	1.1	350	79	60
40	24	18	430	79	60
45	10	13	110	54	46
48	5.9	6.9	89	46	37
53	7.6	6.0	54	30	24
55	3.4	7.0	51	28	20
58	5.5	15	43	28	19
60	6.4	7.0	54	30	21
62	5.5	5.2	48	32	21
67	5.5	6.0	74	19	41

For dates, 1 = March 1; 32 = April 1; 62 = May 1.

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Kamela K. Schell and John L. Wedberg

The effect of picnic beetles (Glischrochilus quadrisignatus) *on European corn borer* (Ostrinia nubilalis) *larval mortality*

Abstract *A study was conducted to ascertain the effects of the picnic beetle* (Glischrochilus quadrisignatus [Coleoptera: Nitidulidae]) *on European corn borer* (Ostrinia nubilalis [Lepidoptera: Pyralidae]) *larval mortality. The experiment consisted of two treatments: corn plants with a European corn borer larva only and corn plants with a European corn borer larva and picnic beetles. Significantly more corn borer larvae survived in the control than in the treatment receiving picnic beetles. Picnic beetles caused a 17.5% increase in corn borer mortality.*

The picnic beetle (*Glischrochilus quadrisignatus* [Say]), which is distributed throughout the northern United States (Luckman 1963), is associated with a variety of foods including plant sap, fungi, fruits, and vegetables and is often found in the corn agroecosystem (Luckman 1963; Foott and Timmins 1971). As McCoy and Brindley noted (1961), the introduction of the European corn borer *(Ostrinia nubilalis* [Hübner]) to the Midwest provided the picnic beetle with an additional food source in the form of injured corn plants and European core borer (hereinafter ECB) frass. The picnic beetle is primarily saprophagous and feeds on a variety of fermenting and decomposing plant material. However, on the basis of early reports by Everly (1938) and Barber and Dicke (1944) that picnic beetles may be ECB predators, McCoy and Brindley (1961) investigated the possible reductive effects picnic beetles have on ECB populations. They reported that during the period of peak beetle populations, the number of dead ECBs and empty tunnels increased. McCoy and Brindley also reported that picnic beetles do not actively prey on ECB larvae in the confines of an ECB tunnel. Rather, it appeared that the activity of picnic beetles may cause accidental injury to the ECB larvae, which the beetles subsequently fed on. Empty tunnels are a result of picnic beetle movement irritating ECB larvae so as to drive them from their tunnels (McCoy and Brindley 1961). When Carlson and Chiang (1973) assessed the role of sucrose sprays on concentrating predatory insects against the ECB, they found a negative correlation between the number of beetles per plant and number of ECBs per tunnel. They concluded that picnic beetles reduce ECB populations after the larvae have entered the stalk. The literature supports the idea that picnic beetles can have a deleterious effect on ECB populations; however, the evidence has been circumstantial, and no rigorous study has been conducted to confirm these effects. The purpose of this study was to evaluate the effects picnic beetles have on a known population of ECBs.

Methods and Materials

This experiment was conducted at the University of Wisconsin Arlington Agricultural Research Station in Columbia County during the summer of 1994. The experiment was a completely randomized design with two treatments and six replicates. Each plot consisted of ten corn plants. The Kansas pipette tip procedure (Higgins, described by Bode and Calvin 1990) was used to introduce one-fourth instar ECB larvae into the stalks of the corn plants on 26 August 1994. A single larva was placed in the third internode above the brace roots. The larvae used in this study were reared from eggs bought from Dekalb Genetics. When the treatments were applied, the corn (Pioneer 3751) was in approximately the R3 milk stage of development, the kernels had yellowed, and the silks were brown and dry (Ritchie et al. 1982). To facilitate entry of the 1 ml pipette tip (Fisher Scientific, Reference Tip) into the corn stalk, a 20 d common framing nail was driven through a block of wood and used as a hole punch. The nail was forced into the stalk to a depth of 2 cm, making it easier to insert the pipette tips. All plants were punched, and the stalks were given 15 minutes for the flow of plant sap to diminish before the pipette tips containing ECB larvae were inserted. This delay was necessary since it was known from prior experience that pipettes inserted immediately after the stalk was punched resulted in high ECB mortality: the larvae drowned in plant sap collecting in the pipette tip. The larvae were brought to the field in pipette tips. The wide end of the pipette was plugged with clay, and the tip was plugged with cotton to prevent the ECB larvae from escaping. The cotton was removed from the pipette tip when it was time to insert the ECB larvae into the corn plants. The larvae were allowed three days to burrow into the stalks. On 29 August one-half of the stalks were infested with three picnic beetles per plant via pipette tips. The picnic beetles used in this study were collected in banana-baited Lindgren funnels at the Arlington Agricultural Research Station. Forty-eight hours after the picnic beetles were introduced into the corn plants, the stalks were split open and the condition of the ECB larvae was recorded. The percent of ECB larvae alive, dead, or missing was calculated for each treatment, and a chi-square analysis was used to analyze the data.

Results and Discussion

A significant difference was found between corn plants containing an ECB larva only and corn plants containing both an ECB larva and picnic beetles ($X^2 = 15.715$, P <

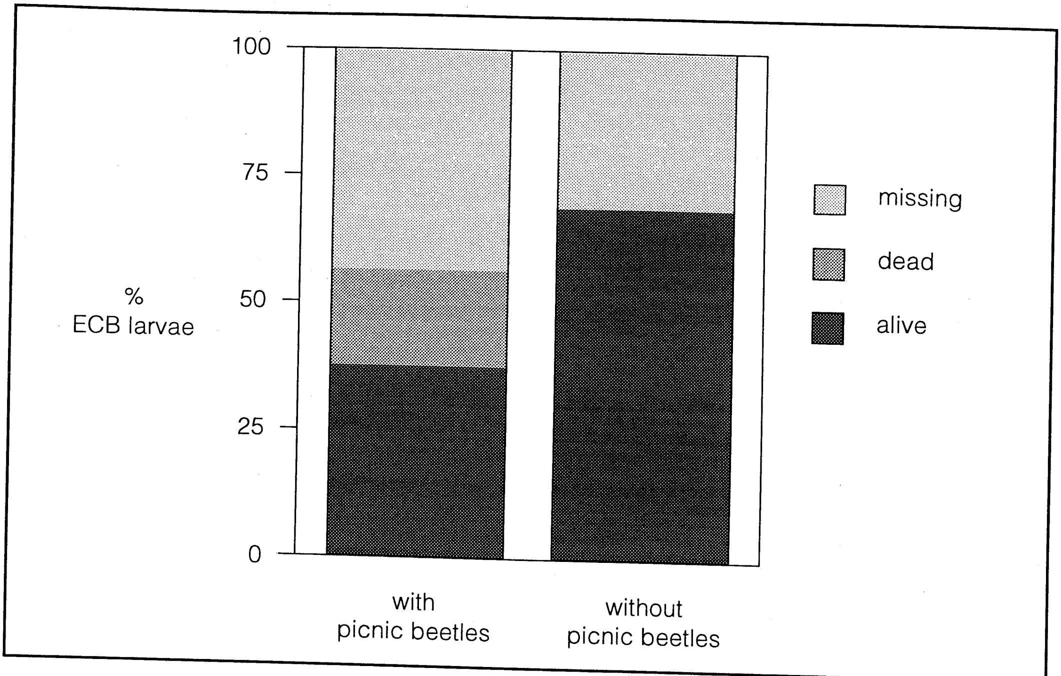

Fig. 1. Percent of European corn borer larvae missing, dead, and alive in cavities containing European corn borer larvae and picnic beetles and in cavities containing European corn borer larvae only.

0.001). Of the plants infested with picnic beetles, 61.4% of the ECB larvae were either dead (17.5%) or missing (43.9%); by comparison, plants in the control group contained no dead larvae and 33.3% missing larvae (Fig. 1). Significantly more ECB larvae (66.7%) survived in the control than in the treatment receiving picnic beetles (38.6%). These data quantify the direct effects picnic beetles can have on ECB mortality and confirm the earlier suspicions of McCoy and Brindley (1961) and Carlson and Chiang (1973). It appears that the death of 17.5% of the larvae in this experiment probably resulted from mechanical injury of larvae by picnic beetles. The inability to observe events within the plant, however, makes it impossible to know whether nitidulids are actually preying on ECB larvae or injuring them via accidental mechanical damage. Although on two occasions picnic beetles feeding on ECB larvae were observed in the field, it is possible that the larvae were injured or weakened prior to picnic beetle feeding. Generally, picnic beetles appear to be disinterested in ECB larvae when the two are placed together in petri dishes.

Picnic beetles have been shown to reduce ECB populations after the larvae have entered the stalk. However, this reductive effect may be more pronounced during the first generation than the second generation. Picnic beetles are attracted to and feed on corn pollen, and second generation ECBs lay eggs on corn plants that have tasseled and are near the pollen-shedding stage. Once pollination begins, picnic beetles may concentrate more heavily where pollen collects than where ECB larvae and frass collect, which reduces opportunities for contact with second generation ECB larvae and reduces their value as a predator.

Although picnic beetles have a reductive effect on ECB populations, this positive result should be weighed against the possible deleterious effects picnic beetles may have on the corn system itself. Picnic beetles have been implicated in the transmission of the corn fungal pathogens *Fusarium* spp. (Windels, Windels, and Kommedahl 1976) and *Gibberella zea* (Attwater and Busch 1983). The plant injuries (i.e., ECB cavities and ECB ear damage) that attract picnic beetles are excellent entrance points for plant pathogens. The spread of stalk and ear rots may be exacerbated by movement of picnic beetles from plant to plant.

Moreover, picnic beetles themselves may be considered corn pests if their numbers become heavy. Picnic beetles are considered secondary invaders of injured or over-ripe fruits and vegetables, and a buildup of picnic beetles may occur anywhere a plant has been damaged. In the case of silking corn ears, Luckman (1963) found picnic beetles to be primary invaders, possibly attracted to pollen fermenting in the silks. A large picnic beetle population in sweet corn may warrant control measures where contamination of processed corn with insect body parts occurs.

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