Transactions of the Wisconsin Academy of Sciences, Arts and Letters. volume XXXVI 1944

Madison, Wis.: Wisconsin Academy of Sciences, Arts and Letters, 1944

https://digital.library.wisc.edu/1711.dl/B44YAM2CN6YXH8B

TRANSACTIONS

OF THE

WISCONSIN ACADEMY

OF

SCIENCES, ARTS AND LETTERS

VOL. XXXVI

NATURAE SPECIES RATIOQUE

MADISON, WISCONSIN

1944

OFFICERS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

PRESIDENT

H. A. Schuette, *University of Wisconsin*

VICE PRESIDENTS

IN SCIENCE: Ruth Walker, *Milwaukee*
IN ARTS: Walter Bubbert, *Milwaukee*
IN LETTERS: Helen White, *University of Wisconsin*

SECRETARY-TREASURER

Banner Bill Morgan, *University of Wisconsin*

LIBRARIAN

Halvor O. Teisberg, *University of Wisconsin*

CURATOR

Edward P. Alexander, *State Historical Museum*

COUNCIL

The President
The Vice-Presidents
The Secretary-Treasurer
The Librarian
E. A. Birge, *past president*
Charles S. Slichter, *past president*
L. J. Cole, *past president*
Charles E. Allen, *past president*
Rufus M. Bagg, *past president*
Paul W. Boutwell, *past president*
A. W. Schorger, *past president*

COMMITTEE ON PUBLICATIONS

The President
The Secretary-Treasurer
Philo M. Buck, Jr., *University of Wisconsin*

COMMITTEE ON LIBRARY

The Librarian
O. L. Kowalke, *University of Wisconsin*
Ruth Marshall, *Wisconsin Dells*
James F. Groves, *Ripon College*
W. N. Steil, *Marquette University*

COMMITTEE ON MEMBERSHIP

The Secretary-Treasurer
E. F. Bean, *Wisconsin Geological Survey*
P. W. Boutwell, *Beloit College*
W. E. Rogers, *Lawrence College*
A. W. Schorger, *Madison*

Representative on the Council of the American Association for the Advancement of Science
Banner Bill Morgan

TABLE OF CONTENTS

Page

Brule River Survey: Introduction. E. SCHNEBERGER and A. D. HASLER 1

Topography and Geology of the Brule River Basin. E. F. BEAN and JOHN W. THOMSON, JR. 7

A History of Fishing in the Brule River. D. JOHN O'DONNELL 19

Vegetation of the Brule Basin, Past and Present. NORMAN C. FASSETT 33

A Survey of the Larger Aquatic Plants and Bank Flora of the Brule River. JOHN W. THOMSON, JR. 57

The Quail in Early Wisconsin. A. W. SCHORGER 77

Small Mammal Censuses Near Prairie Du Sac, Wisconsin. HAROLD C. HANSON 105

The Lake Sturgeon, *Acipenser Fulvescens* Rafinesque, in Lake Winnebago, Wisconsin. EDW. SCHNEBERGER and LOWELL A. WOODBURY 131

The Bur Oak Openings in Southern Wisconsin. A. B. STOUT 141

Some Aquatic and Sub-Aquatic Plants from the Region of Glacial Lake Wisconsin. JOHN CATENHUSEN 163

The Mosses of Wisconsin. L. S. CHENEY and RICHARD EVANS 171

Notes on Wisconsin Parasitic Fungi. V. H. C. GREENE 225

Notes on Wisconsin Parasitic Fungi. VI. H. C. GREENE 245

Preliminary Reports on the Flora of Wisconsin. XXXI. Boraginaceae. EMIL P. KRUSCHKE 273

Parasites of Northern Wisconsin Fish. RALPH V. BANGHAM 291

Syrphid Flies of the Genus *Cheilosia*, Subgenus *Chilomyia*, in North America (Part II). C. L. FLUKE and F. M. HULL 327

Preliminary List of the Hydracarina of Wisconsin. RUTH MARSHALL 349

The Physaloptera (Nematoda) of Carnivores. BANNER BILL MORGAN 375

Winter Oxygen Content and Biochemical Oxygen Demand in a Wisconsin Artificial Lake. CHARLES H. LEWIS and NEIL E. STEVENS 389

Further Observations on Alkaline Flooding Water in Cranberry Growing. NEIL E. STEVENS 395

Studies of Silurian Fossils in the Thomas A. Greene Collection at Milwaukee-Downer College. KATHERINE F. GREACEN and JOHN R. BALL 415

Boron Deficiency in Beets as Correlated with Yields and Available Boron. K. C. BERGER and E. TRUOG 421

The Acidity of Honey. H. A. SCHUETTE and FRANK J. SCHUBERT 427

Gasogens. C. V. SWEET 435

Professor Beatty's Interpretation of Shakespeare. JULIA GRACE WELLS 441

Racial Classifications of the Seventeenth and Eighteenth Centuries. J. S. SLOTKIN 459

List of Publications Dealing with Wisconsin Limnology, 1871-1945. CHANCEY JUDAY and ARTHUR D. HASLER 469

Proceedings of the Academy 491

INSTRUCTIONS TO AUTHORS FOR SUBMITTING MANUSCRIPTS

Manuscripts should be neatly typed in double spacing, one side of paper, 8½x11 inches, allowing at least 1 inch margin. The bibliography and quotations should also be double spaced. The original ribbon copy must be submitted. Only manuscripts submitted by members of good standing can be accepted.

Tables should be typed on separate sheets and placed in the back of the text. Tables with several columns should be ruled. Indicate on the margin where table should be inserted. All graphs and drawings must be made on good grade white drawing paper and with black India ink. The dimensions of the printed page (4x7 inches) should be kept in mind for preparing figures and tables for proper reduction.

All photographs are to be submitted unmounted and indicate the amount of reduction. Glossy prints are preferred. Captions for photographs, graphs, drawings, should be typed on separate sheets and placed at the end of the paper.

Footnotes or bibliography may be placed at the end of each article. Avoid footnotes which occur at the bottom of the page. All bibliography is to be kept uniform. Use the following as sample for guide:—
Doe, J. H. 1934. The ecology of Wisconsin. Trans. Wisconsin Acad. Sci. 14: 721-748. In citing the *Transactions* use the above abbreviation.

Manuscripts should be mailed flat, not folded or rolled. Manuscripts should be submitted in final form for the printer so that any changes on the galley-proof would be errors by the printer. Extensive changes or deletions from galley or page proof are prohibitive. The Academy will pay part of the cost for reprints. Orders should be placed at the time the manuscript is submitted.

Correspondence relating to publication in the *Transactions* or to other Academy business should be directed to the Secretary-Treasurer. Banner Bill Morgan, Department of Veterinary Science, 211 Genetics Building, University of Wisconsin, Madison, Wisconsin. Publications intended for the Library of the Academy should be sent directly to the Librarian, Halvor O. Teisberg, 120 State Historical Building, Madison, Wisconsin.

BRULE RIVER SURVEY: INTRODUCTION*

Brule River Survey: Paper No. 1

E. SCHNEBERGER

Biology Division, Wisconsin Conservation Department

A. D. HASLER

Department of Zoology, University of Wisconsin

The Brule River in Douglas County is one of Wisconsin's largest and most scenic streams. Its past fame as a trout stream does not need elaboration as it suffices to state that even presidents of the United States were attracted to the stream to try their luck. However, during the past few years the fishing has declined even though heavily stocked and "improved" by the installation of a large number of stream improvement structures.

The need for an intensive study on this stream became evident when it was realized that during a five-year period extending from 1937 to 1941, a total of $34,247.67 was expended for the planting of fish and that stocking was not bringing about the desired results of maintaining or improving fishing.

It naturally follows that a well-balanced management plan cannot be developed without knowing the factors which govern the fish producing capacity of the stream. The purpose and objective of the Brule River Survey may, therefore, be stated as "the evaluation of the physical, biological, and chemical characteristics of the Brule River and its watershed so that an efficient and well-balanced fish management plan might be developed and placed into operation." To this end the Conservation Commission sought the services of the scientists from the University of Wisconsin and a co-operative research project was evolved. A fund of $9,000 for a two-year study was established by the

* A co-operative project sponsored by the Wisconsin Conservation Deparmtent and the University of Wisconsin. The results of the survey will appear in a series of papers that will be printed in the TRANS. WIS. ACAD. SCI. ARTS & LET. Reprints of these articles will be made available to interested parties upon application to the Wisconsin Conservation Dept., Madison 2.

Conservation Commission and work began in September, 1942. Owing to wartime difficulties—manpower shortage and travel restrictions—many phases of the original plan could not be carried out in the expected detail. Nevertheless, the important basic items have been subjected to analysis. The technical results of the studies will be published in the Transactions of the Wisconsin Academy of Sciences, Arts and Letters with a popular interpretation of the results appearing in the Wisconsin Conservation Bulletin. Publication will be in a series of scientific papers issued as rapidly as the studies warrant. Several appear in this issue.

The Brule River is in many ways an ideal stream upon which to conduct a broad detailed study. It is one of the few larger streams that has not been altered by dams. It does not receive sewage from industry or a municipality. It contains a variety of ecological conditions. The upper section of the stream lies in a boggy, marshy area and then broadens out into widespreads approaching lake conditions. The middle section immediately below the widespreads is a stretch of "fast" water containing many rapids. The lower section continues as a stretch of rather flat, quiet water and empties into Lake Superior. On the other hand, the stream is too large for a complete study to be conducted during a two-year period with a limited personnel.

Some of the problems of general interest undertaken in this study are as follows:

To determine the number of fish reaching the anglers' creel, a census was begun with the opening of the season, May 1, 1943. Census clerks were stationed at the points where the concentration of fishermen was the greatest. These individuals procured from the angler the number and species of fish caught, the length, weight, and sex of each. Scale samples were collected which are later used to determine the age and rate of growth. To interpret the efficiency of plantings of hatchery raised trout, 5,000 legal sized trout (brook and rainbow) were marked and placed into the Brule during the summer of 1943 and 7,000 (brook trout only) in 1944. All fish planted during the course of the study were marked and only trout of legal size were used. The clerks recorded the marked trout in the creels and the data from such returns will be compared with the original plant to determine the contribution to the creel. Recapture of marked trout in experiments conducted by the Conservation Department and other states indicate that approximately 20 to 75 per cent of spring and summer planted legal size fish are caught by the anglers. In such studies it has been found that recaptures from fall plantings are appreciably lower.

Rainbow and brown trout are exotic species while brook trout were the original inhabitants of the Brule. Each of these species has definite optimum requirements; therefore, a knowledge of their suitability to the stream must be the guiding factor in its management. Consequently, this association was a case for study. The rainbow trout in particular present some interesting problems. It is apparent that most of the adults inhabit Lake Superior, migrating up the Brule River in the spring to spawn. Angling for the migrating fish furnishes the fisherman a great amount of sport. It would be well then to learn more about the life history of this species in the Brule.

To shed light on some of these questions, a weir has been constructed at Stone's Bridge. This weir has a two-way trap which is inspected daily by an attendant. The fish entering the trap from upstream are fin clipped or tagged and transferred over the weir and released downstream. Likewise, the fish entering from downstream are also fin clipped or tagged and released in the direction in which they were going. Information gathered at this weir will provide data on brook trout biology. Recapture of trout through this station will answer some of the questions listed above. In addition, this trap will enable the biologists to determine the number of other species (suckers, northern pike and walleyed pike) that spawn or migrate in the Brule. An experiment was also initiated to test the ability of brown trout to maintain themselves without stocking.

As a trout stream, the Brule is peculiar because of the two large "widespreads" (lakes) which are well suited for northern pike. It is hoped that the findings will give a clue to the extent that northern pike prey upon or are injurious to the trout population. These widespreads expose a greater surface of quiet water to the warming rays of the sun, resulting in a higher temperature in that area, consequently its effect on fish must be studied.

The severe winter of 1942-43 created a problem because of the formation of "anchor ice" on the bottom of the stream. It forms on the bottom during cold clear nights and rises subsequently in the day because of the warming of the sun. It is proposed to learn the effect of this ice on the trout habitat because it was noted that considerable quantities of rocks and debris, in addition to the organisms attached to them, were lifted and carried downstream.

In order to study the amount of fish that a stream will support and at the same time yield a moderate crop to the angler, estimates are being made of the quantity of food organisms found on various types of bottom in the Brule. Because trout feed extensively in the summer on terrestrial insects (those which have fallen in from overhanging vegetation), the biologists are measuring the value of streamside cover in fish food production. These findings will be correlated with the variety of organisms found in the stomachs of fish which the creel census clerks procured from the angler's creel. The rate of growth of resident and marked trout will also be correlated. In addition, density of trout population in various sections of the stream will be measured by means of electrical anesthesia. The population density can be then correlated with the success of the creel and with the chemical and biological conditions.

Historical records and accounts of residents of the Brule emphasize the detrimental effect of denuding the cover. Through an intensive study of the cover of the watershed the plan is to quantitate this effect. One of the co-operators compiled maps based upon records of surveyors who tramped the section lines of the Brule watershed in 1840. These maps will give an estimate of the concentration of timber of that period which can then be compared with the present stand. Another compiled figures of the measurements of timber from aerial photographs and corroborated these by observations in the field. This study converts the impression of the lay observer into definite numbers. Because the cover of a watershed influences the conditions of erosion and the amount of water flow by springs and runoff, it is felt that this information will give data which will be an aid in recommending procedures for improved cover conditions on the watershed. Still other investigators are studying the erosion on the river banks, from the many highways and roads and from farm land.

The general overall supervision and planning of the project was the responsibility of the authors. D. John O'Donnell, biologist of the Wisconsin Conservation Department operating from the Conservation Department Biology Laboratory at Spooner and the Brule Ranger Station, was in charge of all field operations with W. S. Churchill and J. R. Jacobson as permanent assistants. Temporary assistants were L. D. Prey, Helen Hall, and Curtis Austin. Wholehearted and unselfish aid and cooperation have been received from many sources and the authors take this opportunity to express their thanks to the multitude of persons who in one way or another assisted in the project. Thanks are especially due to N. C. Fassett, Professor of Botany, University of Wisconsin, and John W. Thomson, Superior State Teachers College, and now of the University of Wisconsin, who conducted studies on the vegetation in the stream and on the watershed; R. I. Evans, Department of Botany, University of Wisconsin, who made studies of the origin of the bottom sediments of plant nature; F. C. Christopherson, Keith S. Brigham and Robert H. Brigham, U. S. Geological Survey, who offered important aid in the construction of instruments to measure stream flow and their maintenance; and E. F. Bean, State Geologist, who restudied the geology of the Brule, in addition to organizing a soil erosion team (M. F. Schweers, Soil Conservation Service and O. R. Zeasman, University of Wisconsin) to study the erosion problems arising from the stream banks, roads and farmland.

Others who gave conspicuous service and who helped unselfishly were J. E. Hanson, in charge of the Brule Ranger Station, and his dispatcher, Wm. Johnson; J. W. McNaughton, conservation warden, E. Lambert, H. Swanson, J. G. Ordway of Cedar Island, and L. P. Jerrard who explored the Brule and drafted a map valuable to the study.

E. J. Vanderwall, Conservation Director, Ernest F. Swift, Assistant Conservation Director, and H. L. Russell, Chairman of the University of Wisconsin Lakes and Streams Committee, helped extensively in the arrangements for procuring services and materials from experts and departments of their respective organizations. Without their insight and willingness to act promptly, the project would have lacked many of its broad aspects.

TOPOGRAPHY AND GEOLOGY OF THE BRULE RIVER BASIN

Brule River Survey: Paper No. 2

E. F. BEAN AND JOHN W. THOMSON, JR.

Geological and Natural History Survey; Department of Botany, University of Wisconsin

As is the case with several other streams rising in northern Wisconsin the Brule River does not have the profile characteristic of a stream in a semi-mountainous region. Instead of a curve which is flat near the mouth and steeper toward the source the gradient is very gentle in its upper reaches and steeper down stream. (Fig. 1) It rises in the boggy bottom of a mile-

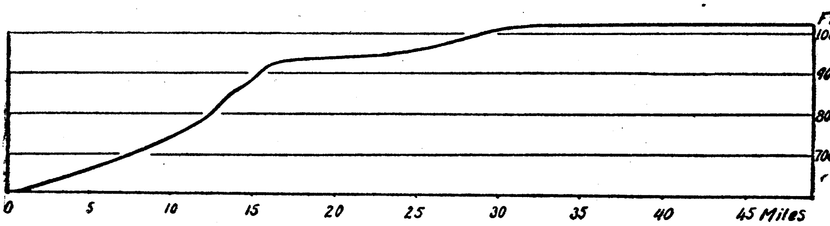


FIGURE 1. Profile of the Brule River.

wide trench one hundred feet below the level of the sandy Barrens. The bog is so flat that the divide between the Brule and the St. Croix is indistinguishable.* Rising at an elevation of

---

* Following are approximate elevations of the river:

1. Stesne's Club House, Sec. 36, T.46N., R.11W 1016
2. St. Louis Club House, Sec. 16, T.46N., R.10W 1013
3. McDougal's Club, Sec. 3, T.46N., R.10W 995
4. River at USH 2 at Brule 941
5. Near center of Sec. 26, T.48N., R.10W 917
6. Near N¼ corner of Sec. 26. T.48N., R.10W 895
7. SE¼ NE¼ 22, T.48N., R.10W 845
8. Johnson's Bridge 817
9. 100 feet N of S line of Sec. 10, T.48N., R.10W 765

   Lake Superior 602

Nos. 1-3 House Executive Document 330, 54th Congress, 1896.
Nos. 4, 5, 7 and 8 Wisconsin Geological Survey.
Nos. 6 and 9 House Document 227, 72nd Congress, 1st Session, 1930.

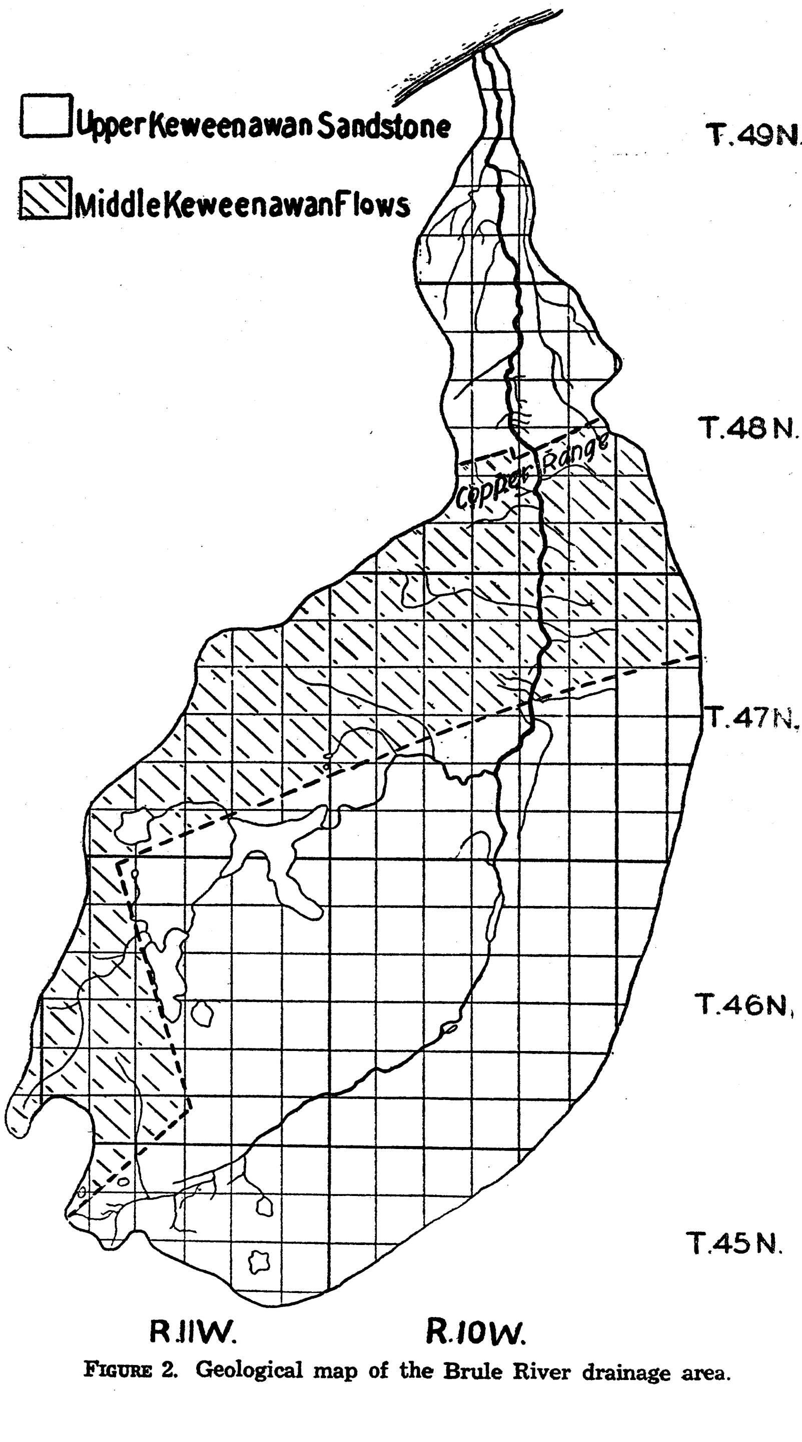


FIGURE 2. Geological map of the Brule River drainage area.

1,022 feet the stream flows northward to Lake Superior. The Copper Range (Fig. 2) which rises to a height of over 600 feet above the lake is the most conspicuous feature of the drainage basin.

The total fall of 420 feet in the air-line stream length of 30 miles can be divided as follows:

	Miles	*Fall in feet*	*Fall in ft. per mile*
Source to Copper Range	30	92	3
Copper Range	5	85	17
Sandstone	14	243	17

The actual length of the stream is increased by the numerous incised meanders from an air-line length of 30 miles to 49 miles. In the upper section much of the fall is in the Dalles in section 15, T.46N., R.10W. and in the rapids above the mouth of Nebagamon Creek. Much of the descent across the trap series is in the lower mile. In the sandstone section there are numerous small falls and rapids. The descent in the first 2¼ miles below the Copper Range is 80 feet.

With a drainage area of 190 square miles, the average width is a little over 6 miles. At the Copper Range the width is but 4 miles. Near Lake Superior the width of the drainage area is less than one mile. Some of the higher elevations are: on the Copper Range near Maple, 1,240 feet; glacial hills southwest of Lake Minnesuing, 1,280 feet; and southeast of Brule, 1,260 feet. The divide south of the Range has a maximum elevation of 1,280 feet and an average, except for the col near St. Croix Lake, of at least 1,150. The average descent from the divide to the river is about 200 feet. The river flows in a deep valley; hence much of the descent is near the stream. At the Range, the trap rises 220 feet in three-fourths of a mile. Near Brule, the valley depth is about 100 feet.

Having such a narrow drainage area, it is not to be expected that the Brule should have either long or numerous tributaries. The Little Brule rises less than a half mile from the Brule and flows northerly in what may have been a former channel of the main stream to join the Brule near Brule village. Nebagamon Creek rises a short distance northwest of the Brule-St. Croix col and flows north and northeasterly to join the Brule near Winneboujou. It drains Minnesuing, Steele, and Nebagamon lakes, as well as large areas of swamp. North of the Range, the lake clay plain slopes northward at the rate of about 40 feet per mile. It is deeply dissected by small tributary streams.

Geology

Two geological systems are found in the basin—Keweenawan and Pleistocene. There is no evidence of the existence of any rocks belonging to the intervening period of about a half billion years.

Keweenawan

This period began with the deposition of sediments, interrupted by the outpouring of lavas from extensive fissures. These lavas flowed southward over parts of Wisconsin and Michigan and northward over parts of Ontario and Minnesota, indicating that the highest part of the region and the source of the lavas were located near the present center of Lake Superior. The total thickness of these flows exceeded 20,000 feet. As thousands of cubic miles of molten material were withdrawn, there was downwarping forming a structural basin or syncline. In this basin there was accumulated a great thickness of sediments derived from the upturned margins of the syncline. The most conspicuous of these was the Great Conglomerate. Following this was the last of the lavas known as the Lake Shore Traps. Upon the Lake Shore Traps were deposited upper Keweenawan shale, conglomerate and sandstone.

The only rocks outcropping in the Brule basin are Middle Keweenawan traps and the Upper Keweenawan sandstone (Fig. 2), which occupy the north limb of the northeast-pitching syncline whose axis extends southwesterly from Chequamegon Bay. The lava flows vary in thickness from a few inches to several feet. *Trap* is the name used for a dark igneous rock. *Basalt* is a dark colored, fine grained trap rock. Diabase is a dark rock, coarser in texture than a basalt. From the exposures on the Amnicon and Middle rivers, it is inferred that the contact on the Brule is a thrust fault which resulted in bringing of the older igneous rocks up over the younger nearly horizontal sandstone, with the plane of the fault dipping about 38° to the south (Fig. 3). The flows strike N.65° E. and dip SE 40°.

Thwaites estimates that the displacement along the fault plane was from 6 to 12 miles. No rock exposures along the Brule show the fault contact between the sandstone and trap, but magnetic readings and outcrops of sandstone to the north and of trap to the south show that the fault is about one-half mile south

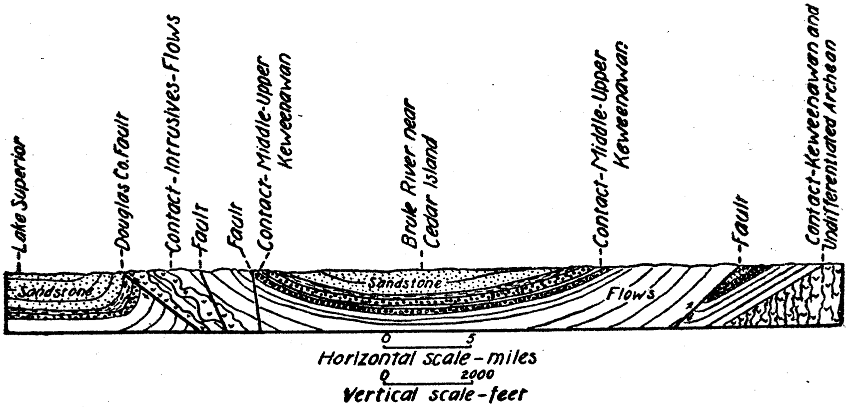


FIGURE 3. Cross-section of the Brule River drainage area.

of Johnson's Bridge in section 22, T.48N., R.10W. Topographically, the fault can be identified by the steep 200 to 300 foot rise of the north face of the trap ridge from the plain to the north. Magnetic readings indicate that the trap is from 3 to 4 miles in width (Fig. 2). With but one exception the outcrops are confined to the ridge, about a mile in width, south of the fault. The only outcrops in the river are in the SW¼ of Section 23, T.48N., R.10W. This ridge is called the Copper Range because both native copper and copper sulphides have been found along this entire range. The Percival location in section 27 is the best known prospect. In section 31, T.46N., R.11W., there are two outcrops of diabase dipping southward about 15°.

Sandstone exposures are numerous along the Brule River from about ¼ mile south of Johnson's Bridge to Lake Superior. The sandstone is flat-lying, the dip to the south varying from 0° to 3°, except near the fault, where some beds dip north at an angle of 20°. These beds are probably upturned slightly by the thrust faulting. Although no rock is exposed in the basin south of the Copper Range, it is certain that the underlying rock is upper Keweenawan sandstone dipping southerly at a low angle. The upper nine miles of the Brule's course is parallel to the trend of the syncline.

The relief prior to glaciation was much sharper than at present, due both to the degradational effect of the ice and to the mantle of glacial drift which tended to fill depressions. The Copper Range was even more conspicuous than at present. To the north and south were Keweenawan sandstone lowlands.

Pleistocene

There were probably several invasions of ice, the latest of which moved in a general southerly direction and is responsible for the soils of the area. The ice sheet must have reached a considerable thickness before it overrode the Copper Range and moved on southward. It was, therefore, able to erode the sandstones and to do a considerable amount of smoothing and plucking of the trap ridges. At the time of maximum advance, the ice was thinnest over the Range and thicker both to the north and south. As a result of this, when forward movement of the ice ceased, the Range was the first to emerge, leaving stagnant ice masses to the south and the large Superior lobe of ice in the lowland to the north.

When the ice finally disappeared, there were left in the drainage basin four types of glacial deposits: (1) terminal moraine, (2) outwash, (3) glacial drift modified by lake action, and (4) lake clay. (Fig. 4)

1. *Terminal Moraine.* There is no continuous belt within the drainage area that might be classed as recessional or terminal moraine built at the stationary front of the ice sheet. Instead there are isolated areas with considerable local relief and knob and sag topography. The occurrence of boulders in the channels of the Brule indicates that ground or terminal moraine deposits were buried by outwash sand and gravel and later exposed and concentrated to a boulder pavement by stream erosion. The larger boulders which cover the valley floor at Cedar Island indicate that the area of terminal moraine around the fire tower in section 13, T.46N., R.10W. was originally connected with the terminal moraine across Brule Valley to the west. Terminal moraine belts together with stagnant ice masses constituted the southern border of Glacial Lake Duluth.

2. *Outwash.* Extending southwesterly from northern Bayfield County for over one hundred miles is a sandy belt from 5 to 15 miles in width, which has long been called "the Barrens." Much of the Barrens should be classified as pitted outwash, the pits being formed by the burial and subsequent melting of ice blocks. That these pitted areas are outwash rather than terminal moraine is shown by the fact that the summit levels are relatively uniform, that boulders are not numerous, and that

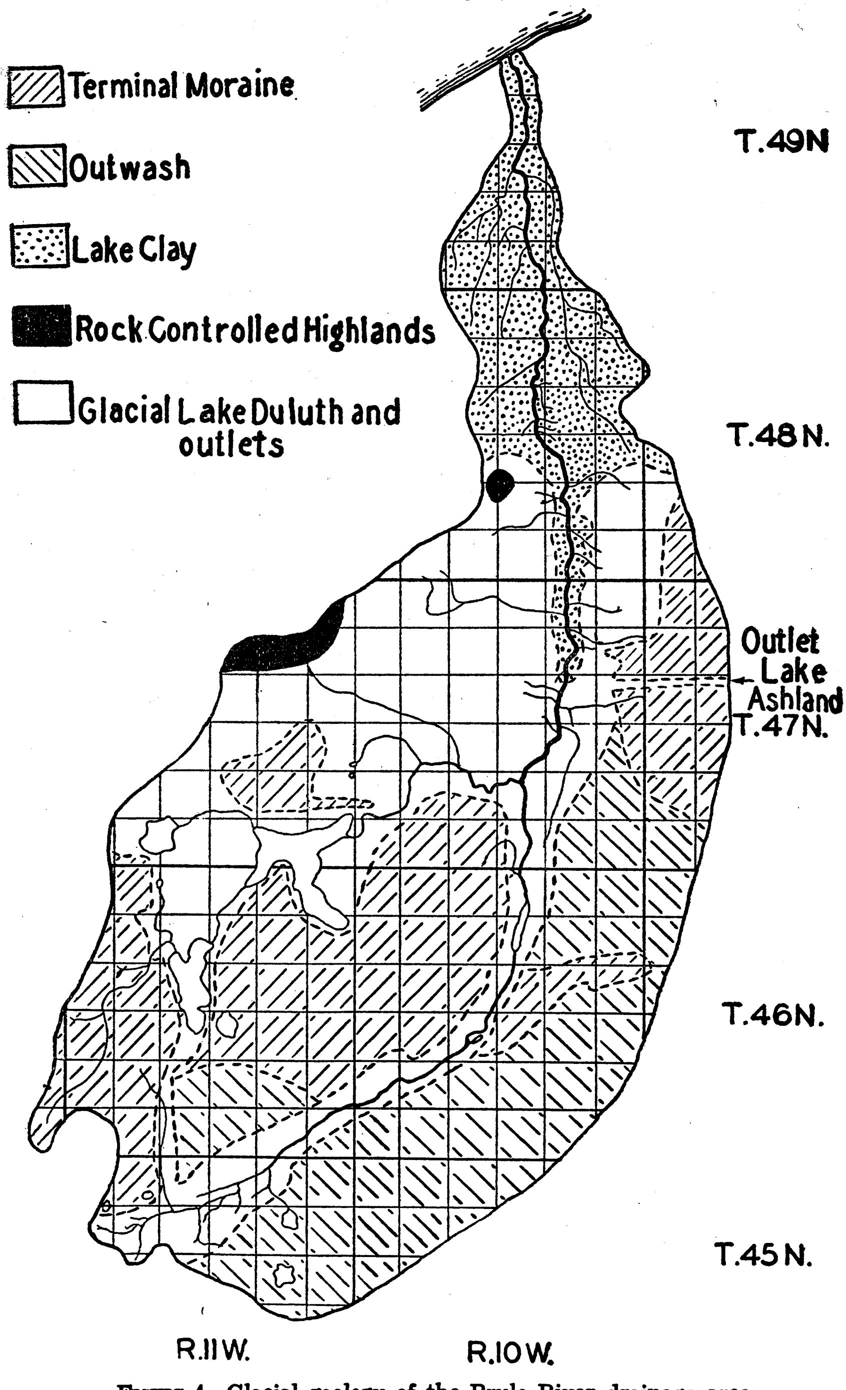


FIGURE 4. Glacial geology of the Brule River drainage area.

cuts show well-stratified sand and gravel. Much of this material came from the interlobate moraine to the northeast. It is natural in an area so largely underlain by friable sandstone that the glacial drift should be sandy and that the glacial streams should build sandy outwash plains. The general level of "the Barrens" is about 1,180 feet. Along the Brule there are terraces, indicating that sand and gravel was deposited by streams flowing away from the melting ice and later dissected by outwash streams or by outflow from the glacial lakes. Near the source of the river, in section 34, T.46N., R.11W., the first bench, which is about 100 feet above the swampy valley floor, is at 1,120 feet and is less than one-half mile wide. The second bench is also a little less than one-half mile wide, has an elevation of 1,160 feet, and ends in a steep terrace which rises about 20 feet to a third bench at 1,180 feet, which is not so well defined.

3. *Glacial Drift Modified by Lake Action.* A guess can be made as to the landscape prior to the development of the first glacial lake. Ice blocks may have still filled depressions now occupied by lakes. Water from the melting ice accumulated between the margin of the ice lobe in the Lake Superior basin and the divide to the south, forming glacial lakes, with levels determined by the elevation of low points in the surrounding highland. It is probable that stagnant ice masses as well as land may have formed part of the barrier. Glacial Lake Duluth began as a string of small marginal lakes on the border of the ice lobe. Upon further shrinkage of the ice, these lakes became confluent. This lake stood at three different levels, the highest being 1,160 feet, and the lower ones, in order 1,120 and 1,060 feet. These lake levels are reflected in (1) large flat areas produced by the erosion and deposition of relatively shallow water; (2) beach lines; (3) wave-cut cliffs; and (4) terraces cut by outlet streams. It is quite likely that outwash streams continued to deliver sediments to "the Barrens" while the glacial lakes were in existence. At the 1,160 level, an arm of the lake covered the area now occupied by Lake Nebagamon and Lake Minnesuing, with drainage south from the latter lake. That such a course was possible is indicated by (1) the present level of Lake Minnesuing, about 1,132, draining by sluggish Minnesuing Creek to Lake Nebagamon; (2) a valley extending southward from the south end of Lake Minnesuing to the present Brule valley drained for all but

a mile of its length by Wilson creek. The topography indicates that another arm of the lake extended south past Winneboujou and drained to the southwest, leaving the intervening higher land as an island.

Due to the cutting down of the outlet, or retreat of the ice, the lake level fell to 1,120 feet, and later to 1,060 feet. At each of the new levels the Brule adjusted its channel and developed a terrace faced by a steep slope. There is an abandoned tributary stream channel in sections 25 and 26, southeast of Brule, that formerly drained northwest. Its banks are very steep and expose sand and gravel. It probably received drainage from melting ice to the east. The channel at the mouth is at the 1,060 foot level, suggesting that it flowed into Lake Duluth at that level. Similar channels enter the valley from the east in T.46N., R.10W. It is difficult to determine the exact outlines of the lake at the various stages because topographic maps are lacking for critical areas, and because the amount of post-glacial uplift has not been determined. Leverett states that "the head of the outlet now stands about 250 feet higher than at the time when the lake discharged through it." Hansell, using more complete information, has estimated the uplift of the head of the valley to be between 50 and 60 feet. Using his data, the uplift at the mouth of Brule was only 20 feet more than at its source. If this is true, tilting is not of importance in consideration of Brule River history.

When the level of the glacial lake dropped below 1,022 feet, the direction of flow of the Brule was reversed and the stream flowed north *into* the glacial lake instead of draining it. This is supported by the fact that the stratified deposits in the river above that level dip south, while the bedding dips north in deposits below the 1,020 foot level. With flow to the north, in spite of greatly reduced volume, the Brule River was able to incise its channel and cut a gorge in lake deposits below 1,020 feet.

On the north side of the Copper Range, there is a 980 foot bench. Below 980 feet to the present lake shore the soil is dominantly red clay deposited in the bottom of the glacial lake.

The transition from Lake Duluth to Lake Algonquin was probably a gradual one as lower and lower passages for drainage across the Upper Peninsula of Michigan were opened by the melting away of the ice in the eastern part of the Lake Superior basin. There was a brief period when the flow of Glacial Lake

Duluth was southward through the Au Train-Whitefish Valley to Glacial Lake Chicago. The Lake Algonquin beaches are weak and widely spaced. As a result of the successive lake levels, a great deal of the drainage basin south of the red clay belt has a greatly modified topography. Glacial lake beaches and wave-cut cliffs are striking features but cover a relatively small area.

The effect of the glacial lake was to subdue the topography. Depressions were filled and elevations planed down. The coarser material was shifted the least; hence boulder concentrates characterize the flat uplands, sand lies on the slopes, clay was moved farther and deposited along the foot of slopes and in depressions. Ground moraine, with little initial relief, was smoothed to a flat or swamp area. Terminal moraine below lake level was smoothed but retained some of its original knobs and sags. Outwash plains, if not pitted or dissected, exhibit little change.

4. *Lake Clay.* Heavy red lake soil extends from the Copper Range north to Lake Superior. Along the Brule valley, the clay extends four miles further south to Brule. Well records indicate lenses of sand and gravel extending northward, dipping at a low angle and separating beds of clay. These water-bearing lenses are at shallow depths near the Copper Range, but several miles farther north are at a depth of one or two hundred feet.

Post Glacial Changes

The clay belt has been deeply trenched by narrow, steep-sided valleys which range from a few feet to over a hundred feet in depth. This is in marked contrast to sandy Barrens farther south, where the water sinks into the sand and erodes but little. In the areas of terminal moraine and of drift modified by glacial lake action, there is some gullying on the steeper slopes.

Ground Water

In the clay belt, direct runoff is heavy because the clay is relatively impervious and the swamps provide relatively little surface storage. The conditions in the drainage area above the clay belt are favorable to uniform stream flow. The Barrens are a perfect source of stream supply because the sand acts as a sponge, absorbing a high percentage of the rainfall, and delivering it to the stream in numerous springs at a uniform rate. We believe that the springs are due to boulder clay covered by sand and gravel. Water falling upon the surface descends to the more imprevious material which it follows until an outlet is found. The headwaters, therefore, have a relatively constant flow. The glacial drift, modified by lake action, has large areas of swamp which serve as reservoirs. Runoff is retarded on the extensive flat areas. In the terminal moraine much of the rainfall is held temporarily in the kettles. The lakes also serve to retard runoff. Precipitation in the winter months generally falls in the form of snow and usually has slight effect on stream flow during that period.

"*Effect of ground storage and springs on stream flow.* The flow of the Brule River is subject to less fluctuation than that of any other stream in this district, the lowest observed flow being 118 second-feet and the highest, 1,490 second-feet. The natural regulation is due primarily to the yield from a number of large springs situated along the south branch or Upper Brule River. These springs vary in area from one-quarter of an acre to three acres, and are about 5 or 6 feet in depth. In the bottom of most of the lakes or springs there may be seen, boiling up through the sand gravel, jets of water varying from one inch to as much as 10 feet in diameter. The water flows are remarkably high for this district."*

* House Document 227, 72nd Congress, 1st Session, 1930, p. 16.

A HISTORY OF FISHING IN THE BRULE RIVER

Brule River Survey: Paper No. 3

D. JOHN O'DONNELL

Wisconsin Conservation Department
Biology Division

The famous Brule River, located approximately 30 miles east of the city of Superior, in the northwestern part of Wisconsin, is one of the better known of the important trout streams in the United States. Owing to the fact that the trout populations have apparently declined since the days of lumbering operations, it was deemed desirable to make a complete physical, chemical and biological investigation of the Brule River, with the aim of establishing a stream management program for the river. The investigational work started in October of 1942 as a cooperative project between the Wisconsin Conservation Commission and the University of Wisconsin. It was first necessary to review the literature and determine the known facts concerning past conditions in the river. The present report is a short resume of the history of the Brule River valley, with the stress placed principally upon the fish and fishing conditions.

The very earliest history concerns the changes in the river during geological times. Since any geological history is concerned primarily with physical changes, these aspects are omitted and will be covered in a subsequent report on the geology of the Brule River valley.

The more recent history of the Brule River valley begins necessarily with the story of the Indian. The earliest record is that of the Mound Builders, who apparently had an advanced type of culture and were proficient in the metal arts. They mined copper in what is now known as the Minong Range and at Manitou Falls on Black River, and used both fire and water in mining the metal. The copper was worked into various weapons, implements and ornaments and when one of their number died, various copper pieces were placed in the mound with the body. These

Mound Builders vanished completely before the year 1400 A. D.

The next group of Indians, of which we have any knowledge, were the Mascoutins, "People of the Fire," a branch of the Potawatomi, who lived by trapping beaver, harvesting the wild rice, spearing whitefish and hunting deer. About 1400, the Dacotah, "The Seven Council Fires," left their homes in what are now known as Virginia and North Carolina, and trailed the bison westward and came to Wees-kon-san. The Dacotah drove out the peace-loving Mascoutins. The next large tribes were the O-dug-am-eeg (Outagamie), and the O-saug-eeg (Sauk) tribes which were forced westward by the Iroquois. These three tribes shared the wild rice lakes around the the Bois Brule-St. Croix headwaters. They also trapped beaver and other small animals.

About 1400 A. D. the Ojibwa Indians migrated westward, being forced out by the Iroquois. They moved very slowly but eventually reached what is now known as Sault Sainte Marie, where they established their principal village. Even here they were attacked by the Iroquois so they continued to move westward. In 1492 they reached Shan-ah-waum-ik-ong (Chequamegon Bay) where they engaged in battle with the Dacotah and Outagamie tribes, who forced them to move off the mainland and withdraw to Mo-nung-wah-na-can-ing (now Madeline Island). They built a village on the island and planted maize and pumpkins. All of their hunting for game was done on the mainland. These hunting excursions into their own territory so alarmed the Dacotah and Outagamie tribes that they engaged the Ojibwa tribe in an immense battle during the year 1612. The Ojibwa, however, won the battle and gained a foothold on the mainland, thereafter spreading to the south and west. As they moved westward they again fought the Dacotahs for control of the rice lakes and the small game hunting about the Bois Brule, which they called the Wa-sah-que-da-ce-be, "Burnt River." This peculiar name, "Burnt River," must have been used because of some notable forest fire or fires in its valley, before the day of the white man.

By 1620, the Ojibwa tribe had control of most of the territory but about this time the Sioux tribe moved into the area and many fierce battles were fought, until a truce was effected in 1671. After 1671, the two tribes collaborated in their hunting of small animals and in the harvesting of wild rice from the lakes. The

Ojibwas carried furs from the Brule valley to the French on the St. Lawrence in eastern Canada.

An account of the discovery of the Brule River has been given by Francis Parkman, who was called by Bancroft "the greatest American historian." He narrated that, "Daniel Greysolon DuLhut, in June 1680 while Hennepin was in the Sioux villages, set out from the head of Lake Superior, with two canoes, four Frenchmen and an Indian, to continue his explorations. He ascended a river, apparently the Burntwood and reached from thence a branch of the Mississippi which seems to have been the St. Croix."

In DuLhut's own words he recorded in his journal in June, 1680, "not being satisfied with my explorations by land, I took two canoes with a savage who was my interpreter, and with four Frenchmen, to seek the means of making it by water. [Referring to a trade route into the Northwest]. For this purpose I entered into a river which has its mouth eight leagues from the extremity of Lake Superior on the south side, where after having cut down some trees and broken through about 100 beaver dams, I went up the said river, and then made a carry of half a league to reach a lake which emptied into a fine river which brought me up to the Mississippi."

In 1693, Pierre LeSueur was dispatched by authorities of New France to keep open and protect the old route through the Brule and St. Croix Rivers. He built a fort on Madeline Island to guard the north approach and another on an island in the Mississippi, below the mouth of the St. Croix and near the town of Red Wing, Minnesota, to guard the southern approach.

Jonathan Carver, the first English traveler in Wisconsin, portaged from the St. Croix to the Brule River and descended to Lake Superior. He reported a number of beaver dams. However, in another period of his travels he says "this river was so scant of water we were obliged to raise it with dams for passage." His trip was made in July, 1767. Incidentally Carver renamed the river Goddard's River for an early fur trader.

In 1782, Jean Cadotte used the Brule-St. Croix route. The stream was hard to navigate owing to the beaver dams.

In 1803-04 Michel Curot, a fur trader, established trading along the Brule and St. Croix Rivers. He carried on intensive trapping of beaver and the river was cleaned of beaver and many dams were destroyed. No mention was made of seeing any fish. His first trip up the Brule River started on August 23, 1803 and the first day he traveled as far as the end of the first *décharge.*[1] The next five days were spent in navigating the first three *décharges.* During the next three days, travel was much easier and the party reached a point which they called La Grande Prairie.[2] The next day the party continued and passed what they called the first rapid. They moved through an area of quick water but no rapids and passed what is now known as Little Joe Rapids. Two days later they had arrived at a place which Curot called the "Rapide à Vassel."[3] During the next day rapid progress was made in the flat quiet water and a point was reached a league and one-half below the St. Croix portage. On September 5, the passage up the Brule had been completed and the party started the portage over into the St. Croix. A total of twelve days was required for the trip from the mouth of the Brule to the point of portage into the St. Croix.

One of the first Americans to visit the stream was Henry Rowe Schoolcraft, who was an Indian agent at Sault Sainte Marie. In 1831, his party came to the Brule and was guarded by Lieutenant James Allen of the Fifth United States Infantry with a number of troops. Schoolcraft speaks of moose hunting on the Burntwood River, while Allen says "the river is exceedingly cold and clear and is filled with thousands of real mountain brook trout." Allen had hard work descending the stream with awkward soldiers who were unaccustomed to guiding canoes in strong water. "Often," says Schoolcraft, "on looking down its channel there are wreaths of foam constituting a brilliant vista. This stream might appropriately be called Rapid or Mad River." Schoolcraft made no mention of beaver dams and apparently they had disappeared because of the thorough trapping of Michel Curot. Schoolcraft was the first to mention trout in the river. According to the records of the earlier explorers the river con-

---

[1] A décharge indicates a place where it is necessary to portage. The first décharge was about three miles above the mouth of the Brule. The bed of the river at this point was solid brown sandstone and the place is now known as Gregory Falls.

[2] Properly speaking there are no prairies on the Brule. This camping area is supposed to have been on the eastern bank above the mouth of the Little Brule River where the banks are somewhat flat.

[3] Above what is now known as Nebagamon Rapids, the river expands into a number of lakes, Cochran's, Spring, Lucius, Big and Sucker. Falls Rapids, above Sucker Lake, although very short, are considered the hardest on the upper river, and these are probably what Curot called "Rapide à Vassel."

tained hundreds of beaver dams but no fish, although most of them referred to fish in the St. Croix waters, especially in Lake St. Croix.

From the time of the earliest Indians to the period of Schoolcraft the river had been called by many names: Nemitsakouat, Wisakoda, Bois Brule, Burntwood, Goddard, Brule and Mad River.

In 1846, John R. St. John was charting the country in the interest of mining companies and wrote a report on "A True Description of the Lake Superior Country." He writes of the Bois Brule: "The shore of the river is a sandy alluvium, as the rivers Montreal and Ontonagon, with the red sand rock, and the country of the Brule has the same general characteristics after leaving Great Lake Point, that marks the country of the Ontonagon, and the river itself, after leaving Keweenaw Point. Its mouth is thirty to fifty feet wide, sandy, and five feet of water on the bar. It surpasses all other streams in its brook trout, some of them, I have the assurance of Mr. Jacob, weighing ten pounds. Its waters colder and clearer, if possible than any other river."

In 1874, a Mr. R. P. Petre of Baltimore with his party, fishing the Brule, removed the barbs from their hooks because the trout were so easily taken that the time spent in removing the hooks from the mouth of the fish was considered time wasted. Mr. John Bardon of Superior, in the winter of 1877, saw "millions" of trout swimming under the clear ice of the Brule. He cut a hole through the ice and netted 1,500 pounds of trout without seemingly depleting their numbers. In 1878, "Long John" Murphy and his companion reported catching 500 trout by hook and line in three days.

In 1880, a prominent manufacturer, Samuel Budgett of Bristol, England, conceived the idea of improving the condition of some of his better employees. He purchased a large area of land at and near the mouth of the Brule River. He then selected approximately thirty families, representing various trades, brought them from England and started the first white settlement at the mouth of the Brule. He named the colony "Clevedon." The harbor at the mouth of the river was improved and fishing boats, nets, cooperage equipment and a sawmill were provided. Small farms were opened up and although the settlers were a sturdy lot they were not successful and after a number of years a great many left and the colony disintegrated.

In a report by E. T. Sweet on the Geology of the Western Lake Superior District, published in 1880, the following description is given of the upper part of the Brule River:

> "About four or five miles above the dalles on Sec. 30, commence the Upper Spring lakes. These lakes extend to within a mile of the dalles, and are usually merely former channels of the river. There are somewhat more than a dozen of them, each covering from three acres to a quarter of an acre. They are usually parallel to, and on the east side of, the main channel. They are not often more than five or six feet deep, but the water is very clear, and in the bottom of most may be seen jets of sand and fine gravel continually boiling up, varying in size from an inch to five or even ten feet in diameter. In passing over the surface of some of the larger lakes in a canoe, from fifty to a hundred of these springs may be counted. In these lakes are the breeding grounds of the vast numbers of brook trout that inhabit the upper waters of the Brule. I have seen them, upon a clear day, in these lakes, as thick as minnows in a common pond. The bottom of the stream above these lakes, and of the much larger lakes immediately below them, contain a deep, loose black mud, filled with insects and worms, the favorite food of the trout. It has been aptly said that this is the angler's paradise. One may capture in a short time all that he can carry. Joseph Gheen, a half-breed Indian, has recently built a cabin upon Sec. 21, near the lakes, from which point he takes the fish during the winter months to Duluth and Ashland. About a mile below the Spring lakes, swift rapids are found about two hundred yards in length, and near the termination the river is only seven or eight yards wide. The fall of the river here is about fifteen feet, and the place is known as the Dalles of the Brule. The banks are of clay and boulders only, and seven or eight feet high. At the foot of these rapids is the third Pucwagawong [Chippewa Indian—a place where reeds or flags grow] or Flag lake. It is only 250 yards in length and perhaps 150 in width. From the foot of the third to the head of the second Flag lake there are rapids of not more than a hundred yards in length. The latter lake is a mile in length and from two to four hundred yards in width, with a depth of three or four feet. The bottom is very muddy, and it is said that during the summer, reeds, grasses, and moss form an almost complete mat over the surface of the water."

The lakes referred to as having boiling springs and as being the breeding grounds of the brook trout consist of the spring ponds which were bought by Henry Clay Pierce and fenced off from the river proper some time shortly after 1905. It is interesting to note that the widespreads which are now known as Big Lake and Lucius Lake were reported as having a mud bottom and becoming choked with aquatic vegetation during the summer months.

About 1880, the Brule River valley was opened for travel. Railroads and wagon roads were built and the river was becoming known as an excellent fishing area. Trout were reported as plentiful, and all fishing was done from canoes and boats. About this time articles began to appear occasionally in the Superior papers with reference to the Brule River and the trout.

In June, 1884, it was reported that the trout fishing in the Brule River was excellent. In May, 1885, there appeared an article which stated that no finer trout fishing can be found anywhere than can be found in the Brule. Speckled trout twenty-four inches in length have been taken from this stream. The principal fishing grounds, from the town of Brule, were up the river about five miles by road, and about eight by river. These grounds are above the lower rapids and extend about six miles to the upper rapids. This is considered the best fishing area on the river, although there are trout in all parts. The bottom is sandy and rocky and the water is clear, cool and sparkling. The banks rise gradually from the river and are covered with gigantic pine trees. In one report of a party of three fishermen they state that in one day's fishing they caught 100 speckled trout and that on the next day they caught an additional seventy-four, one of which was sixteen inches in length. The trout were jumping out of the water in all directions.

In 1892 the village of the town of Brule was platted. The townsite was owned by a group of central and southern Wisconsin lumber operators. The business and other activities of the town were controlled by the Brule Lumber Company, whose holdings consisted of over 3,000 acres in the Brule valley, which was considered the richest and most dense timber district of northern Wisconsin. It was estimated that the company cut approximately fifty million feet of logs as a minimum. In the winter of 1892 about four million feet of logs were cut.

In an article dated 1893 it was stated that, "along the Brule River which flows through the Town of Brule, the timber is very heavy and is of a very superior quality. The Brule River is a beautiful stream and is celebrated for its trout fishing. Some of the finest specimens of trout ever hooked in the Northwest have been taken from these waters and as a result the river has gained a general celebrity for its beauty and limitless fishing resources."

In October of 1894 an article was written giving a resume of the season, as follows:

> "The steamer North West has brought many eastern people to the Brule, and has largely increased the number of campers. It is estimated that nearly a thousand people have encamped on the upper Brule this summer. Taking the clubhouses in their order, going up the river to-wit: St. Paul or Winneboujou clubhouse, 50; Milwaukee or Gitche Gumee clubhouse, 30; Ashland or Missishin, 50; Lucius (public clubhouse on McDougall's land), 300; Tibbits camp (public), 60; Kline's of Duluth, 10; St. Louis, 22; White Birch, 50. This range of clubhouses extending along the river, from the St. Paul clubhouse on the north near the D. S. S. & A. tracks, south fifteen miles to the White Birch clubhouse near the Omaha railroad, covers practically, the fishing grounds of the Brule. The fishing laws ought to be further modified to prevent shipping at any season. One party shipped over 2,700 trout to Superior this summer, supplying three restaurants. Over sixty campers were on the grounds as early as May."

In 1895 the following notes were published with reference to the Brule. "The primeval forest overhangs the river on both sides and the picture as nature originally painted it remains intact. The rustic furniture and other handiwork of nature are the same today as they were when the red man alone paddled his canoe upon its waters". "The public and the clubhouse people on the Brule do not get on well together. The latter own a great deal of the land on the river and their enjoyment would be unalloyed if they could keep all other persons from fishing in the waters of the Brule. They will not let a person erect a tent on their lands." The record of one party of four men staying at Joe Lucius clubhouse was as follows: "Captain McDougall caught a fine string and some of them were big fellows. G. L. Rice caught 74, McHugh and Monson each caught as many as their consciences would permit of." "Mr. A. W. Shaver caught 100 trout and then quit when they were biting the best, remarking to his guide: 'Bill, this is too much like club fishing; guess I'll quit.'"

The lumber interests started cutting in 1892 and had all of the virgin timber cut by about 1909. During this period, when the logging dams were in the river, the catch of speckled trout continued to decline. By 1906 many complaints were being made that something had to be done to save the trout. About 1905, Henry Clay Pierce started to build his estate and one of the features was a large fish hatchery where he produced speckled trout. "It is stated that in his ponds at the present time (1908) there are enough trout to put the Brule back in the class of the best streams in the entire country. They are of all kinds and sizes."

In 1906 an article was written on "The Boise Brule" in which are given many statements in regard to the fishing.

> "It is the real and ideal home of the trout. In the days before logging dams were built it was filled with brook trout. An ordinary fisherman might catch a hundred fish a day with hook and line, old fishermen tell you. The upper river is surrounded by innumerable springs which form a natural home for trout. The logging dams have created great havoc among the fish during the past few years, as they interfere with the yearly migration of the trout, these fish following the habits of the salmon. The dams almost depleted the stream for the reason that there was no fish way and the mature trout could run out but could not return the next year. A few years ago rainbow trout were planted in the river, and these have grown and multiplied very rapidly. The fish do not migrate to and from the lake as do the brook trout (the present stock of rainbow trout in the Brule River migrate to and from Lake Superior). To a certain extent this drawback of the dams has been remedied, as most of the lumber is cut. It has been proposed and in fact is being strongly urged by a number of prominent people (notably Hon. C. D. O'-Brien and Mr. Weyerhouser) that the state of Wisconsin take steps declaring the Brule River and its valley for a mile on either side a state park forest and fishing preserve. This would give to the people of the state, and country generally, one of the most beautiful resorts in the northwest, would prevent for all time the building of dams and cause the removal of present obstructions, and bring back to its original conditions the fairest river of the northwest, the Bois Brule."

In 1909, during the last part of July, the floods on the Brule were reported as follows: "The rain Tuesday started the floods which are reported to have destroyed some of Cedar Island. Last night the river was more unruly than ever and the waters were inundating the surrounding country. The loss to the Pierce estate alone is estimated at many thousands of dollars and other lodges and cottages along the shore have been wrecked by the rioting river."

Among the notables to visit the Brule was General Grant, who came here in the 70's on a fishing trip. Grover Cleveland was the guest of Senator Vilas at his lodge on the Brule in the 80's and Calvin Coolidge spent the summer of 1928 on the Brule and was entertained by Henry Clay Pierce.

In 1936, with the use of WPA labor, a project of "stream improvement" was started on the river. In that year a total of 232 structures, such as deflectors, bend covers and other "stream improvement" devices, were installed in the stream. In addition 13 beaver dams were removed. In 1937, the work was continued and 36 structures were placed in the river with 17 additional structures being installed in 1938, plus 1,829 yards of dredging in Big Lake and Lucius Lake. The cost of the "improvement" work was approximately $40,000. In addition to the WPA program, a vast amount of work was done by the CCC, such as installing structures, planting willows and cleaning out large amounts of down trees and other materials in the river which provide cover for trout. The particular stress at this time was to convert the river into a comparatively "easy" canoe stream.

On January 12, 1938, the Conservation Commission issued an order, F-309, which prohibited all forms of fishing except flyfishing on the Brule river between Stone's Bridge and Winneboujou. This order had been issued as a result of a petition containing 83 names of property owners. Of the signers, 19 were from St. Paul, 9 from Minneapolis, 19 from Duluth, 4 from Lake Forest, Illinois, 1 from Washington, D.C., 10 from Milwaukee, 1 from Superior, and 20 from Brule. The order, however, caused such a storm of protest that on April 12, 1938, the Commission issued order F-317 which rescinded order F-309.

For quite a number of years complaints have been made almost yearly to the Conservation Department that something should be done to improve the fishing. As a result of a complaint made in December, 1941, that certain species of fish other than trout be removed from the waters of the Brule River, a check of the available information on the Brule River was made at that time. It was found that the Conservation Department possessed very little factual data on the physical, chemical, and biological characteristics of the river; information which is absolutely necessary in order to set up and execute an intelligent and successful fish management program on any stream. It was also found that although a number of cursory examinations had been made of the river, no management program had been or even could have been made from these investigations. The usual result was to increase the number of fish planted. In order to determine the financial extent of the stocking, the plantings of trout during the period of 1937 through 1941 were checked. It was found that a total of 616,850 brook trout, 150,175 brown trout, and 464,850 rainbow trout had been planted. This amounts to a grand total of 1,231,701 trout of all species which consisted of 4,717 adults, 73,929 yearlings, 1,137,055 fingerlings and 16,000 fry. Based upon accumulative rearing costs a total of $34,247.67 had been expended in rearing the trout planted in the Brule River over a five-year period. Thus a considerable expenditure of funds was made with indeterminate results and very limited information was collected as a basis for a stream management program.

As a result, it was recommended that a complete investigation be made of the Brule River with the aim of establishing a stream management program for the river. The Fisheries Board of the Conservation Department accepted these recommendations and submitted a resolution to the Conservation Commission requesting the creation of a fund of $9,000 to permit a two-year survey of the Brule River to determine the present existing conditions and to then formulate a future fish management program.

The Conservation Commission acted upon the above resolutions at their July meeting, 1942. At that time they created a fund of $9,000 to be used for a two-year study of the Brule River. Also, to aid in the execution of this study, the Conservation Commission asked the University of Wisconsin to assist in the undertaking. As a result of the above actions a co-operative agreement was completed in August, 1942, between the Wisconsin Conservation Commission and the University of Wisconsin for the detailed survey of the Brule River. The actual investigation started on October 1, 1942, and will continue for a period of two years, after which time, a tentative fish management program will be formulated for the Brule River based upon the critical examination of the results obtained from the surveys.

Literature Cited

Andrus-Juneau, Isura

1941. The Brule-St. Croix Portage. Douglas County Historical Museum Collections. Superior, Wisconsin.

Carver, Jonathan

1838. Travels in Wisconsin. Harper & Brothers.

Curot, Michel

1803. A Wisconsin fur-trader's journal. Wisconsin Historical Collections, 20, 1911.

Doty, James Duane

1895. Expedition with Cass and Schoolcraft, 1820. Papers of James Duane Doty. Wisconsin Historical Collections, 13.

Kellog, Louise Phelps

1928. The Historic Brule. The Wisconsin Archeologist, 8: 1.

Lucius, Jos. and Charles E. Brown

1941. The Blue Springs Indian Shrine. Trans. Wisc. Acad. Sci. Arts and Letters, April, 1941.

McManus, James H.

1920. The trails of Northern Wisconsin. The Wisconsin Magazine of History, 4: 125-140.

Pickering, H. G.

1933. The Brule. The Anglers' Club Bulletin, 12: 1, New York.

Schoolcraft, Henry Rowe

1834. An exploratory trip through the St. Croix and Burntwood (or Broule) rivers in 1832. Harper & Brothers.

1851. Personal memoirs of a residence of thirty years with the Indian tribes on the American frontiers. Lippincott.

St. John, John R.

1846. A true description of the Lake Superior country. New York.

Sweet, E. T.

1880. Geology of the Western Lake Superior District. Geology of Wisconsin, 3: 321-322.

Turner, Frederick J.

1889. The character and influence of the fur trade in Wisconsin. Proc. 36th Ann. Meet. State Hist. Soc. of Wisconsin.

Wilson, Leonard R.

1938. The postglacial history of vegetation in northwestern Wisconsin. Rhodora, 40: No. 472.

The Superior Evening Telegram:

June 21, 1884; May 23, 1885; March 4, 1892; March 5, 1892; October 14, 1893; October 5, 1894; April 11, 1895; April 27, 1895; Feb-

ruary 3, 1904; June 26, 1905; May 5, 1906; October 22, 1908; July 22, 1909; July 15, 1910; September 4, 1911; July 15, 1912; August 7, 1915; November 27, 1915; June 26, 1928; March 18, 1931; January 7, 1938; January 21, 1938; April 26, 1938; May 2, 1938; July 5, 1938; October 13, 1938; October 24, 1939; June 11, 1940; February 2, 1941; May 14, 1941.

The Wisconsin State Journal:

January 7, 1938; February 4, 1938; February 11, 1938.

VEGETATION OF THE BRULE BASIN, PAST AND PRESENT

Brule River Survey: Paper No. 4

NORMAN C. FASSETT

The Brule River flows northward in eastern Douglas County, Wisconsin, to Lake Superior (Map 1). It is notable to geologists in that it occupies the valley carved by the outlet of the Glacial Lake Duluth, which was in the western end of what is now Lake Superior, during the recession of the Superior lobe of Substage 4 of Wisconsin glaciation. It has long been notable to sportsmen as a trout stream; indeed, this study was initiated for the purpose of determining whether there have been changes in the vegetation of the drainage basin which might be responsible for changes in the environment of the fish.

Map 2 was derived from a study of the notes of the government surveyors who laid out the section lines in the region in 1852-56. Map 3 was derived largely from the survey in 1932 by the Wisconsin Land Economic Inventory, somewhat modified by notes of the Wisconsin Geological Survey in 1925 and by personal observation in 1942-43. Details of the methods of deriving these maps will be discussed later.

The Brule Basin may be conveniently divided into four general areas, (1) the gorge of the upper Brule, shown by the brown band along the river on Maps 2 and 3, (2) the sand barrens, shown mainly by the stippled red on both sides of the upper Brule on Map 2, (3) the valley of Nebagamon Creek, the largest tributary, entering the Brule in T.47, R.10W., and (4) the lower Brule basin, embracing essentially the area in solid pink and solid orange on the northern third of Map 2.

THE BOG

The upper Brule is remarkable in that it flows northeastward in the ancient channel of a much larger stream, the outlet of Lake Duluth (which occupied what is now the west end of Lake Superior) in early post-glacial times, and flowed southwestward to what is now the St. Croix River and eventually to the Mississippi. The route of this outlet, south and southwest through what is now the Brule, past Solon Springs and down the St. Croix, may be easily traced on Map 1. This channel was cut through sand, and is now occupied by a continuous bog (brown on both maps). On every section line crossing the river in this region the surveyors of 1852-56 recorded the fact that they entered a bog, covered largely with White Cedar, Tamarack, and Black Spruce. Their descriptions are quite consistent with that of Owen,[1] who wrote: "The whole country has a very singular aspect, with lakes [several lakes, represented as one continuous lake in the northern part of T.46N., R.10W. on Maps 2 and 3] of still water, connected by short and swift rapids, that meander through a dense growth of cedar and tamarack. . . . After navigating four lakes [Owen is traveling up-stream] . . . the Brule meanders through a series of cedar swamps, separating into several channels, the main one being sixty or seventy yards wide. . . . The river now very soon contracts its dimensions to a mere creek, just wide enough to float a canoe between the bushes that overhang its banks." In 1880, Sweet[2] wrote: "The head of the Brule is less than two miles from the Upper St. Croix lake [the head of the St. Croix River, which still flows to the Mississippi]. Several small spring branches unite with the main channel in the northern part of T.45N., R.11W., and the exceedingly sluggish stream winds through dense cedar, tamarac and alder swamps, for a distance of eight or ten miles."

These descriptions, some nearly a century old, are just as applicable today. Nearly all of the long narrow bog shown in brown on Map 1 is duplicated on Map 3. Plates 1-3 show various places along this bog as they now appear. In a few places (Plate 4) the trees have been cut and the land probably burned over; here the bog is quite spoiled and has gone to grass or sedge-meadow.

The Barrens

The Barrens, developed chiefly on an outwash sand plain, are shown on the maps by red stippled areas, and originally

---

[1] David Dale Owen, Report of a geological reconnaissance of the Chippewa Land District. Senate Executive Document 57; 58-61. 1848.

[2] E. T. Sweet, Geology of the western Lake Superior district. Geology of Wisconsin, 3:321-322. 1880.

(Map 2) extended for several miles on each side of the upper Brule. The appearance of this region three-quarters of a century ago can be best portrayed by a few verbatim excerpts from the notes of the surveyors.

On the line between T.45 and 46N., R.10W., in May, 1855. Travelling west between Sections 3 and 34:

"40:00[3] set ¼ section Post
Black Pine 5 N 28 W 45 links[4]
Black Pine 5 S 58 W 32 links
"80:00 Set corner to Sections 3, 4, 33 and 34
Black Pine 5 N 54 W 28 links
Black Pine 5 N 80 E 28 links
Black Pine 5 S 5 E 51 links
Black Pine 5 S 20 W 61 links
"Surface rolling.
"Pine barrens."

A little calculation will show that these 5-inch Jack Pines, presumably the largest trees at that location, were spaced approximately 80 feet apart.

On the same line, west between Sections 5 and 32:

"40:00 Set ¼ Section Post
Dead Black Pine 8 S 49 W 40 links
Dead Black Pine 9 N 28 E 50 links
"80:00 Set corner to Sections 5, 6, 31 and 32
Dead Black Pine 10 N 45 W 53 links
Dead Black Pine 10 N 66 E 59 links
Dead Black Pine 10 S 50 E 31 links
Dead Black Pine 10 S 25 W 36 links
Black Pine 5 N 28 W 45 links
"Black Pine Brush from 4 to 8 feet high as thick as it can stand. No green timber in sight."

After surveying a township (36 square miles) each surveyor wrote a brief description of it. The one for T.46N., R.9W., written in September, 1856, is characteristic of the regions shown as stippled red on Maps 2 and 3: "This is a Township of barrens that is almost worthless for agricultural purposes, or anything else, as there is but very little Timber in it, and that is scrubby Black Pine; and there is hardly a drop of water in the Township, in fact *now,* except [for?] small ponds in the South

[3] These figures indicate chains from the section corner at which the surveyor commenced; there are eighty chains to a mile.

[4] Black Pine is Jack Pine. *Pinus Banksiana.* The "5" indicates diameter at breast height, in inches. This tree was 45 links from the corner post, and the direction was 28 degrees west of north; a link is 7.92 inches.

end of it [outside the Brule basin], the Prairie that I have noted on the West side; can hardly be called a Prairie, as no very great time has elapsed since it was covered with small Pine which has been blown down, and burned up, remnants of which still lie on the ground." (Some of these surveyors may have been weak in the rules of punctuation, but they could write a vivid description.)

In the township just described there were occasionally no witness trees at all; for example, at the quarter-section between sections 18 and 19, the surveyor "Set quarter Section post in a Mound of earth and sod, drove charred stick 10 inches long." Not even a stick of uncharred wood was to be found!

The monotony of small Jack Pines was occasionally broken by a few scattered large Norway Pines (*Pinus resinosa,* called "Yellow Pine" by many surveyors). In T.46N., R.10W., going north between Sections 22 and 23, in August, 1854, the record runs:

"40:00 Set quarter Section Post
Black Pine 6 N 34 E 22 links
Black Pine 6 S 43 W 6 links
"80:00 Set post corner to Sections 14, 15, 22 and 23
Black Pine 10 N 45 W 1.40 links
Yellow Pine 20 S 40 E 180 links
"Surface rolling. Soil 3d rate
"Timber Pine—brush."

In T.45N., R.10W., at the quarter-section post between sections 6 and 7, the record is: "Yellow Pine 20 S 35 E 1080 links. No other near." The nearest tree at this point was therefore more than 700 feet away, a large Norway Pine towering over the brush.

Description of T.46N., R.10W. as of 1856: "This is one of those barren Townships that is almost worthless for agricultural purposes. The Surface is rolling excepting that portion adjoining the Brula, which is very broken; the Brula River flows through a valley that is 150 or 200 feet below the general level of the country; on the east side of the River the Bluffs are steep, but on the West side the land rises gradually from the River bottom, so that the top of the Bluff cannot well be defined; the River bottom is one continuous Cedar Swamp that is miry and unfit for cultivation. The timber on the entire Township is worthless."

On Map 4 the figures indicate the diameter at breast height, in inches, of Jack Pines used as witness trees. A dot on a section line indicates that the species was recorded as present, but not used as witness trees. The significant thing about these trees as recorded on the map is the uniformity of size in many regions. There is a large area, for example, in T.45N., R.10W., where nearly all the trees are five inches in diameter. In southeastern T.46N., R.10W. there is another area of uniformity, the trees here being six inches. These large areas of trees of uniform size, and therefore uniform age, are without doubt due to the ability of this species to repopulate an area after a fire. Near the Brule River, and along the northwestern border of the range of the tree in this area, fires were not quite so frequent and widespread, and the Jack Pines were less uniform and reached a larger size.

Next to Jack Pine, the most abundant trees on the Barrens were Oaks. Occasionally an Oak reached a diameter of ten inches, but most of them were described as Oak Brush.

The barrens of 90 years ago, then, were a region of frequent fires, covered with small Jack Pine of a uniform size in each area, the size dependent upon the elapsed time since the last severe fire; occasionally a few large scattered Norway Pines were present. Oak trees and Oak Brush often accompanied and sometimes replaced the Pines.

The barrens as they appeared in 1942 are shown in Plates 5 to 7. They are frequently burned and nearly treeless; Plate 7 is in the area of the great fire of 1936. Often they are covered with small Jack Pine of a uniform size in each area (Plate 5). Occasionally a few large scattered Norway Pines are present (Plate 6). Oak trees and Oak Brush often accompany and sometimes replace the Pines.

The Valley of Nebagamon Creek

The surveyor's description of T.46N., R.11W. is short but brings out a significant point. "This Township is heavily timbered with Oak Maple Sugar,[5] Aspen and Pine: and a dense undergrowth of Hazel and Aspen. The surface is rolling: and covered with rock: = trap rock. The soil is of the poorest quality. A great deal of the timber is down, patches of windfall

[5] The "Maple" of the surveyors is Red Maple; Sugar Maple is almost invariably called "Sugar."

thickly scattered over the entire Township." This description indicates diversity in forest cover, for Sugar Maple is a climax tree in this region, while Hazel and Aspen are usually the result of fairly recent burning. An expression of this diversity, as well as some indication of the reason, may be seen on Map 2. The valley of the Nebagamon occupies the western part of T.47N., R.10W., the southeastern part of T.47N., R.11W., and the northwestern half of T.46N., R.11W. This area is dissected by numberless bogs of various sizes (in brown on Map 2) and lakes. Under these conditions, fires, which seem to have been the major factor in setting back the ecological succession, would have been much less widespread than on the broad flat sandy barrens. Much of the region suffered from fire and was largely in Aspen (stippled orange on Map 2). But where somewhat protected from the spread of fires, in the neighborhood of lakes and bogs, mixed pine-hardwoods developed (orange on Map 2), or the succession even went to climax forest (yellow on Map 2).

Most of the soil in the valley of the Nebagamon is loam, but along its northwestern border, and thence running northeastward across the Brule valley, is the Copper Range, a ridge of trap rock (Map 11). Conditions on the Copper Range appear to have favored the development of climax forest; most of this forest was just outside the Brule Basin paralleling its northwestern border, but the strip of yellow northwest of the large bog in T.47N., R.11W. is the edge of this forest. Just northwest of this strip of yellow on Map 2, about a mile outside the Brule Basin, is the present-day town of Maple[6] (Map 12).

Maps 9 and 10 show the locations of trees of five species, taken as indicators of climax forest.

When compared with Map 2, Map 3 shows considerable change in the land cover of this area. Much of the land is cleared, particularly in the vicinity of the larger lakes. Considerable portions of the bogs seem to have had their flora altered, so that some parts are now better classed as Black Ash, Red Maple and Elm (olive-green on Map 3) or Tagalder, Willow and Dogwood (stippled olive-green on Map 3) than as Tamarack. This is however a difficult point to judge, for all of these species were doubtless present on the bogs when the surveyors traversed them, and all are now present. Close study of the

[6] "Maple," in this case, is without doubt Sugar Maple.

surveyors' notes, and then of the Land Economic Inventory maps and of the areas themselves, indicates that there have been in some areas changes in the proportions of each species, from a predominance of bog conifers to a predominance of broad-leaved species. But certainly Maps 2 and 3 cannot be interpreted literally to the extent of stating that any particular acre of ground has undergone a specified qualitative or quantitative change.

Comparison of bog areas on these maps also shows that much of what the surveyors indicated as bog is now covered with aspen.

Besides the possible destruction of much of the bog area, another result of the occupation of this region for about a century has been the degradation of the forests, so that most of what was mixed pine-hardwoods or climax forest on Map 2 is now Aspen scrub (Plate 8). Close inspection of Map 3 will show a few small remaining stands of White Pine (Plate 9), mixed forest, and even Sugar Maple.

The Lower Brule Basin

The soil in the lower Brule Basin is red clay, deposited under the waters of Glacial Lakes Duluth and Algonquin. The areas of red clay are shown approximately on Map 11. This clay has great water-holding capacity; it dried out much less easily than did the sand and the loam, and so was less subject to fires. This region was therefore the most heavily wooded of all the Brule Basin, and here grew the largest individuals of White Pine (Map 5), Fir (Map 7), and Aspen (Map 8).[7]

In September, 1852, T.49N., R.10W. was described as follows:

> "This township has a clay soil. The surface is generally level back from the streams. The Streams except Brule River fail during the dry season but during the spring and fore part of the Summer offered plenty of water, running as they do through a clay formation. The valleys are narrow gullys or ravines.
>
> "It is well timbered with White Pine in every part and Brule River offers every facility for a lumbering business. This stream rises in the small lakes south of the Summit; through which it breaks and discharges its self into the Lake after [falling?] over 100 distinct rapids in its de-

---

[7] This probably includes both the Trembling Aspen and the Large-toothed Aspen. Perhaps the larger Aspens of the clay region were mostly the latter species.

> scent. Every bend has its rapids through this township until it [flows?] into Section 10 [at the mouth of the stream] where the water becomes sluggish and deep.
>
> "During the months of April and May the Indians and Trappers carry on a successful fishing business along the lake shore. Trout Whitefish and Siskowet being the principal kinds packed for the market.
>
> "The waters of the small streams are so strongly chalybeate that the leaves turn them black in the fall."

The witness trees were, in order of frequency: White Pine, up to 30 inches and averaging 18 inches; Spruce (doubtless White Spruce), up to 16 inches and averaging 11 inches; White Birch, up to 19 inches and averaging 11 inches; Black Ash up to 16 inches; White Cedar up to 14 inches; Yellow Pine up to 20 inches; Fir up to 12 inches; Tamarack up to 16 inches (apparently growing larger on the clay than in the bogs); Red Maple up to 12 inches; Aspen up to 22 inches; and Black Oak. The trees most frequently mentioned in the summaries of each mile, were, in order, Spruce, Fir, Birch, Pine, Aspen, White Cedar, Tamarack, Ash and Red Maple, while the undergrowth was almost always described as Alder, Hazel and Green Ozier, sometimes Maple (probably the Mountain Maple, *Acer spicatum*).

This mixture is shown on Map 2 as Spruce-Fir. Woods of this type were seen in 1942-43 only on the high ground near the abandoned house on the west side of the river near its mouth (Plate 10). Elsewhere the forest has been destroyed by lumbering, fires, and agriculture, so that much of the area is now cleared land (Plates 11 and 13) and the rest has a scrubby growth of Alders, Willow and Red-osier Dogwood (stippled olive-green on Map 3), grading to Aspen and small Firs on the higher ground (stippled pink on Map 3; Plate 12). A few areas are shown on Map 3 as mixed Pine-hardwood (orange) and as Aspen (stippled orange), but actually these four types grade into each other and the boundaries must not be interpreted too strictly.

The description of T.48N., R.10W., written in August, 1852, reads as follows:

> "This Township is well watered and well timbered. The Streams get low during the dry season but do not dry up entirely. The surface is gently rolling and hilly. The soil clay and sand, wet, adapted to the raising of Grass. The timber is large and valuable.

> "Bois Brule River runs through the center of the township, is a rapid durable stream affording every facility for a Lumbering business. Mines are reported to have been worked in this Township on Section 18 or 19 but were not found by me. On Section 23 overlooking the river the Amygdaloid Trap Rock is Magnetic and resembles cast iron in lustre when broken. Traces of copper were found on Section 27.
>
> "The local attraction of the needle was so great that the plain compass could not be used in the vicinity of hill extending across the Township."

The Copper Range (Map 11) was well forested; between Sections 22 and 27 the summary reads "Black Oak, Sugar, White Pine, Yellow Birch, Lind [= Basswood], Elm, Aspen, White Cedar, Fir, Spruce and Tamarac." The Sugar Maple, Basswood and Yellow Birch may be taken as indicators of climax forest. This hill (Plate 13) still shows the species which were originally listed; but the woods have been cut and burned, and the hardwoods are sprouting from the stumps (Plates 15 and 16).

As compared with the uniformity of the township directly to the north, this showed a smaller number of species on each mile, but greater variation between miles. Pines were general throughout the township, but where they were accompanied by Spruce and Fir the land has been shown on Map 2 as "Spruce-Fir forest," and where they were mixed with Oaks, Linden, Maple, etc. "mixed hardwood" has been the designation. Now, of course, the big pines are cut, and their charred stumps are in a dense growth of Aspen (Plate 16). A few good stands of forest remain along the River (Plate 14).

An area of about 8 square miles in the northwestern part of T.47N., R.10W. and the southwestern part of T.48N., R.10W. is shown as Alder-Dogwood-Willow on the recent map and as mixed hardwoods on the old map. This is a poorly drained area which seems to have a very mixed vegetation. The surveyors recorded Tamarack in every mile traversed (even excluding those reported in swamps), White Pine in every mile, the largest being 20 and 26 inches, Aspen, Birch, Spruce, Fir and White Cedar almost always, Maple and Yellow Pine often, and occasionally Yellow Birch, Black Ash, Sugar Maple and Elm. The undergrowth was usually described as Elder, Hazel, Green Ozier and Maple. Excluding the larger trees, this is much as the area is today; it is mostly covered with swamp shrubs, with a few trees on the better-drained locations. Geologists Emrich and Schafer, in 1925, recorded T.47N., R.10W., between 7 and 8, as Alder, Maple, Ash, Birch, Cedar and Spruce. The Land Economic Survey, in 1933, recorded it as recently burned. The original vegetation of this area seems to have been much like that in T.49N., R.10W. shown as Spruce-Fir on the map, except that here the proportions of these two species are much lower.

SOURCES FOR DATA

The exterior lines, which are those forming the boundaries of the township, were surveyed by the following deputy surveyors, in the following years:

Between	Townships	46	&	47	North,	Range	9	West.		Geo.	R.	Stuntz,	1852
"	"	47	&	48	"	"	9	"		"	"	"	1852
"	"	45	&	46	"	"	10	"		Albert	C.	Stuntz,	1855
"	"	46	&	47	"	"	10	"		Geo.	R.	Stuntz,	1852
"	"	47	&	48	"	"	10	"		"	"	"	1852
"	"	48	&	49	"	"	10	"		"	"	"	1852
"	"	45	&	46	"	"	11	"		Albert	C.	Stuntz,	1855
"	"	46	&	47	"	"	11	"		Geo.	R.	Stuntz,	1852
Township	45	North,	between	Ranges	10	&	11	West.		Albert	C.	Stuntz,	1855
"	46	"	"	"	9	&	10	"		"	"	"	1856
"	46	"	"	"	10	&	11	"		"	"	"	1856
"	46	"	"	"	11	&	12	"		"	"	"	1856
"	47	"	"	"	9	&	10	"		Geo.	R.	Stuntz,	1852
"	47	"	"	"	10	&	11	"		"	"	"	1852
"	48	"	"	"	9	&	10	"		"	"	"	1852

The surveyors and dates for the interior lines, which bound the 36 sections within each township, were:

Township	46	North,	Range	9	West.	Hiram	C.	Fellows,	1856
"	47	"	"	9	"	Geo.	R.	Stuntz,	1854
"	48	"	"	9	"	"	"	"	1854
"	45	"	"	10	"	Hiram	C.	Fellows,	1856
"	46	"	"	10	"	"	"	"	1856
"	47	"	"	10	"	Geo.	R.	Stuntz,	1852
"	48	"	"	10	"	"	"	"	1852
"	49	"	"	10	"	"	"	"	1852
"	45	"	"	11	"	Hiram	C.	Fellows,	1856
"	46	"	"	11	"	"	"	"	1856
"	47	"	"	11	"	Geo.	R.	Stuntz,	1854
"	46	"	"	12	"	William	E	.Daugherty,	1856

These surveys were conducted from June to November; each township took a week or ten days. For each section corner and quarter-section (one in the middle of each mile) two witness trees were recorded; for section corners on exterior lines there were four witness trees. At the end of each mile the principal trees seen along that mile were listed. For each township there was a general summary.

These records were studied by Dr. John T. Curtis and the writer in the fall of 1942 and a map of the vegetation as of 1852-56 was drawn. When Dr. Curtis was called to conduct some work in Haiti the writer continued alone, later revising this map. In some cases, determining the vegetation of a section line has been easy. If only small Jack Pine of uniform diameter is listed, it is pine barrens, and if only small Aspen is listed, it is as obviously Aspen thicket. Bogs are easy, particularly since the surveyors made up maps showing the outlines of the bogs. It must be noted, however, on Map 2, that small bogs are shown only on section lines, since those in the interior of the sections were not seen by the surveyors.

Some sections have been very difficult to classify, and a few examples will be given to show the method of interpreting the meagre data.

T.47N., R.10W., west between sections 28 & 33. At the quarter-section post were recorded an Aspen 8 inches D.B.H., 35 feet from the post, and a Black Pine 6 inches D.B.H., 40 feet from the post. The summary of the mile was: Timber Pine Birch Aspen and Lind. Undergrowth Alder & Hazel, woods very thick. Seldom can you see more than 2 chains." Here the Basswood ("Lind") would suggest that the forest was developing toward climax, but it is listed last and was probably the least abundant; also, Basswood is so rare in the region that any occurrance would be noted. The witness trees are Jack Pine and Aspen, both some distance from the post, so the trees were not very closely spaced. Visibility is low due to density of growth, but this dense undergrowth is Alder and Hazel. The picture develops, therefore, as a sparse growth of medium-sized but fast-growing trees, probably not over 20 years old, with a dense scrubby undergrowth. This is recorded on Map 2 as Aspen scrub (stippled orange).

T.47N., R.10W., north between sections 1 & 12. At the quarter-section post were recorded a White Cedar 10 inches D.B.H. and a Yellow Birch 9 inches D.B.H. The summary was: "Spruce Yellow Birch Tamarack White Pine Aspen & Black Oak. Undergrowth Birch & Fir." The southern half of this section line was recorded as bog, which accounts for the Tamarack and the White Cedar; the latter was south of the quarter-section post and so located in the bog. The higher ground had Yellow Birch which is ordinarily taken as indicating climax forest, but here it was mixed, not with Sugar Maple, but with Pine, Spruce, Oak and Aspen. This section line is therefore recorded on Map 2 as Mixed Pine and Hardwoods (orange).

These examples are given to show that there may be some question regarding the type of vegetation on any particular mile. However, it is the opinion of the writer that the generalizations drawn from these records are reliable; while Map 2 may not represent accurately each individual mile, it is correct in showing that the region southeast of the upper Brule was in Barrens, and that the regions about Lakes Nebagamon and Minnesuing were a mixture of bog, Aspen thicket, mixed forest, and Maple forest.

Map 3 was made up primarily from the Land Economic Inventory maps of Douglas County, published in 1933, and of Bayfield County, published in 1928. The classification of land cover used on these maps differs in some respects from that used on Map 3, so that there was in some cases a question of interpretation. A preliminary map made up from the Inventory maps was used in the field, and checked with conditions as observed in 1942 and 1943 by the writer, with the help and advice of Dr. John W. Thomson and Mr. E. F. Bean. While not assuming to make corrections on the Inventory maps, the writer has taken the privilege of making his own interpretation both of the Inventory maps and of the observed land cover. In many cases changes were necessary due to actual changes in cover since the Inventory surveys. Some of this area was surveyed by a party of the Wisconsin Geological Survey, and notes on the vegetation made by Geologists D. G. Emrich and Sidney Schafer. Again, their classification of land cover was different from those used by the Inventory survey and by the writer, but their notes have proved useful in several areas.

Maps 4-10, showing the ranges of individual species of trees, are compiled entirely from the surveyors' reports. The figures represent D.B.H., and each is placed near its appropriate section or quarter-section corner, in the direction, but not at the distance from the corner, in which the tree was recorded. A dot on a section line means that the species was mentioned in the summary of that mile.

The data concerning soils on Map 11 are from the General Soil Map of Wisconsin by A. R. Whitson and others, published in 1926 by the Wisconsin Geological and Natural History Survey. Since the soils boundaries on this map were very general, and are moreover transferred to a larger scale by their use on Map 11, they must not be regarded as accurate within the Brule Basin, but rather to indicate broadly the areas of different soils. The rock outcrops on Map 11 are from the Land Economic Survey, and the location, but not necessarily the exact boundaries, of the Copper Range are sketched in from field observation.

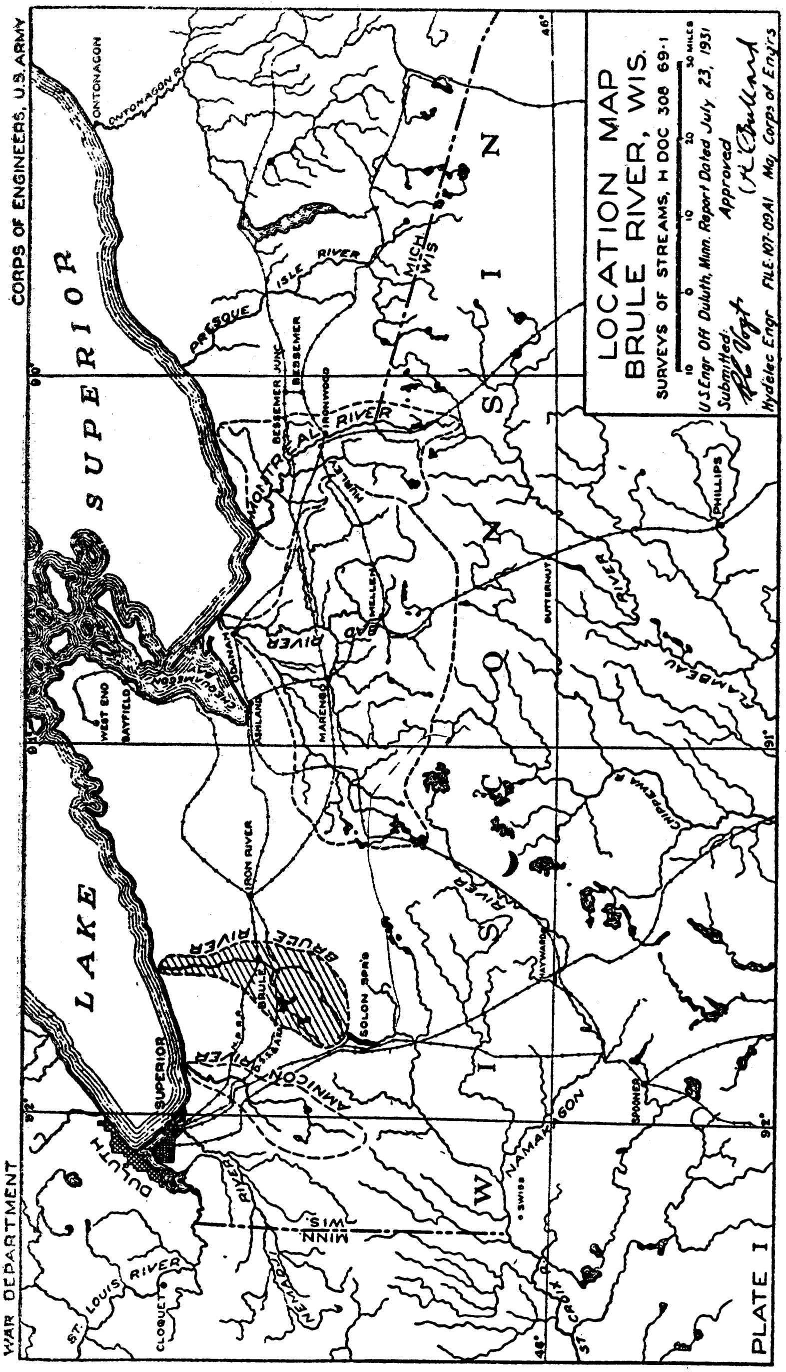
VEGETATION AND WATER FLOW

While the BRULE BOG remains undamaged, the upper Brule River will continue to be as it is now; cutting the trees or burning the bog would reduce the Brule River to a warm-water stream, probably to one devoid of trout. In the BARRENS, water seeps into the sand and enters the Brule River as springs, in spite of the fact that the vegetation of the barrens has been burned since time immemorial; future burning will therefore do no damage. Much of the NEBAGAMON RIVER BASIN is now less heavily forested than it was in the past; partial restoration of the forests should be effected. The area of RED CLAY along Lake Superior presents a complex problem: the forest has been very largely destroyed and the water-holding capacity of the upper soil levels doubtless reduced, but erosion on farm lands and roadsides, and the slumping of clay banks, probably present the most serious problems.

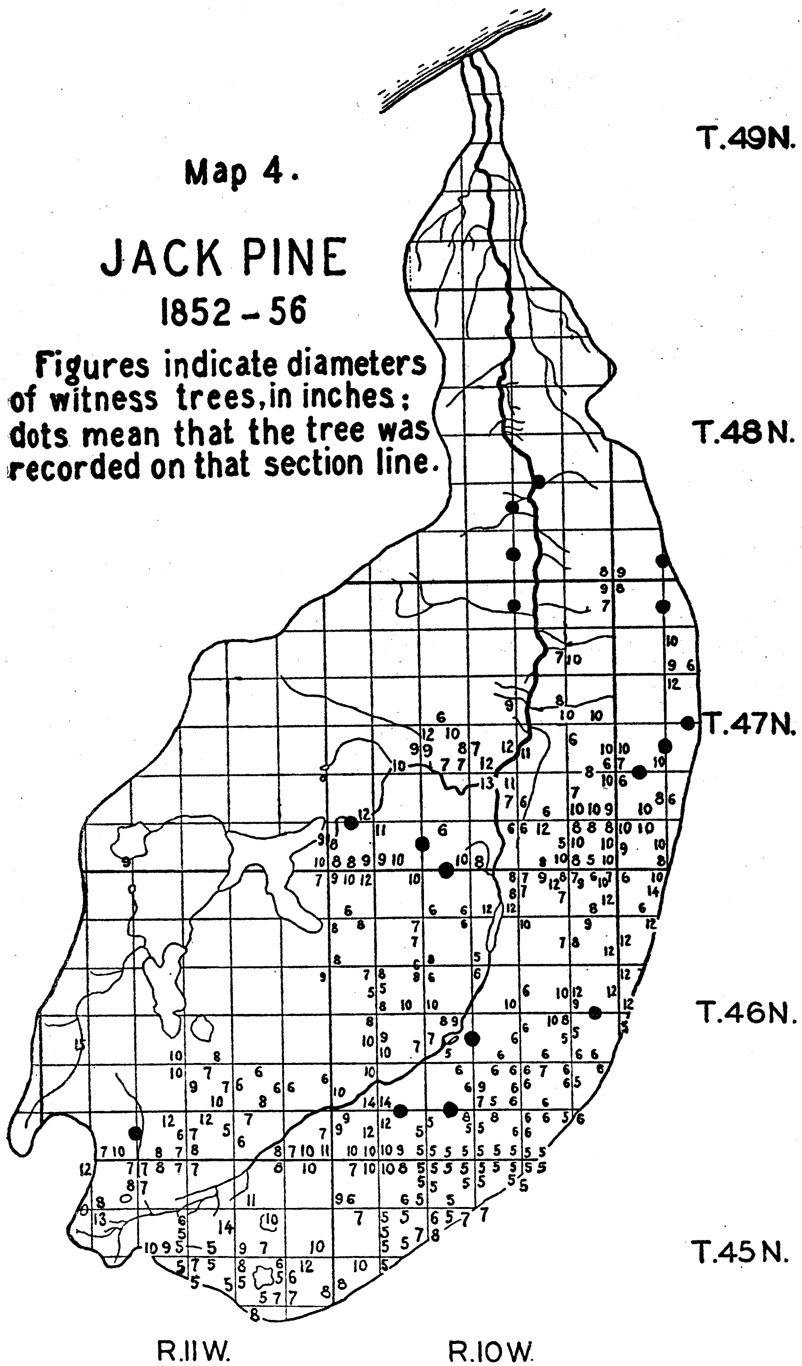
SUMMARY

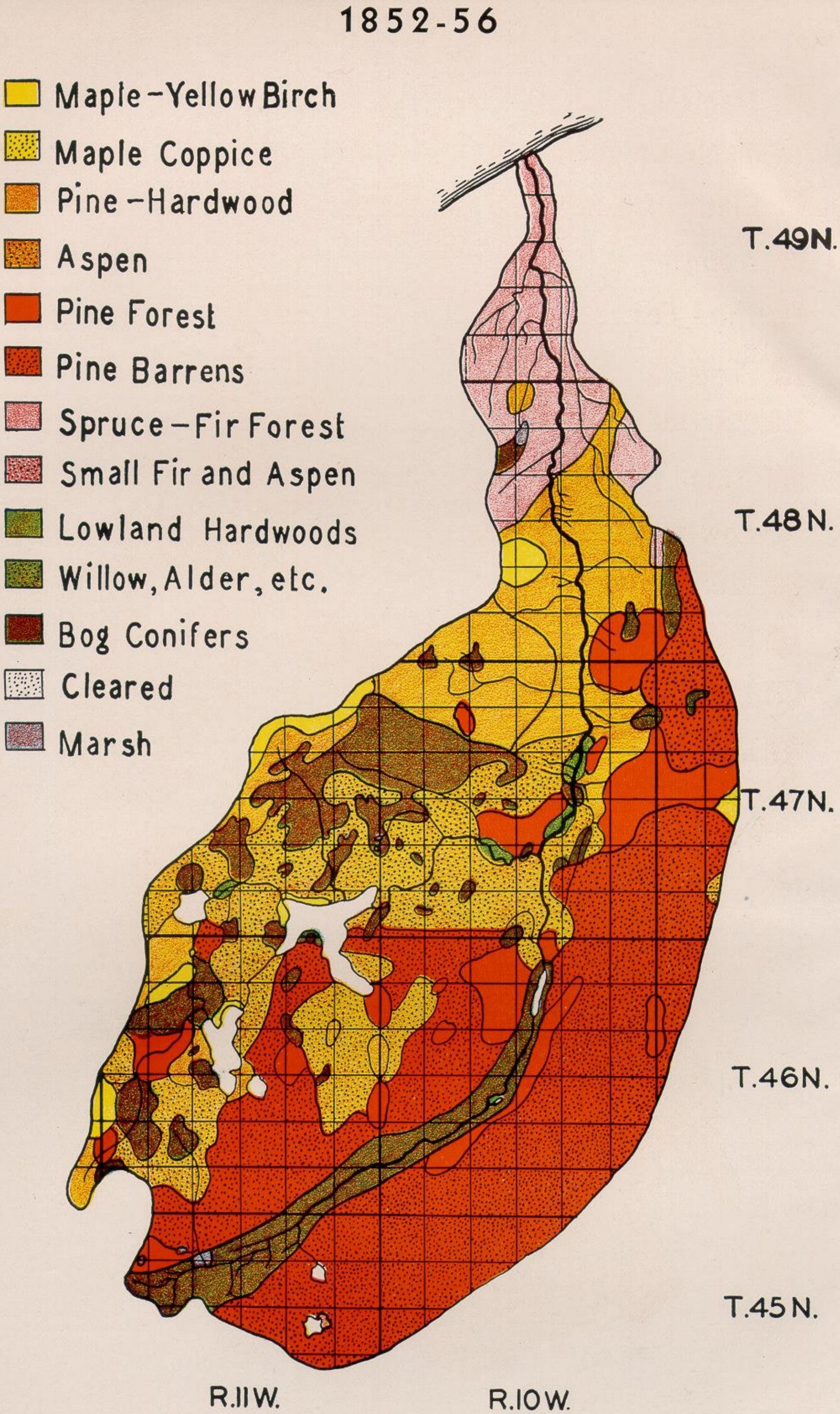
The vegetation of the drainage basin of the Brule River, which enters Lake Superior in northwestern Wisconsin, has been determined, as of 1852-56, by a study of witness trees and field notes recorded by the government surveyors of those dates, and as of 1932-43 by study of the Land Economic Survey maps of 1933 and by direct observations in the region. The bog, about a mile wide and ten miles long, which borders the upper Brule is in nearly its original condition, except for the removal of scattered large pines and the complete cutting and burning of a few small portions. The sandy Barrens, mostly southeast but also to some extent on the northwestern side of the upper Brule, is frequently burned over, with a usually sparse ground cover of small Jack Pines and scrub oaks, just as it was a century ago. The valley of the principal tributary, Nebagamon Creek, originally had a

land cover varying from pine barrens and Aspen scrub to mixed pine and hardwoods and Maple forest. This was because it was so dissected by lakes and bogs that fires were local, rather than widespread as in the Barrens. Much of this area is now cleared, the patches of maple and of pine are much reduced, and aspen scrub has largely replaced the better types of forest. The Copper Range, a ridge of trap rock crossing the Brule valley parallel to and about nine miles south of the Lake Superior shore, originally had a good growth of Maple-Yellow Birch forest, now early destroyed and represented by local areas of maple coppice. The red clay, bordering Lake Superior for about ten miles in this region, was covered with dense forest of White Pine, Spruce, Fir, White Birch, Black Ash, White Cedar, Yellow Pine, Aspen, etc., with an undergrowth of Alder, Hazel, Red Maple, Osier and Willow. The cutting, burning and pasturing has left most of this area with a shrubby growth of Alder, Hazel, Osier, and Willow, with some patches of Aspen and little Fir trees.

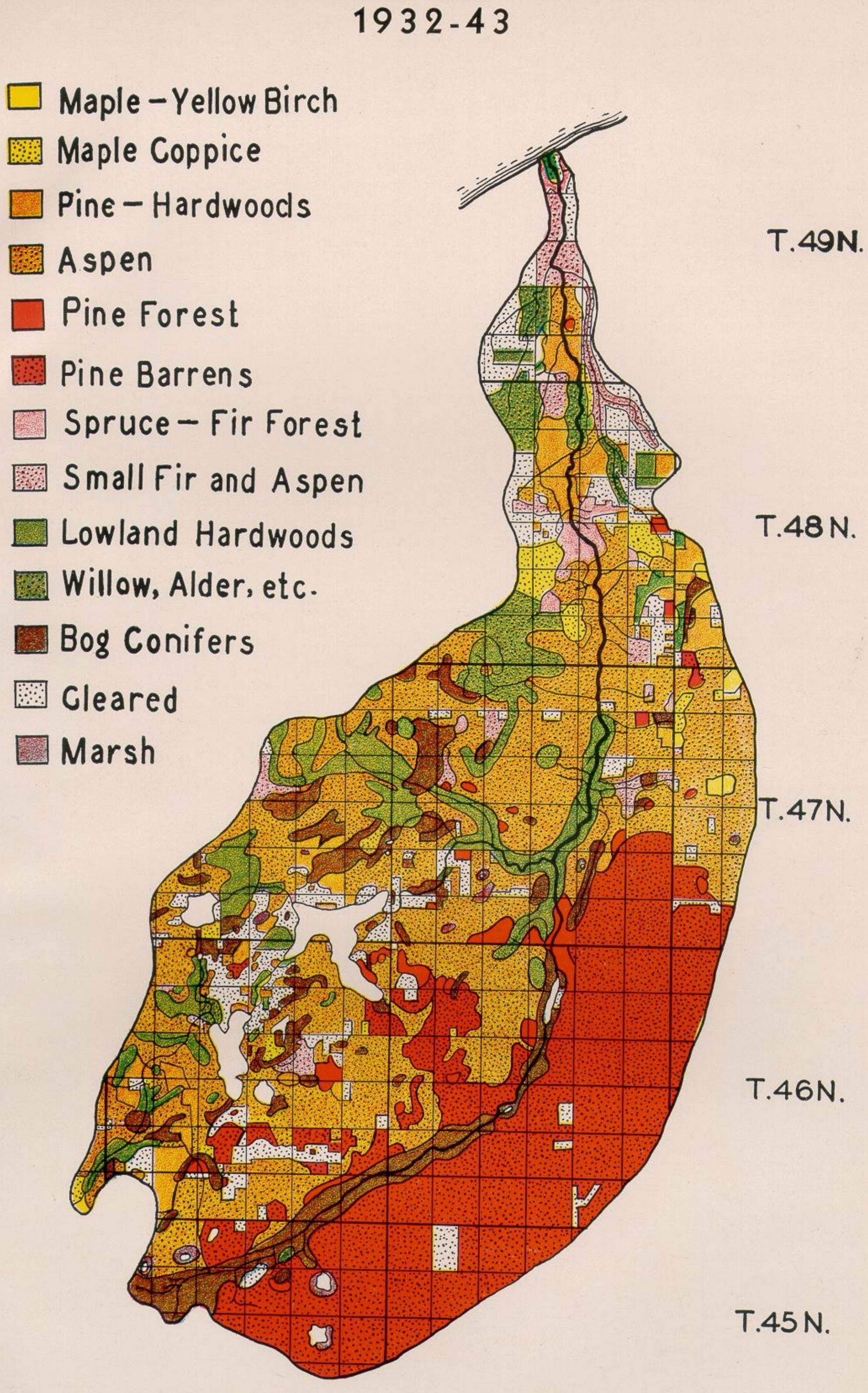


Map 1. From the House of Representatives Document No. 227, 72nd Congress, first session.

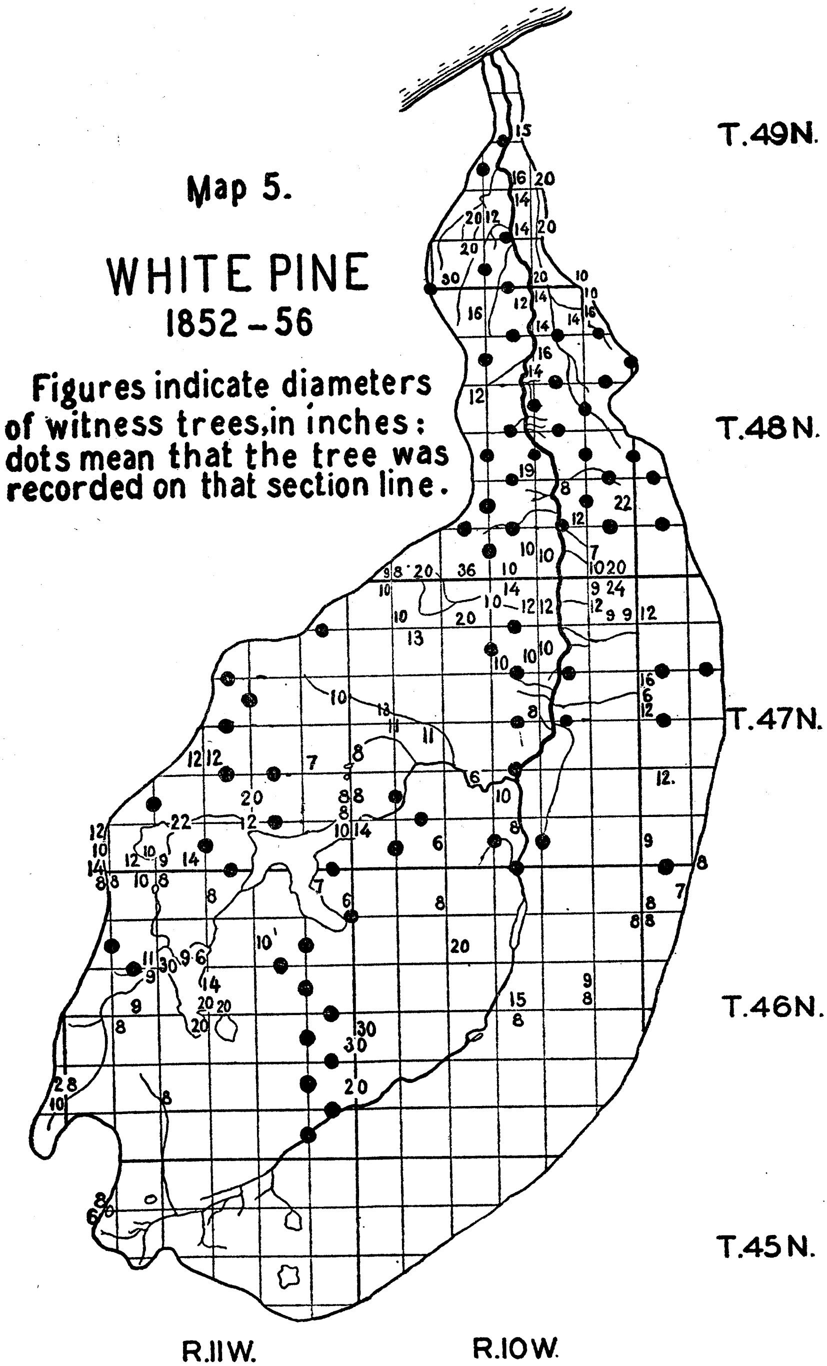

Map 4.
JACK PINE
1852 - 56
Figures indicate diameters of witness trees, in inches; dots mean that the tree was recorded on that section line.
T.49N.
T.48 N.
T.47N.
T.46N.
T.45 N.
R.11 W.
R.10 W.

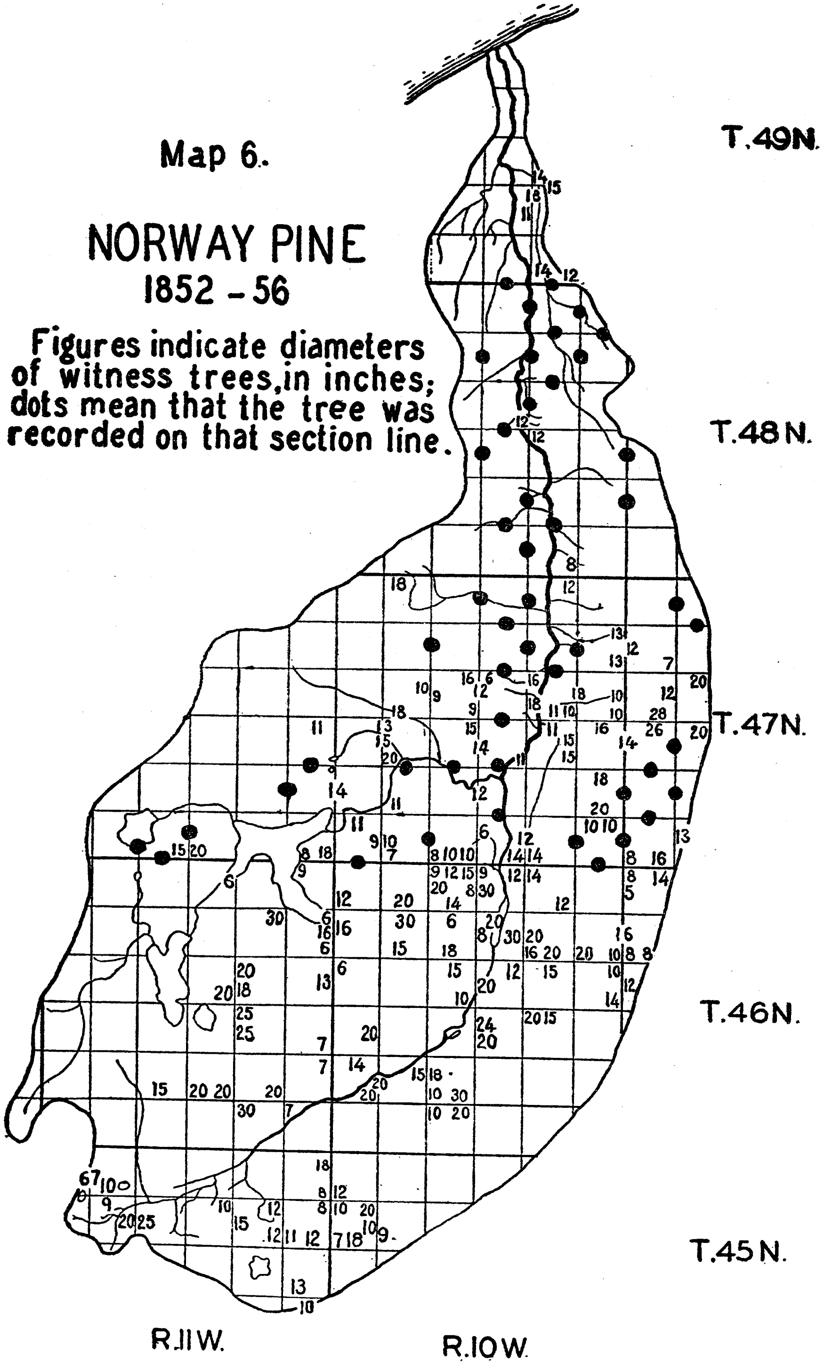

1852-56
Maple-Yellow Birch
Maple Coppice
Pine-Hardwood
Aspen
Pine Forest
Pine Barrens
Spruce-Fir Forest
Small Fir and Aspen
Lowland Hardwoods
Willow, Alder, etc.
Bog Conifers
Cleared
Marsh
T.49N.
T.48N.
T.47N.
T.46N.
T.45N.
R.11W.
R.10W.

MAP 2


1932-43
Maple - Yellow Birch
Maple Coppice
Pine - Hardwoods
Aspen
Pine Forest
Pine Barrens
Spruce - Fir Forest
Small Fir and Aspen
Lowland Hardwoods
Willow, Alder, etc.
Bog Conifers
Cleared
Marsh
T.49N.
T.48N.
T.47N.
T.46N.
T.45N.
R.11W.
R.10W.

MAP 3

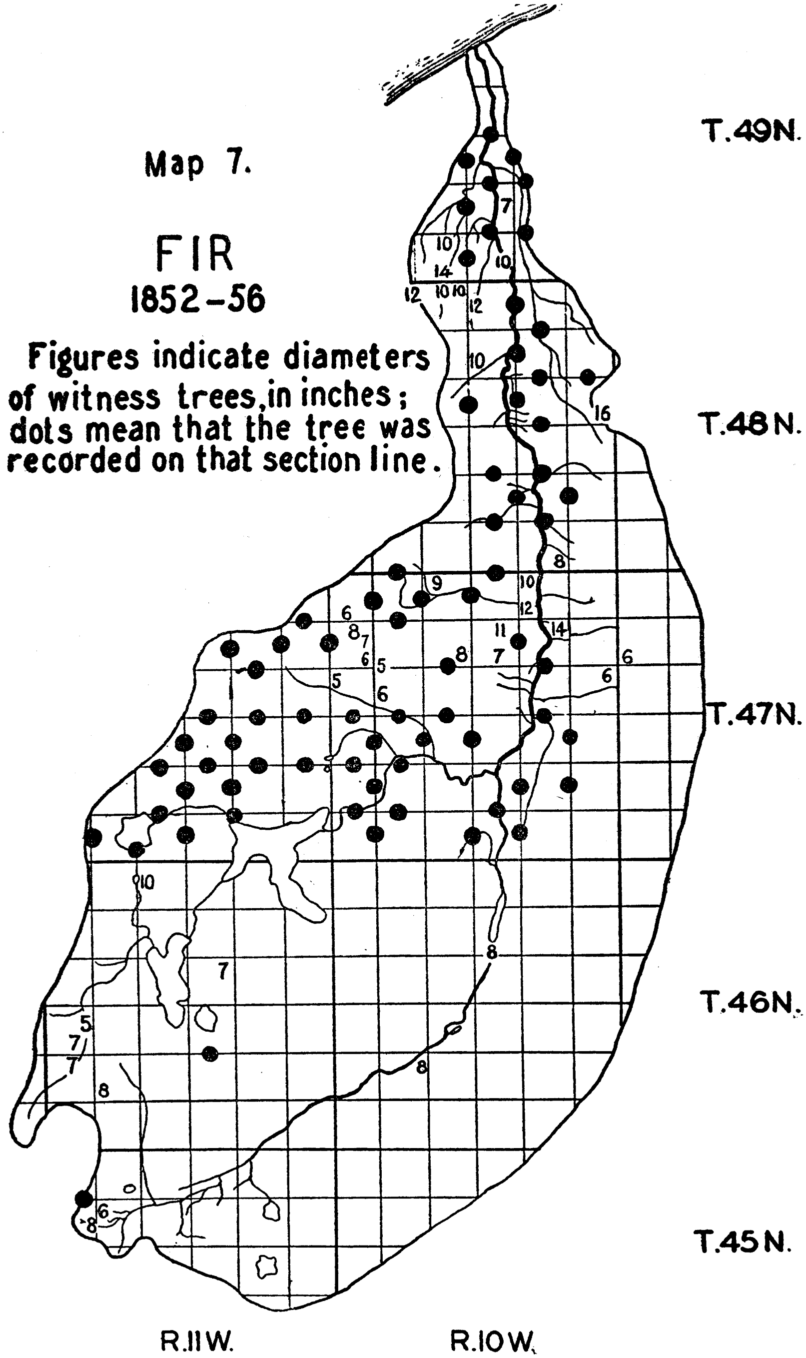

Map 5.
WHITE PINE
1852-56
Figures indicate diameters of witness trees, in inches: dots mean that the tree was recorded on that section line.
T.49N.
T.48N.
T.47N.
T.46N.
T.45N.
R.11W.
R.10W.



Map 6.

NORWAY PINE
1852 - 56

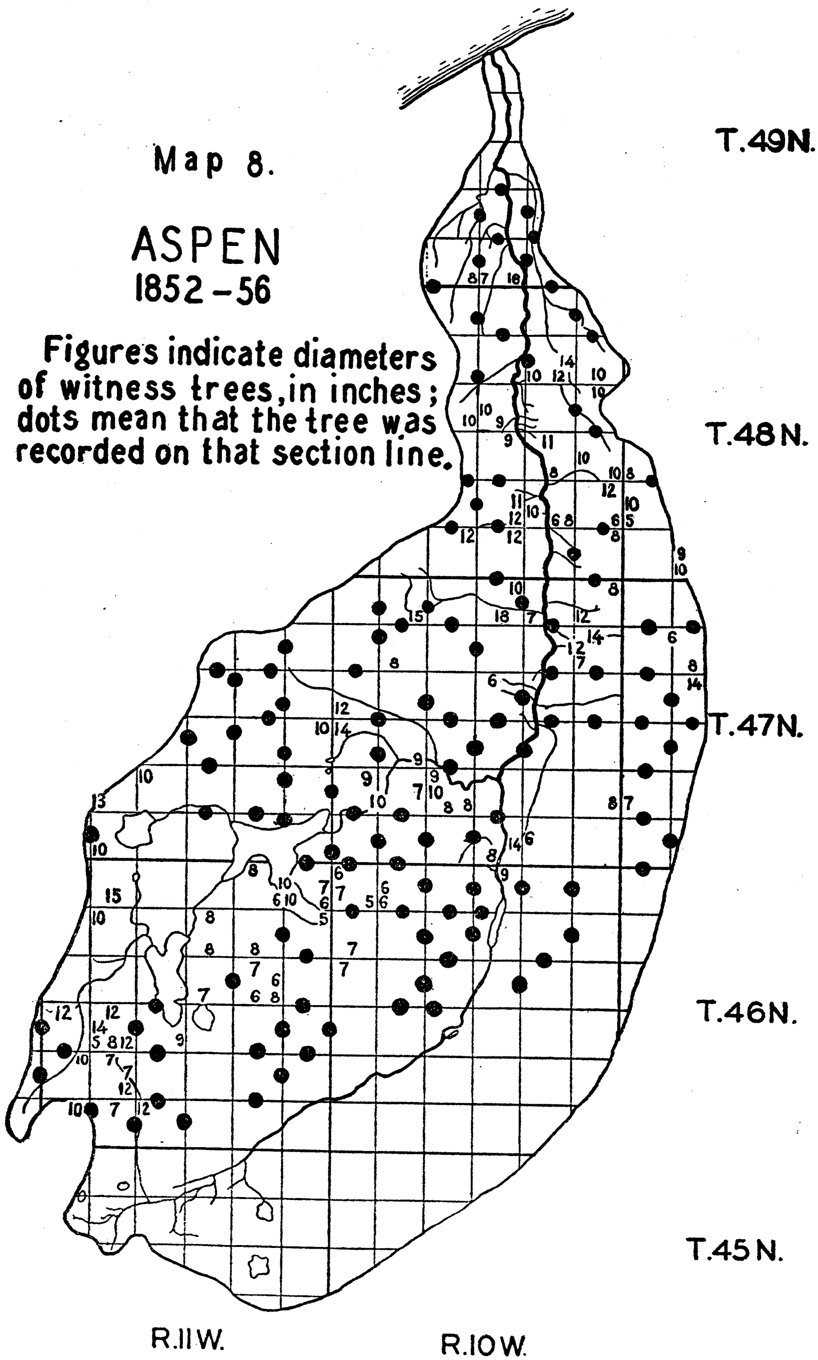
Figures indicate diameters of witness trees, in inches; dots mean that the tree was recorded on that section line.

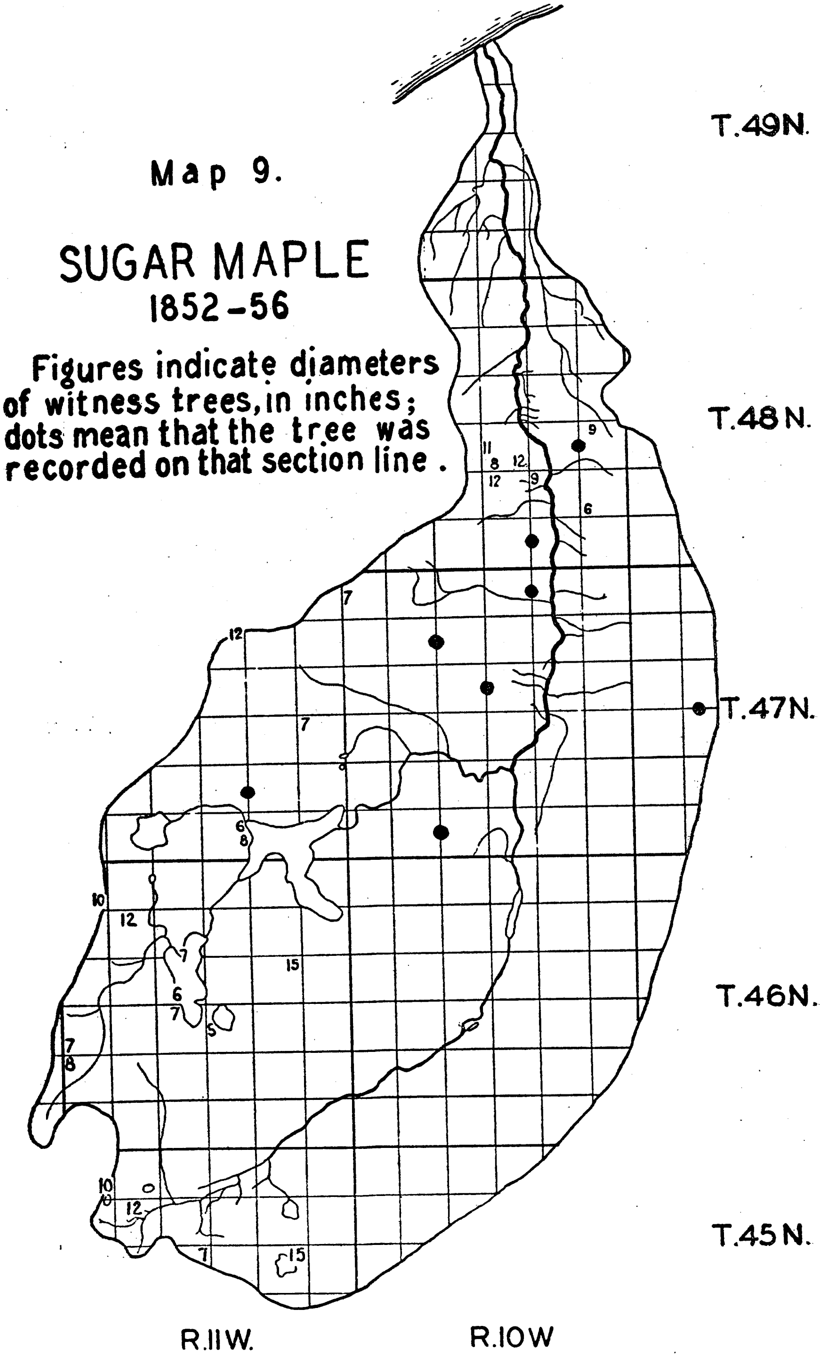


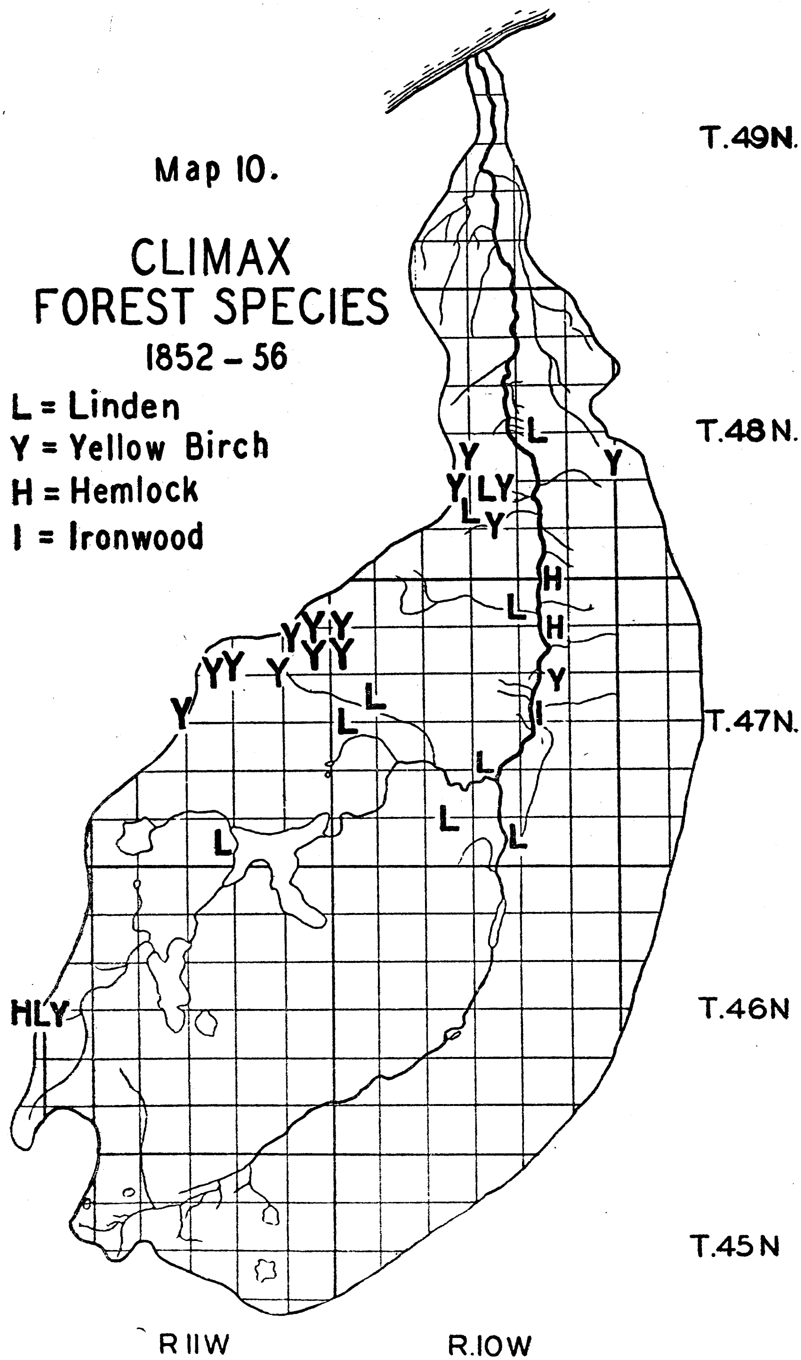
Map 7.

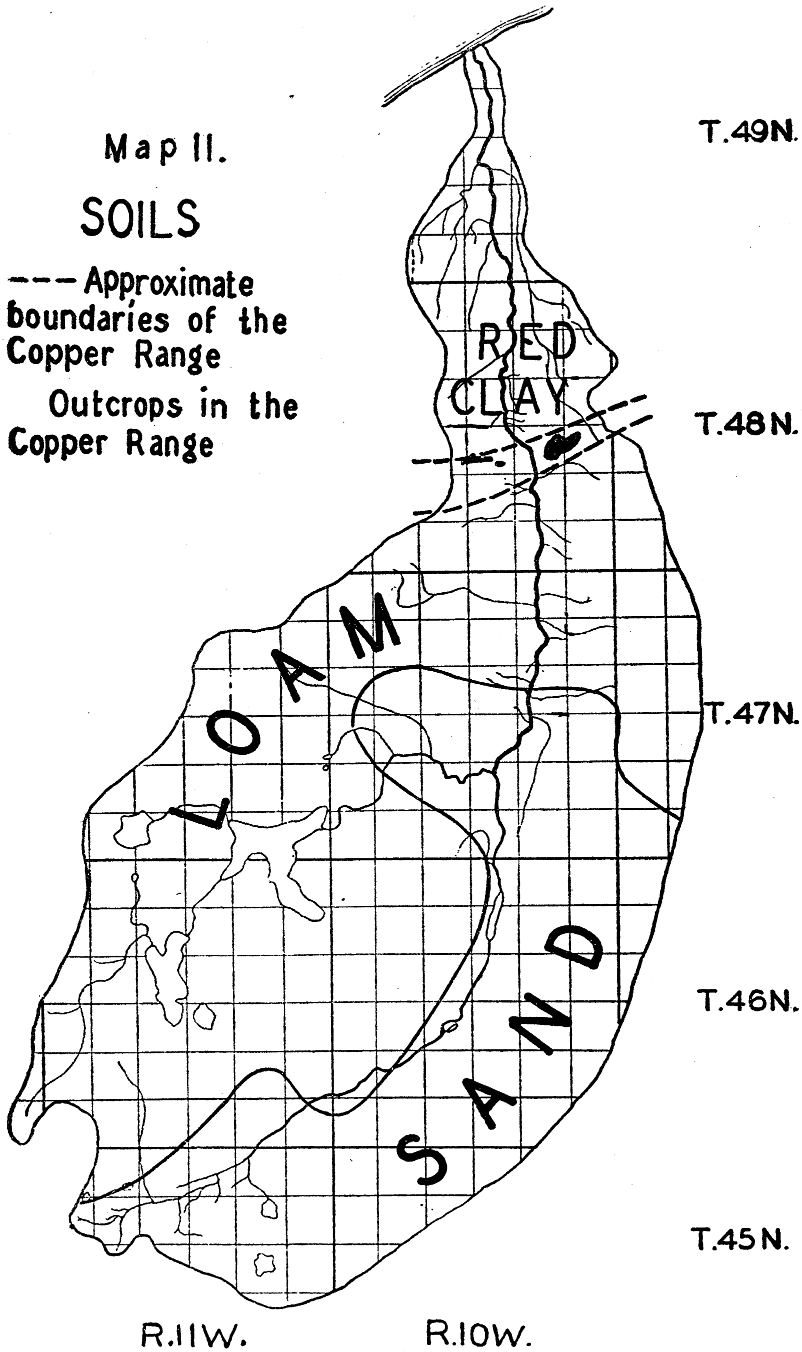
FIR
1852–56

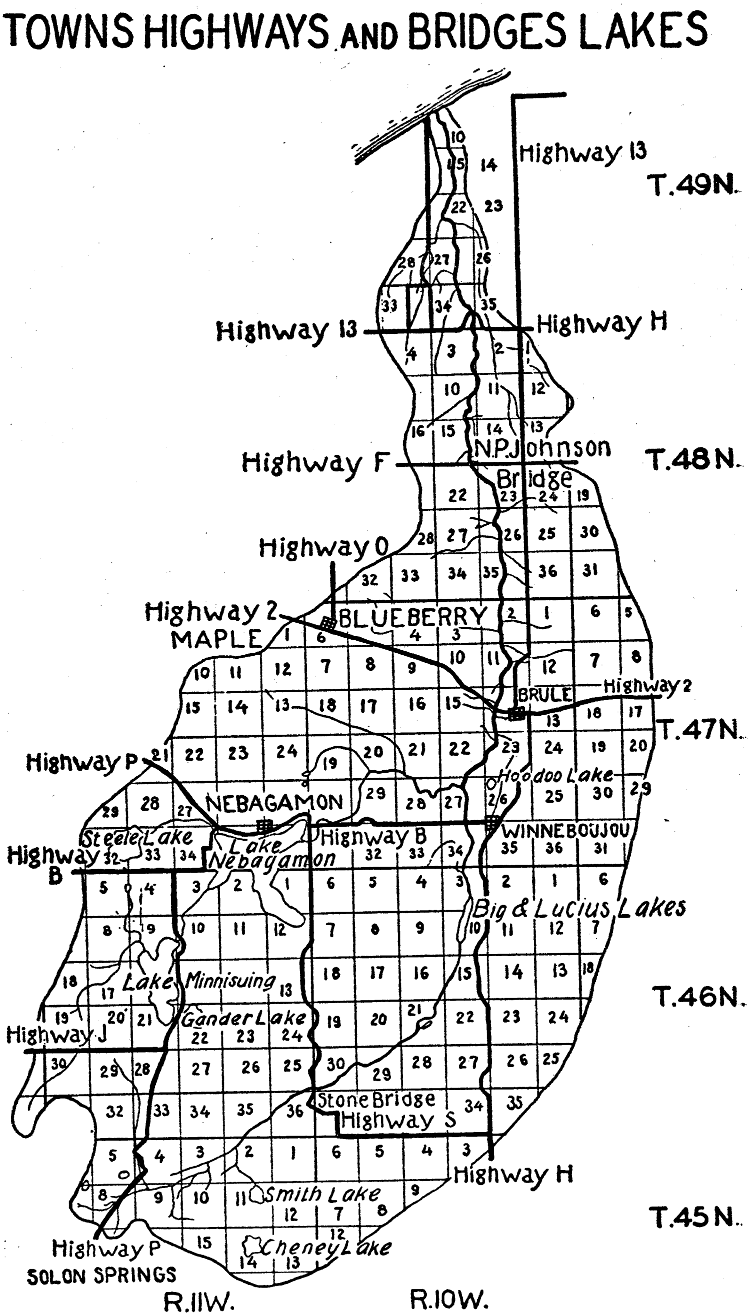
Figures indicate diameters of witness trees, in inches; dots mean that the tree was recorded on that section line.


Map 8.
ASPEN
1852-56
Figures indicate diameters of witness trees, in inches; dots mean that the tree was recorded on that section line.
T.49N.
T.48N.
T.47N.
T.46N.
T.45N.
R.11W.
R.10W.


Map 9.
SUGAR MAPLE
1852-56
Figures indicate diameters of witness trees, in inches; dots mean that the tree was recorded on that section line.
T.49N.
T.48 N.
T.47N.
T.46N.
T.45 N.
R.11W.
R.10W


Map 10.
CLIMAX
FOREST SPECIES
1852 – 56
L = Linden
Y = Yellow Birch
H = Hemlock
I = Ironwood
T.49N.
T.48 N.
T.47N.
T.46N
T.45N
R 11W
R.10W


Map II.
SOILS
--- Approximate boundaries of the Copper Range
Outcrops in the Copper Range
RED CLAY
LOAM
SAND
T.49N.
T.48N.
T.47N.
T.46N.
T.45N.
R.11W.
R.10W.


TOWNS HIGHWAYS AND BRIDGES LAKES
Highway 13
T.49N.
Highway 13
Highway H
Highway F
N.P.Johnson Bridge
T.48N.
Highway O
Highway 2
MAPLE
BLUEBERRY
BRULE
Highway 2
T.47N.
Highway P
Hoodoo Lake
NEBAGAMON
WINNEBOUJOU
Steele Lake
Lake Nebagamon
Highway B
Highway B
Big & Lucius Lakes
Lake Minnisuing
T.46N.
Gander Lake
Highway J
Stone Bridge
Highway S
Highway H
Smith Lake
T.45N.
Highway P
SOLON SPRINGS
Cheney Lake
R.11W.
R.10W.

Map 12.

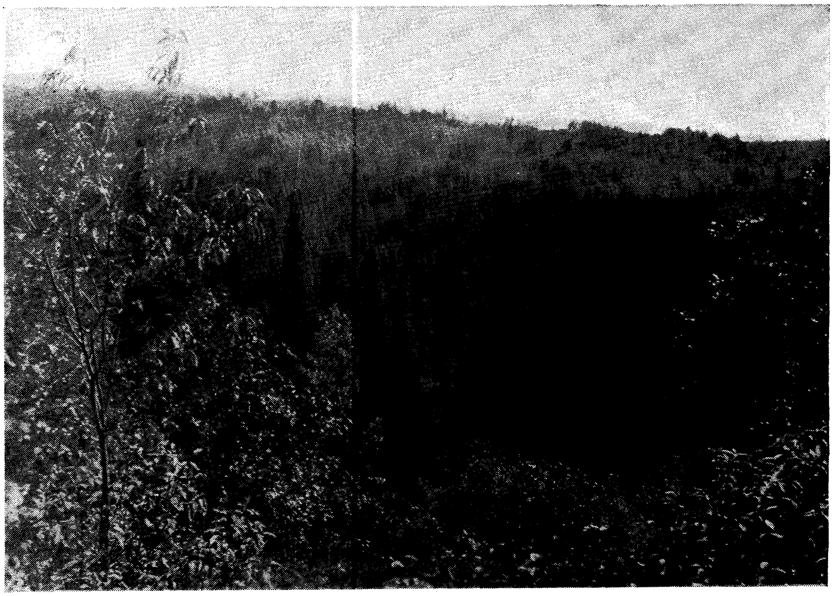


PLATE 1. Looking eastward across Brule Bog. Sec. 3, T.45N., R.11W. Photograph by Dr. J. W. Thomson.

PLATE 2. The Brule Bog near Cedar Island. Sec. 21, T.46N., R.10W.

PLATE 3. The Brule Bog near Stones Bridge. Sec. 30, T.46N., R.10W.

PLATE 4. The Brule Bog at Highway P. Sec. 8, T.45N., R.11W.

PLATE 5. The Barrens. Sec. 32, T.46N., R.10W.

PLATE 6. The Barrens. Sec. 32, T.46N., R.10W.

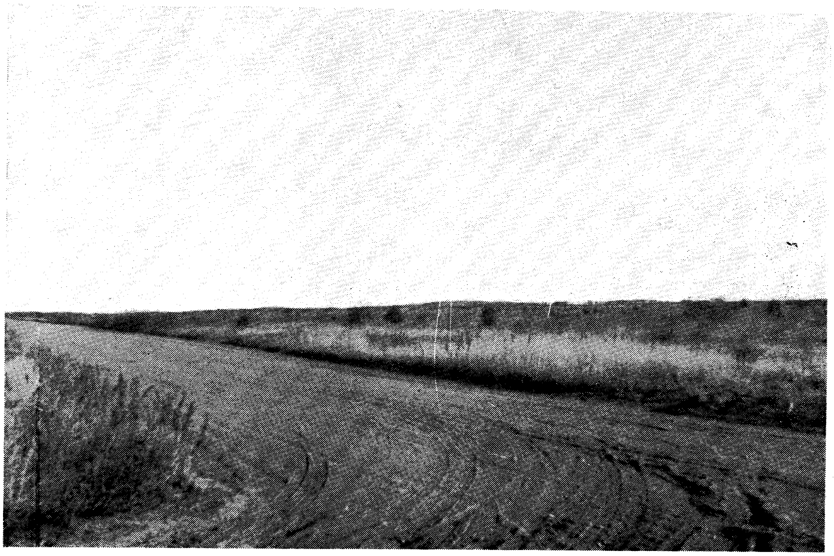


PLATE 7. The Barrens. Sec. 35, T.46N., R.10W.

PLATE 8. Aspen scrub. Sec. 5, T.45N., R.11W.

PLATE 9. White Pine on shore of Lake Nebagamon. Sec. 1, T.46N., R.11W.

PLATE 10. Fir forest at the mouth of the Brule River. Sec. 10, T.49N., R.10W.

PLATE 11. On the red clay, looking north. Sec. 23 and 24, T.48N., R.10W.

PLATE 12. Small Fir and Aspen on red clay. Sec. 15, T.48N., R.10W.

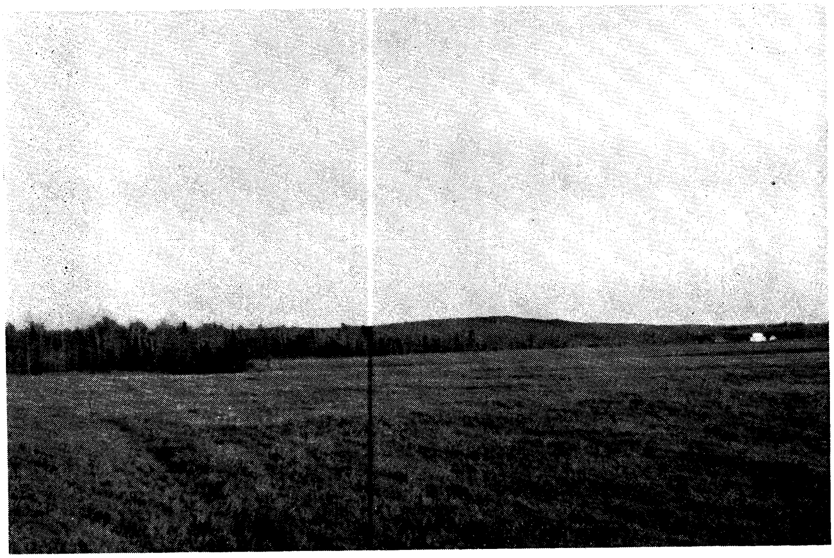


PLATE 13. Cleared land on the red clay, looking southward to the Copper Range. Sec. 15, T.48N., R.10W.

PLATE 14. Fir, Pine, Birch, etc., at N. P. Johnson Bridge. Sec. 15, T.48N., R.10W.

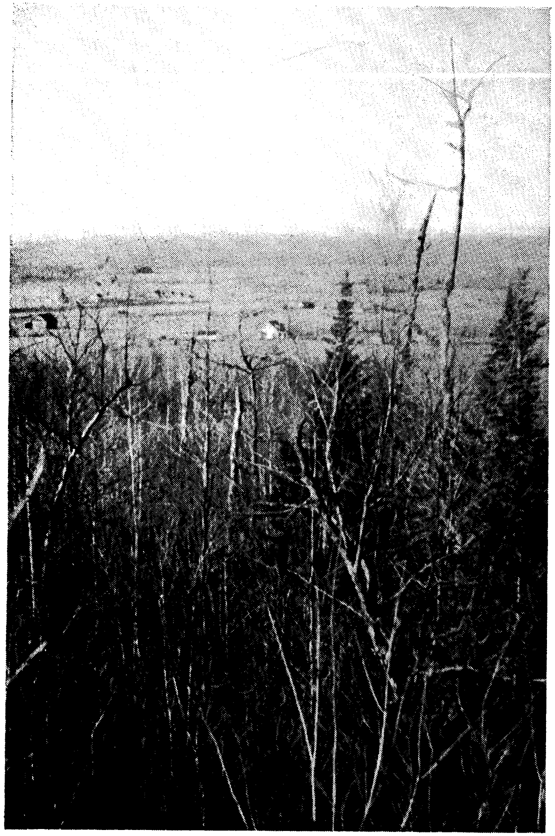


PLATE 15. Coppice growth on the Copper Range, looking northward to the red clay, cultivated in the middle-ground, mostly Willow and Tagalder in the background. Sec. 22, T.48N., R.10W.

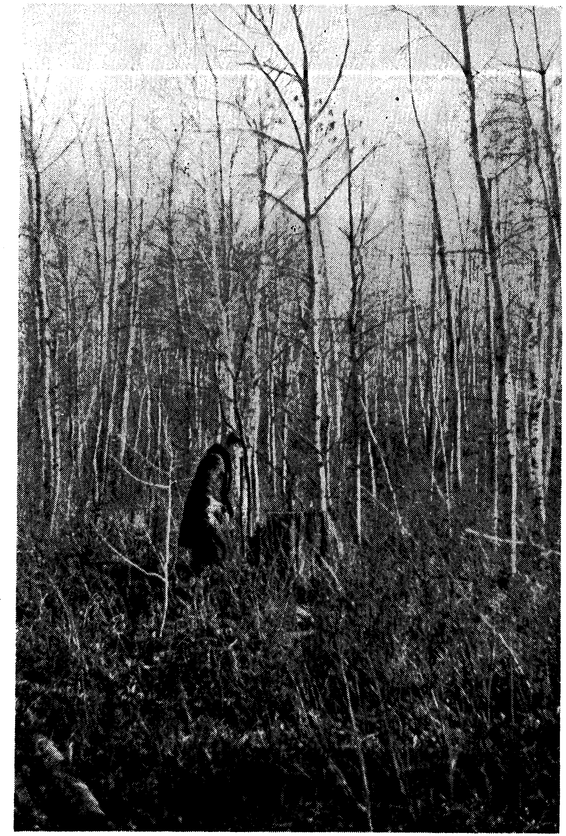


PLATE 16. Pine stump, Aspen and Birch. Sec. 12, T.48N., R.10W.

A SURVEY OF THE LARGER AQUATIC PLANTS AND BANK FLORA OF THE BRULE RIVER

Brule River Survey: Paper No. 5

JOHN W. THOMSON, JR.

This report is a result of a reconnaissance survey of the Brule River from the headwaters to the mouth during 1943. Two full sets of specimens substantiating the observations were collected. One set is deposited in the Herbarium of the University of Wisconsin; the second set is in the Herbarium at Superior State Teachers College. These specimens are designated by special labels. No attempt was made at this time to obtain quantitative data other than general observations on the abundance of the aquatics. These data are expected to be obtained during the summer of 1944.

Funds making possible the field work were supplied by the Wisconsin Conservation Commission from funds allotted to the Brule River Survey in cooperation with the University of Wisconsin. Grateful acknowledgement is made to Dr. N. C. Fassett of the Department of Botany of the University of Wisconsin and to Mr. J. R. Jacobson of Superior, Wisconsin for assistance during the project.

MAJOR DIVISIONS OF THE STREAM

The Brule River may be divided into three major ecological regions. The upper section extending downstream to the mouth of Nebagamon Creek is dominated by the headwaters coniferous swamp. It is a comparatively unspoiled section of the stream. The lower section of this major region is divided into the upper rapids or Dalles and the "lakes." In this section is the greatest abundance and variety of species of higher aquatic plants. The middle section of the Brule, from the mouth of Nebagamon Creek to the beginning of the rapids above Co-op Park is a sluggish, meandering stream flowing through bottomlands with large hardwood trees, mainly elm and ash. Comparatively few aquatics are found in this section. The lower course of the stream, from the beginning of the rapids to the mouth, is a series of short rapids and falls alternating with pools of quieter water. Except at the mouth, the higher aquatic plants are extremely rare in this lower section. The alga, *Cladophora*, is the most abundant macroscopic plant in the lower stream. The dominant bank plants throughout the course of the river are the hoary or tag alder and the red-osier dogwood. Other associations of plants approach the river and contribute their effects upon it. These associations are discussed in the appropriate stream sections.

The Upper Brule

It appears that the greatest factor in the maintenance of the river as a suitable habitat for trout is the coniferous forest swamp which occupies the upper valley. The numerous springs in this region, and the large swampy area with an abundance of absorbent humus make this stream unusual among most streams in this area of northern Wisconsin and are good combinations for maintaining a very even flow of water.

The Coniferous Swamp Association (*Thuja* Association)

The white cedar, *Thuja occidentalis*, or *Thuja* association of F. C. Gates is the dominant one of the upper valley. White cedar and black spruce, *Picea mariana*, are the dominant trees. Tamarack, *Larix laricina*, and balsam, *Abies balsamea*, are common subdominants. Occasional deciduous trees occur. These are mainly white birch, *Betula papyrifera*; black ash, *Fraxinus nigra*; and mountain ash, *Sorbus americana*. Where the association extends along the river, the same shrubs characteristic of the alder swamp association occur in addition: honeysuckles, *Lonicera oblongifolia, L. caerulea* var. *villosa, L. canadensis*; mountain holly, *Nemopanthus mucronata*; mountain maple, *Acer spicatum*; and leather leaf, *Chamaedaphne calyculata*. The shade of the dominants is not so unbroken but to allow a large number of secondary species characteristic of the association to thrive. They include: crested shield fern, *Dryopteris cristata*; rattlesnake fern, *Botrychium virginianum*; club mosses, *Lycopodium lucidulum* and *L. annotinum*; yew, *Taxus canadensis*; cotton grass, *Eriophorum viridi-carinatum*; sedges, *Carex laxiflora, C. tenella, C. trisperma, C. intumescens* var. *Fernaldii*; chinaberry, *Clintonia borealis*; three-leaved solomon's seal, *Smilacina trifolia*; blunt-leaf orchid, *Habenaria obtusata*; leafy orchid, *Ha-*

benaria dilatata var. *media*; dwarf rattlesnake plantain, *Goodyera repens* var. *ophioides*; goldthread, *Coptis trifolia*; bishop's cap, *Mitella nuda*; strawberry, *Fragaria vesca*; fringed polygala, *Polygala pauciflora*; enchanters nightshade, *Circaea alpina*; one-flowered pyrola, *Moneses uniflora*; shinleaf, *pyrola chlorantha* and *P. secunda* var. *obtusata*; snowberry, *Chiogenes hispidula*; bedstraw, *Galium triflorum*; twinflower, *Linnaea borealis* var. *americana*; bog goldenrod, *Solidago uliginosa*; and aster, *Aster puniceus*.

A thick mat of mosses principally composed of species of *Sphagnum, Thuidium, Brachythecium, Anomodon, Mnium,* and *Dicranum* carpets the ground and fallen logs. Lichens are numerous, including *Cladonia rangiferina* (classified in the narrow sense) as the most abundant. Luxuriant thalli of *Peltigera aphthosa, P. horizontalis, P. polydactyla,* and *P. canina* are abundant. Cladoniae are frequent. *Cladonia cenotea, C. gracilis, C. chlorophaea, C. crispata, C. cristatella* and *C. nemoxyna* are perhaps those most frequently seen. In open spaces where windfalls expose the area to increased sunshine, labrador tea, *Ledum groenlandicum*; cranberry, *Vaccinium oxycoccus*; fireweed, *Epilobium angustifolium*; crested fern, *Dryopteris cristata*; bunchberry, *Cornus canadensis*; and sundew, *Drosera rotundifolia* are typical.

Bog acids which hinder decay and the coldness of the water-soaked organic soil below the surface account for the accumulation of material in the valley. If this material is exposed to heat and drying, the organic matter oxidizes, runs off via the stream, and the soil disappears. Mr. J. R. Jacobson of Superior, Wisconsin, suggests that this may be occurring slowly due to the overbrowsing of the white cedar association by deer with consequent more rapid evaporation from the soil. This hypothesis seems reasonable and should be checked carefully in the field. Forest removal, through fencepost and pulpwood cutting, will of course vastly accelerate the destruction. Unfortunately certain areas within this coniferous swamp (near Highway P crossing in T.45N., R.11W., S.9,4) are being cut for pulpwood. Consequently the cut-over areas are drying out and the humus is deteriorating. The destruction of the swamp by such a process will lead to a lessened and more uneven flow of water by removal of the organic matter and raising of water temperatures by exposure of the black stream bottom to the full sunlight. If the stream is to be maintained at or near its present condition, all cutting of trees from the headwaters swamp area should be stopped.

Springs and spring-fed brooks are common in this region. Brook trout have been observed to be very common in these small brooks. No submerged aquatics, but semi-aquatic emergent plants have been observed along the headwater brooks.

Principal plants of the headwaters brooks and springs include: beaked willow, *Salix Bebbiana*; bog willow, *Salix pedicellaris*; watercress, *Radicula Nasturtium-aquaticum* (rather rare in the valley); water horehound, *Lycopus uniflorus*; speedwell, *Veronica americana*; tag alder, *Alnus incana*; true forget-me-not, *Myosotis scorpioides*; golden saxifrage, *Chrysosplenium americanum*; water hemlock, *Cicuta bulbifera*; jewelweed, *Impatiens biflora*; and willow-herb, *Epilobium adenocaulon.*

Alder Swamp Association

In the upper region the Brule River meanders through the white cedar and spruce bog with a zone of alder swamp association fringing it and varying in width from almost lacking, so that the conifers come to the waters edge, to several rods. A few meadows are located in this region. These are mainly dominated by bluejoint, *Calamagrostis canadensis*. Tag alder, *Alnus incana*, is the dominant plant of the alder swamp association and covers the stream in the narrow places making it difficult to get a boat through. Other shrubs which occur frequently are highbush cranberry, *Viburnum opulus* var. *americanum*; buckthorn, *Rhamnus alnifolia*; and red-osier dogwood, *Cornus stolonifera*. Other plants observed in the alder swamp zone include: water hemlock, *Cicuta bulbifera*; water arum, *Calla palustris*; and golden saxifrage, *Chrysosplenium americanum* on exposed mud banks at the base of the alders. In more open spots with greater exposure to the sun, especially in such places as along the edge of the meadows, several additional species of plants are observable along the banks. These are termed the *Myrica Gale* association in F. C. Gates' paper on the bogs of northern lower Michigan but are too limited in extent here to be more than components of the alder swamp association. These plants include: sweet gale, *Myrica Gale*; meadow-sweet, *Spiraea* *salicifolia*; dock, *Rumex Britannica*; meadow-rue, *Thalictrum dasycarpum*; crested fern, *Dryopteris cristata*; jewelweed, *Impatiens biflora*; bedstraw, *Galium Claytoni*; water horehound, *Lycopus americanus*; mint, *Mentha arvensis* var. *lanata*; and iris, *Iris versicolor*.

Bluejoint Meadow Association (*Calamagrostis* Association)

The "meadows" or open grassy places in the upper Brule valley are in openings near the stream and vary from very small areas to several acres in extent. The dominant plant in most of these is bluejoint, *Calamagrostis canadensis*, but other species of plants may locally dominate. In one such area near County Highway P crossing of the Brule, T.45N., R.11W., S.9, the dominant is fowl bluegrass, *Poa palustris*. Other plants characteristic of the Calamagrostis meadow association are niggerhead sedge, *Carex stricta*; chickweed *Stellaria longifolia*; tufted loosestrife, *Lysimachia thyrisifolia*; marsh harebell, *Campanula aparinoides*; tearthumb, *Polygonum sagittatum*, great St. John's-wort, *Hypericum Asycion*; marsh St. John's wort, *Hypericum virginicum* var. *Fraseri*; water horehound, *Lycopus americanus*; and mint, *Mentha arvensis* var. *lanata*. Gates (*loc. cit.*) suggests that such meadows are due to burning. It has not been ascertained whether or not this is the case along the Brule. No stumps were observed in the "meadows" such as would be expected following fires.

Aquatic Plants in Upper Brule

Aquatics in the upper section of the stream which run through the alder and white cedar associations are few in number. Wild celery, *Vallisneria americana*, and bur-reed, *Sparganium angustifolium* are the most abundant. The bottom in this section is mainly covered with a black organic mud largely composed of remains of diatoms and higher plants (material examined by N. C. Fassett and R. I. Evans). In the broader pools at the turns in the stream the higher aquatics are more common than in the narrow stretches between the meander curves, where the alders overhang the stream and a passageway for boats is maintained only by cutting. Probably shading by the alders and the dark color of the water limits the aquatics in such sections of the stream. Watermoss, *Fontinalis antipyretica* var. *gigantea*,

TABLE I. Brule aquatics.

Key b—mud bank in shallow water m—muck bottom in water s—sand bottom g—gravel bottom a—attached to rocks, branches f—floating	Above Stone's Bridge	Stone's Bridge to Pierce Est. Bridge	Pierce Est. Bridge to Winneboujou	Big Lake	Lucius Lake	Winneboujou to Little Joe Falls	Little Joe Falls to Weir	Weir to Co-op	Co-op to ½ mile above mouth	Lower ½ mile to mouth	Slough at mouth
Acorus calamus										b	
Anachar's canadensis				m	m	m,s		m	m	m	
Anacharis occidentalis		m									
Bidens cernua				m							
Callitriche hermaphroditica				s		s					
Callitriche palustris	s	m				m					
Ceratophyllum demersum				m	m						m
Fontinalis antipyretica var. gigantea	a	a									
Leersia oryzoides f. inclusa				m,s							
Lemna minor	f			f							f
Megalodonta Beckii											m
Nitella flexilis		s				s					
Nuphar variegatum										m	m
Potamogeton amplifolius											m
P. Berchtoldi var. mucronatus		s									
P. epihydrus									m		

P. foliosus var. macellus				m	m					
P. natans		m								m
P. obtusifolius	m		s					m	m	
P. obtusifolius var. rutiloides							m			
P. pectinatus		m	s	m	m,s	s				
P. praelongus		m	s	m	m					
P. Richardsonii			s	m	m	s	m		m	
P. tenuifolius	m			m		s		m		
P. zosteriformis				m	m					
Potentilla palustris									b	m
Ranunculus longirostris	s					s				
Ranunculus trichophyllus var. typicus			g			s	m			
Ricciocarpus natans										f
Sagittaria latifolia						m			b	
S. latifolia f. gracilis				m						
S. latifolia f. hastata							b			
Sagittaria rigida						m	b	b		
Scirpus validus				m			m			m
Sparganium angustifolium	m									
Sparganium chlorocarpum										m
S. chlorocarpum var. acaule		b								
Sparganium eurycarpum										m
Sparganium fluctuans										m
Spirodela polyrhiza				f						f
Typha latifolia		b							b	b
Vallisneria americana	m									
Zizania aquatica										m

is frequent in small clumps on rocks or, more often, on the submerged lower parts of the branches of the alder. A few plants of pondweeds, *Potamogeton tenuifolius* and *P. obtusifolius*, were seen. At one place where beaver had erected a dam and the bottom was sandy a few plants of water starwort, *Callitriche palustris* were observed. Duckweed, *Lemna minor*, is represented as scattered plants, mainly in the slow waters along the edges of the stream.

From the bend just above the Stone cabin above Stone's Bridge to the confluence of Nebagamon Creek with the Brule River is the section of the river with the greatest abundance of the higher aquatic plants. This region has been cleared out for the most part so that there is little obstruction of the stream by the alder swamp association or by fallen white cedar or spruce from the swamp conifer association. Artificial obstructions have been placed in the stream in the form of deflectors, wing dams and structures of like nature for the purpose of improving the stream for fishing. The stream is exposed for the most part and does not have the cover and shade of the upper section from the crossing of County Highway P to the crossing of County Highway S. Greater velocity in some sections gives sandy bottom and boulders in the rapids but there are also large stretches, particularly at the spreads called Big and Lucius Lakes in which the river is dropping muck, largely of organic nature. Conditions in this section of the stream seem, on the whole, to be excellent although a certain amount of cover might be desirable to reduce the insolation of the dark colored bottom which raises stream temperatures on clear days. The "spreads" or lakes are an especial problem. If it is desired to reduce the area of bottom exposed to direct sunlight it is possible that the planting of wild rice would be successful. Owen, in 1848, reported wild rice in abundance in "First and Second Flag Lakes" or Big and Lucius Lakes. None was observed to be at present growing in these lakes. Wild rice was observed only in the slough at the mouth of the Brule. Apparently dredging operations eradicated the wild rice formerly growing in these lakes. The conditions seem especially favorable for such an establishment.

In the section of the stream from the big bend just above Stone's Bridge to Big Lake the higher aquatics are abundant. Above Stone's Bridge the dominants are bur-reed, *Sparganium* *angustifolium*; pondweed, *Potamogeton obtusifolius*, *P. tenuifolius* and water crowfoot, *Ranunculus longirostris*. Arum, *Calla palustris*, is frequent along the border of the stream. Just below the bridge at Stone's Bridge there may be added to these species the following: water crowfoot, *Ranunculus trichophyllus*; waterweed, *Anacharis canadensis*; watermoss, *Fontinalis antipyretica* var. *gigantea*, and a very considerable amount of *Spirogyra* and *Hydrodictyon* of the algae. In August and September the filamentous algae appeared in great abundance, long streamers extending downstream, some of them being many yards in length. The condition of these algae in a considerable portion of the stream did not appear healthy to the casual observer. Some investigation of the abundance of these algae, the reasons for it, the poor appearance, and the possible effect on the fish and other life in the river ought to be initiated. Richardson's pondweed, *Potamogeton Richardsonii*, appears in the river in abundance fairly far down near McDougal's Springs. The dominant aquatic in this section of the stream is the *Anacharis*. It is in great abundance, usually over sand or sand and muck bottom.

At McDougal's Springs, the river widens somewhat and the slower current drops a quantity of organic material as well as sand. In this broader stretch in the river, sago pondweed, *Potamogeton pectinatus*, and floating-leaf pondweed, *P. natans*, are abundant.

Potamogeton natans persists down the river to the Pierce Estate bridge then reoccurs in the slough in an old oxbow at the mouth of the river. Just above the boathouse of the Pierce Estate there is an extensive bed of *Potamogeton Berchtoldi* var. *mucronatus* (*P. pusillus* of most manuals) on a sandy bottom. This is the only place in which it occurs in the river.

In the broad stretch recently called "Sucker Lake", but known as the third Flag Lake in early reports on the region, the stream widens out into a shallow stretch flowing over sand containing a small percentage of organic material. In this section Richardson's pondweed is the dominant and there is a little each of sago pondweed; pondweed, *P. oblongifolius*; and water milfoil, *Myriophyllum exalbescens*.

Big Lake and Lucius Lake have very similar aquatic floras. In Big Lake there appears to be a zonation based upon depth of water. At the head of the lake is a sandy stretch with shallow water. Here the principal aquatics are: waterweed, *Anacharis canadensis*; Richardson's pondweed; sago pondweed; and water crowfoot, *Ranunculus trichophyllus.* Water starwort, *Callitriche hermaphroditica* (*C. autumnalis*) is not noticeable in the summer, but in September and October appears in abundance in the sandy area at the head of Big Lake, preferably in slower moving water where a little organic matter has settled in the irregular depressions of the bottom. Deer were observed to browse on the aquatics in the shallow water at this end of the lake. It is not certain what influence they may have on the ecology of the aquatic plants in this section of the stream.

In Big Lake the water slows up so that there is almost no current. The deeper portion appears to be toward the east shore and the shallow water is on the west shore over a broad, gradually deepening bank of largely organic mud. In the shallow water, up to two feet in depth, the dominant aquatic is leafy pondweed, *Potamogeton foliosus* var. *macellus.* From this depth to about six to eight feet there is an abundance of a large number of species: Richardson's pondweed, *Potamogeton Richardsonii*; Muskie weed, *P. praelongus*; pondweed, *P. tenuifolius*; pondweed, *P. obtusifolius*; sago pondweed; flat-stemmed pondweed, *P. zosteriformis*; waterweed, *Anacharis canadensis*; hornwort or coontail, *Ceratophyllum demersum*; water milfoil, *Myriophyllum exalbescens*; and water crowfoot, *Ranunculus longirostris.*

Lucius Lake has a very similar flora to that in Big Lake and the conditions are very similar, with a sandy shallows at the head of the lake, grading into soft organic mud in the major portion of the lake. Aquatics collected or observed here include: *Potamogeton Richardsonii, P. praelongus, P. obtusifolius, P. pectinatus, P. zosteriformis, Ceratophyllum demersum, Anacharis canadensis* and *Myriophyllum exalbescens.* In the shallow water over the mud bottom, *Potamogeton foliosus* var. *macellus* is again dominant.

The banks of Big and Lucius Lakes are lined at each end by narrow strips of the white cedar association, similar to the swamp above the lakes. The white cedar shows excessive browsing by deer, the browse line being very evident (Fig. 5). The major portion of the bank is approached by the white birch and aspen association but here, as along the rest of the river, a narrow fringe of the alder swamp association grows at the water's edge.

From Winneboujou to the mouth of Nebagamon Creek the stream is fairly uniform in character, a series of rapids over bouldery bottom alternating with the sandy stretches. Higher aquatic plants are confined to the sandy areas. Richardson's pondweed, *Potamogeton Richardsonii*; water crowfoot, *Ranunculus trichophyllus*; and waterweed, *Anacharis canadensis* are the principal species present. Smaller quantities of water milfoil, *Myriophyllum exalbescens; Potamogeton tenuifolius*; and sago pondweed, *P. pectinatus* were observed. In the fourth pool below Winneboujou a small amount of starwort, *Callitriche hermaphroditica,* the second station in the river, was observed. The banks through this section have a complex flora but the dominant plant along the river bank is the tag alder. An abundant herb, forget-me-not, *Myosotis scorpioides,* lines the bank especially in springy spots. Black ash and American elm are abundant along the bank. Other trees overhanging the water include white birch, Norway and white pines, white spruce, balsam fir and small-toothed aspen.

Aquatic and Bank Flora in Middle Brule

Below the junction with Nebagamon Creek the stream assumes a placid, winding character as far as the head of Little Joe Falls above the Ranger Station. Here very few aquatics were to be found. The bottom was heavily silted, but even in the sandy stretches only small colonies of aquatic plants were observed. In this section of the stream *Potamogeton tenuifolius*; sago pondweed, *P. pectinatus*; water milfoil, *Myriophyllum exalbescens*; waterweed, *Anacharis canadensis*; and water crowfoot, *Ranunculus trichophyllus* were observed. The dominant bank plant is the tag alder. Elms of large size and black ash are also very common here. A small bluejoint, *Calamagrostis canadensis,* meadow is along the stream bank. St. John's wort, *Hypericum Ascyron*; tearthumb, *Polygonum sagittatum*; horehound, *Lycopus americanus*; and mint, *Mentha arvensis* var. *lanata* were collected in this meadow but are probably of no importance to the stream life as they are insignificant in number. No aquatics were noted in the rapids past the Ranger Station.

Below the Ranger Station the Brule becomes a sluggish stream, meandering through muddy bottoms from T.47N., R.10W., Sec. 23 to just above Co-op Park, T.48N., R.10W., Sec. 26. Silting is very heavy in this section as it is in the clay belt. With this heavy silting and a fine clay-silt bottom, aquatic plants and probably also many forms of animal life find conditions very unfavorable. The principal aquatics in this section, Richardson's pondweed, *Potamogeton Richardsonii*; waterweed, *Anacharis canadensis*; and water crowfoot, *Ranunculus trichophyllus*, grow only in a narrow strip toward the edges of the stream. No aquatics were observed in the center. In shallow water on mud banks, arrowheads, *Sagittaria rigida* and *S. latifolia f. hastata* are common. One mud bank with a foot of water over it, a short distance below the weir at the Ranger Station, had a few plants of a pondweed, *Potamogeton obtusifolius* var. *rutiloides* growing on it, associated with the ribbon-leaved submerged form of *Sagittaria rigida*. Along the banks the ubiquitous alder swamp association is dominant next to the water, but the river bottoms are dominated by large American elm and black ash trees. Many of these overhang the stream and may contribute insects and other fish foods to the water below. Willows are comparatively uncommon along the Brule and are insigificant as bank plants. Slender willow, *Salix petiolaris*; shining willow, *S. lucida*; white willow, *S. alba*; sandbar willow, *S. interior*; and near cottages, golden osier; *S. viminalis* are the common willow species along the lower reaches of the Brule. The shrubby species, shining willow, *S. lucida*, has much to recommend it for bank erosion prevention in the clay soil area. It grows at the very edge of the water, leaning over the stream, and produces an abundance of water roots which help prevent stream erosion of the banks. It appeared to grow best in the heavy clay soil. None of the other species of willow observed in the lower reaches of the Brule approached as far into the stream nor showed such root development as this species. The tag alder and red-osier dogwood are the dominant bank species.

Aquatics and Bank Flora in Lower Section of the Brule

A short distance above Co-op Park, T.48N., R.10W., Sec. 26, the stream begins the series of rapids which, alternating with short, quiet pools, continues to about three-quarters of a mile from the mouth of the river. Except for a very few places between Co-op Park and Highway 13 bridge there are no higher aquatic plants in the river. One small patch of waterweed, *Ana-*

charis canadensis, and a patch each of pondweeds, *Potamogeton tenuifolius*, *P. epihydrus*, and *P. obtusifolius* were all that were observed. They were in eddies in the stream on a muck bottom, six inches to a foot under water. The filamentous algae, *Cladophora* and *Oedogonium*, clinging to the rocks in the rapids where the velocity of the stream was such as to prevent deposition of the silt burden, were the only conspicuous plants. The stream is yellow with silt and erosion of the vegetation by the silt in suspension in the water must be a considerable factor in the ecology. The banks in this section are dominated by alder but many other plants contribute to the cover for fish food in the stream.

The most abundant bank cover plants in addition to the alder are: balsam poplar, *Populus Tacamahacca*; white birch, *Betula papyrifera*; white spruce, *Picea canadensis*; white pine, *Pinus strobus*; willows, *Salix* sp.; red-osier dogwood, *Cornus stolonifera*; white cedar or arbor vitae, *Thuja occidentalis*; red maple, *Acer rubrum*; elm, *Ulmus americana*; balsam, *Abies balsamea*; and black ash, *Fraxinus nigra*. Also observed in minor amounts along the banks were: shadbush, *Amelanchier canadensis*; high-bush cranberry, *Viburnum opulus* var. *americanum*; and virginia creeper, *Parthenocissus vitacea*. Numerous small grassy patches, largely *Calamagrostis canadensis* and *Glyceria grandis*, were interspersed with the alder. These were often bordering the water and may influence the insect food supply falling into the stream.

The banks all through this clay soil country show evidences of slumping into the stream. Apparently the bank is undercut by the stream and seeping water above the bank causes a large landslide to slump down, gradually losing its base by stream erosion, the trees often remaining upright on the slumping surface. There are numerous examples of all stages of this slumping along the lower course of the Brule from Co-op Park to the mouth.

The activity of these banks seems to have been accelerated in recent years, possibly due to removal of the forest cover by pulpwood cuttings and lumbering. David Dale Owen, passing through this territory in 1848, made especial note of a landslide of twenty to twenty-five feet in depth at a distance of about fourteen miles from the mouth of the river. If his observations were accurate, it would be supposed that the slumps are much more common now. (Table 3.) If there are lenses of water-bearing gravels in the clay soil at the head of these slumps, a possibility suggested by Mr. E. F. Bean, State Geologist, it may be difficult to stop the slumping. Diversion channels or drains may be necessary to divert these waters. Piles of green white cedar driven into the slumping mass near the base may hold it. Willows, such as shining willow, *Salix lucida*, may help in slowing the undercutting of the stream edge. Some of these banks are undercutting rapidly enough to show a yellowing of the stream below the bank as it removes the clay. The banks below N. P. Johnson bridge and the Highway 13 bridge are of this rapidly slumping character. On the watershed above the stream it will be necessary to institute soil erosion control practices, particularly on the cultivated soils and along the roadsides, the chief contributors of the silt and colloidal clays which are so detrimental to the lower course of the Brule.

At the mouth of the Brule and extending a short distance upstream there is an abundance of a few species of higher aquatic plants. These mainly are located on the shallow silt and clay bottom on the stream side of the bar across the mouth and extend in distribution up along the sides of the stream much in the way in which these same species, which can apparently survive heavy silting, extend along the sides of the stream below the weir and down toward Co-op Park.

The abundant aquatics in the stream near the mouth include: pondweed, *Potamogeton obtusifolius*; Richardson's pondweed, *P. Richardsonii*; waterweed, *Anacharis canadensis*; and water milfoil, *Myriophyllum exalbescens*. One specimen of yellow water lily, *Nuphar variegatum*, was observed just above the bar at the mouth. At the entrance to an abandoned oxbow slough upstream from the mouth a large colony of sweet flag, *Acorus calamus*, is growing together with cattail, *Typha latifolia*; arrowhead, *Sagittaria latifolia*; great bulrush, *Scirpus validus*; reed meadow grass, *Glyceria grandis*; marsh cinquefoil, *Potentilla palustris*; and willow-herb, *Epilobium adenocaulon*.

The bank plants, here as along most of the river, are mainly tag alder and red-osier dogwood. Slender willow, *Salix petiolaris* and shining willow, *S. lucida* are frequent. A few trees of hawthorn, *Crataegus succulenta*; white willow, *Salix alba*; and red ash, *Fraxinus pennsylvanica* were mixed with the usual white birch, balsam fir, white spruce, American elm, black ash, and small toothed aspen. Smaller plants along the bank included meadow rue, *Thalictrum dasycarpum*; curly dock, *Rumex crispus*; swamp milkweed, *Asclepias incarnata*; Joe-Pye-weed, *Eupatorium maculatum; Aster lateriflorus*; bluejoint, *Calamagrostis canadensis*; nettle, *Urtica procera*; and blackberry, *Rubus nigrobaccus.* A large colony of sandbar willow, *Salix interior*, exists about a quarter of a mile up the river but it is on an old terrace rather than on the banks of the present course. Ostrich fern, *Pteretis nodulosa*, is common in an abandoned, filled in slough in similar situations as it is found along the stretch from Highway 2 to Co-op Park.

A stagnant slough exists in an abandoned oxbow at the mouth of the Brule River. This slough is rich in aquatics, including a number of species not observed elsewhere along the river. Wild rice, *Zizania aquatica*, and floating-leaf pondweed, *Potamogeton natans*, are abundant. Other common aquatics include: large-leaf pondweed, *Potamogeton amplifolius*; coontail, *Ceratophyllum demersum*; milfoil, *Myriophyllum exalbescens*; bur-reeds, *Sparganium eurycarpum; S. fluctuans; S. chlorocarpum*; water marigold, *Megalodonta Beckii*; yellow water lily, *Nuphar variegatum*; marsh cinquefoil, *Potentilla palustris*; cat-tail, *Typha latifolia*; and softstem bulrush, *Scirpus validus.* An abundance of purple-fringed Riccia, *Ricciocarpus natans*, floats on the water between the stems of the emergent aquatics. The common duckweeds, *Lemna minor* and *Spirodela polyrhiza*, are much less common in this slough. During periods of high water, the river may partially drain through the slough, giving a light flow through and across the bar, opening a second mouth to the west of the major mouth of the stream. This second mouth was being used in the fall of 1942 by the river, a shallow flow crossing the bar near the high western bank at the mouth.

Mud Bank Associations

No one species of plant seems to be especially characteristic of the mud banks along the river. In the upper Brule, above Stone's Bridge, there are a few species growing sparsely interspersed among the alders in the alder swamp association. These are golden saxifrage, *Chrysosplenium americanum*; water hemlock, *Cicuta bulbifera*; water starwort, *Callitriche palustris*; and

TABLE II. Mud bank association.

	Upper Brule	Stone's Bridge to Neb. Creek excl. col. 3	Big and Lucius Lakes	Neb. Creek to Co-op	Co-op to Mouth
Acorus calamus					x
Alopecurus aequalis			x		
Bidens cernua			x		
Carex Crawfordii			x		
Carex hystericina			x		
Chrysosplenium americanum	x	x			
Cicuta bulbifera	x	x			
Callitriche palustris	x			x	
Eleocharis acicularis				x	
Eleocharis palustris			x		
Epilobium adenocaulon	x	x		x	x
Eragrostis hypnoides				x	
Glyceria grandis				x	
Leersia oryzoides f. inclusa			x		
Lindernia anagallidea				x	
Mimulus glabratus v. Fremontii			x		
Mimulus ringens				x	
Penthorum sedoides				x	
Poa palustris	x		x		
Sagittaria latifolia				x	
S. latifolia f. gracilis			x		
S. latifolia f. hastata				x	
Sagittaria rigida				x	
Scirpus validus			x	x	x
Sparganium chlorocarpum v. acaule		x			
Typha latifolia		x			x
Verbena hastata				x	

willow-herb, *Epilobium adenocaulon.* Farther downstream between Stone's Bridge and the Pierce Estate bridge the same species exist; but on two different mud banks, in the channel but located to one side of the main water flow, are fair-sized colonies of cattail, *Typha latifolia,* and bur-reed, *Sparganium chlorocarpum* var. *acaule.* In Big Lake, or second Flag Lake, along the west side there are several grassy "islands" some of them being solid enough to stand on. These latter have a sandy soil mixed with a large percentage of organic muck. On these are the greater number of the species included in Table 2. Other "islands" are based on the soft organic sediments in the lake. The plants, mainly rice, cut-grass, *Leersia oryzoides*, compose an almost floating mat. Tickseed, *Bidens cernua*, is included in the same habitats. Farther down the river in the sluggish sections below the mouth of Nebagamon Creek and down almost to Co-op Park there are numerous muck and clay banks deposited along the shores of the stream and in the mouths of abandoned oxbows. The most characteristic plants of these habitats are the arrowheads, *Sagittaria* species, but others listed in Table 2 are also common. The vervain, *Verbena hastata*, and lovegrass, *Eragrostis hypnoides*, seems to prefer sandier banks and shores than the other species. Mud banks are scarce through the section of the Brule which descends the lower rapids to the mouth. Near the mouth, mud banks reoccur and a few species were observed. These were: cattail, sweet flag, softstem bulrush, and willowherb.

TABLE III.

Conspicuously eroded banks along the river

(determined by photo examination)

T.49N., R.10W., Sec. 15-SE corner of NW¼—back from river a little vegetation on top of west bank.
- -center of SW corner of NE¼—narrow slip-bank; vegetion on top near base. West bank.
- -SW corner of NW¼ of SE¼,—very large, directly on river. Along west bank.
- -South side of N½ of SE¼—long slip bank on N side of river. (This is generally east shore.)

Sec. 22-SE corner of NE¼ of NW¼—small incipient slump begun.
- -NW¼ and NE¼ of SE¼—2 small eroded faces along river.
- -SW¼ of SE¼—one long slump.

Sec. 27—NW¼ of NE¼—no slumping but bad wash near cultivation on top of both banks. There is very bad erosion observed from ground along the road cuts on both sides of the river.

Sec. 34-West side of NE¼ of NE¼—bad slump.
- -East side of NW¼ of NE¼—bad slump.
- -NE corner of SW¼ of NE¼—incipient slump.
- -East side of NE¼ of SE¼—2 bad slumps just below Hwy. 13 bridge. The south one is very severe.

T.48N., R.10W., Sec. 3-NW corner of SE¼—Large slump. West side river.
Sec. 10-NE¼ of SE¼—incipient slump. East side river.
-NW¼ of SE¼—very bad slump. West side river.
-SW¼ of SE¼—severe slump.
Sec. 15-NW¼ of NE¼—west bank—slump.
-SW¼ of NE¼—west bank small slump.
-NW¼ of SE¼—west bank—very large slump.
-SE corner of SW¼ of SE¼—very severe slump just below N.P. Johnson's Bridge. West bank.
Sec. 23-NW¼ of SW¼—incipient slump. Vegetation near river. West bank.
-SE¼ of SW¼—slump bank, vegetation line along river. East bank.
Sec. 26-NE corner of NE¼ of NW¼—Slump with line of vegetation along river. East bank.
Sec. 35-South side of NW¼ of SE½—slump bank.
T.47N., R.10W., Sec. 2-SW¼ of NE¼—2 very large slumps.
Sec. 14-SE¼of SW¼—by Yale's cottage. (Does not show from air.)
-East side of NE¼ of NW¼—large severe slump.

Recommendations

In the management of the Brule River as a trout stream it appears that the following recommendations would help in maintaining the present condition of the stream and in improving it somewhat:

1. Stop all cutting of timber in the headwaters swamp area. Allow no cutting from crest to crest of the valley and from St. Croix Lake to Winneboujou.
2. Allow alder swamp association cover to resume growth over the upper section of the stream from Stone's Bridge to the Pierce Estate bridge.
3. Do not remove fallen timber from the headwaters swamp area. It is an essential part of the forest floor, going to form the five to six feet thick layer of woody peat which overlies the outwash sands of the valley floor. In addition it becomes the habitat of many species of plants as it decays. The snags falling in the stream should not be removed more than necessary to allow a narrow passage for boats.
4. Refrain from placing "improvements" in the headwaters swamp area. These are certain to react detrimentally upon the forest by drying and deterioration of the organic soil.

5. If it is desired to narrow the expanse of Big and Lucius Lakes which is exposed to direct insolation, the planting of vegetation such as wild rice, and yellow water lily may assist in accomplishing this aim. Native species of plants should be used rather than exotics.
6. Control of pulpwood lumbering appears to be necessary on the slopes in the lower valley to reduce the heavy silting of the river and slumping of the banks. A wide belt extending back from the stream edge, somewhat further than the edge of the incised recent erosion banks, should be left entirely undisturbed by unwise roadside maintenance, cultivation, or lumbering.
7. Erosion control practices are necessary in the Lake Nebagamon-Nebagamon Creek drainage section and the lower valley from the region of the mouth of Nebagamon Creek northwards.
8. Anchorage of the slipping and badly eroding banks in the clay belt area is necessary to reduce the silting of the lower river which suffocates and erodes aquatic life. This may be done in part by living white cedar or arbor vitae stakes, willow planting (preferably using native species), and slight diversion of the stream. No major alteration of the course of the stream is recommended.
9. Control erosion from the highway ditches and banks draining into the river.

Summary

In a reconnaissance survey of the larger aquatic plants and bank flora of the Brule River it was found that there are three major ecological sections of the stream. The upper section has as its dominant bank associations the alder swamp and coniferous swamp associations. Few aquatic plants are found in the unchanged portion of the stream; many are listed for the altered portion through the coniferous swamp and for the two large spreads or "lakes." The middle section bank flora is mainly alder and a bottomland flora of elm and ash. The aspen association is characteristic of the uplands in the middle section. Few higher aquatic plants are found in the middle section of the river. The lower section, largely flowing through a clay-soil belt, has very few aquatic plants, probably because of the heavy burden of silt in the water. The bank flora of the lower section of

the river is varied and includes a mixture of conifers and deciduous trees as well as the abundant alder. The lower course of the river is in the worst condition. Recommendations for improving the stream condition to maintain a trout population are made.

Literature Cited

Bean, E. F.
1945. Topography and Geology of the Brule River Basin. Trans. Wis. Acad. Sci. 36:7-17.

Bordner, J. S.
1933. Land Economic Inventory of Douglas Co., Wis. Forest and General Cover Map.

Fassett, N. C.
1940. Manual of Aquatic Plants. McGraw Hill.

Gates, F. C.
1942. The Bogs of Northern Lower Michigan. Ecological Monographs 12: 213-254.

Owen, David Dale.
1848. Geological Reconnaissance of the Chippewa Land District. Senate Executive Doc. 57:58-61.

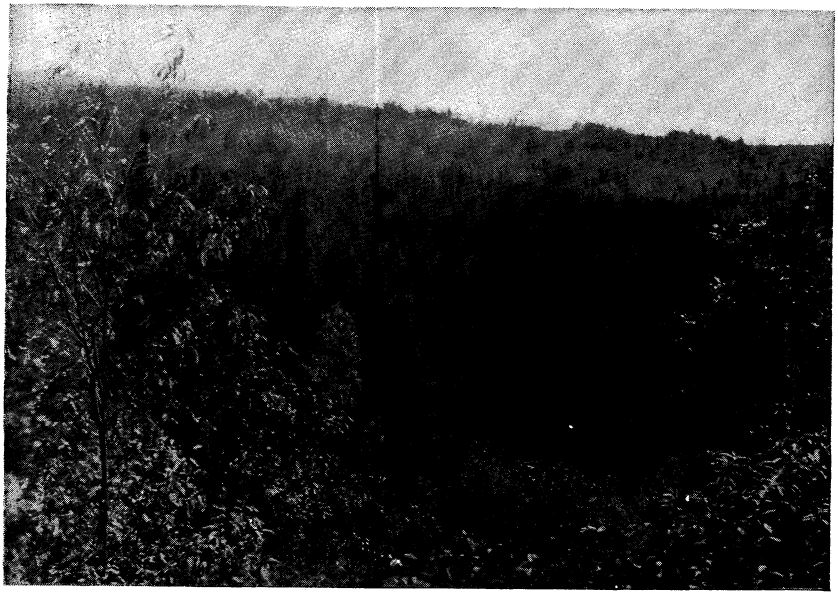


PLATE 1. Looking eastward across the upper Brule valley. Pin Cherry and Aspen association in front. White Cedar, Black Spruce and Balsam in the Thuja association in the valley. Sec. 3, T.46N., R.11W.

PLATE 2. Bluejoint, *Calamagrostis canadensis,* meadow on upper Brule. Sec. 2, T.45N., R.11W.

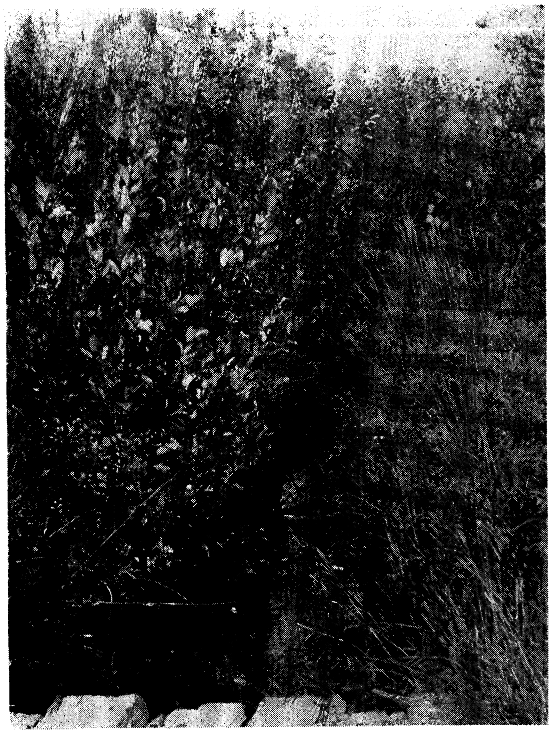


PLATE 3. Vegetation along a tributary of the upper Brule. *Salix bebbiana* on the left, *Calamagrostis canadensis* on the right, *Alnus incana* in the back. Wilson's Fork, Sec. 33, T.46N., R.11W.

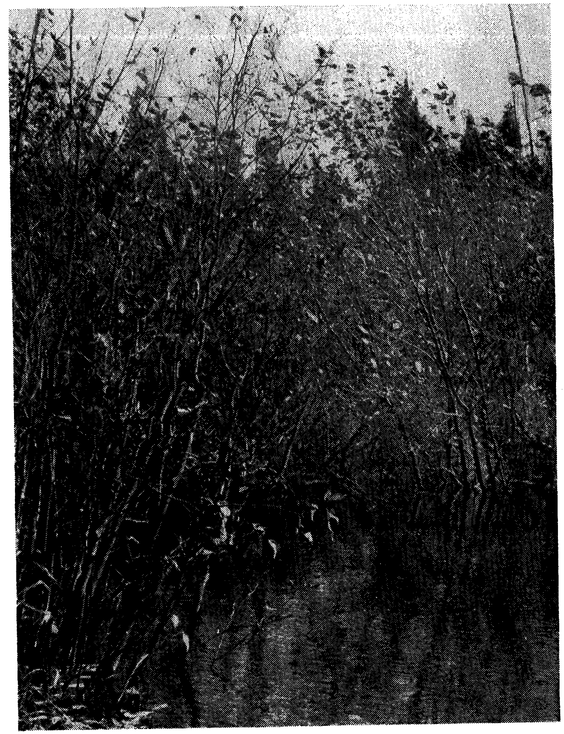


PLATE 4. Alder swamp association in the upper Brule valley. Sec. 3, T.46N., R.11W.

PLATE 5. Browse line in Thuja association at the upper end of Big Lake. Sec. 15, T.46N., R.10W.

PLATE 6. The west shore of Big Lake. Note the very narrow fringe of Thuja association with Spruce. Aspen and White Birch approach close to the lake. Sec. 10, T.46N., R.10W.

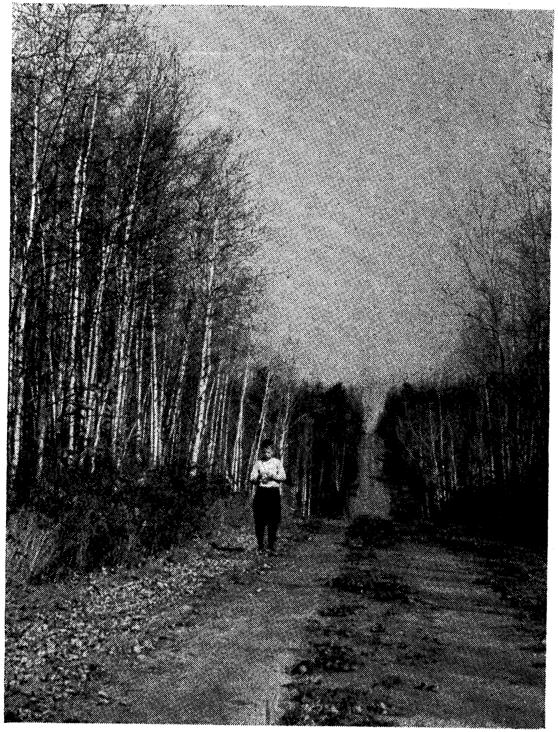


PLATE 7. In the uplands west of Winneboujou. Morainic topography. Quaking Aspen, White Birch are the dominant trees. Red and White Pines are in the background. Sec. 34, T.47N., R.10W.

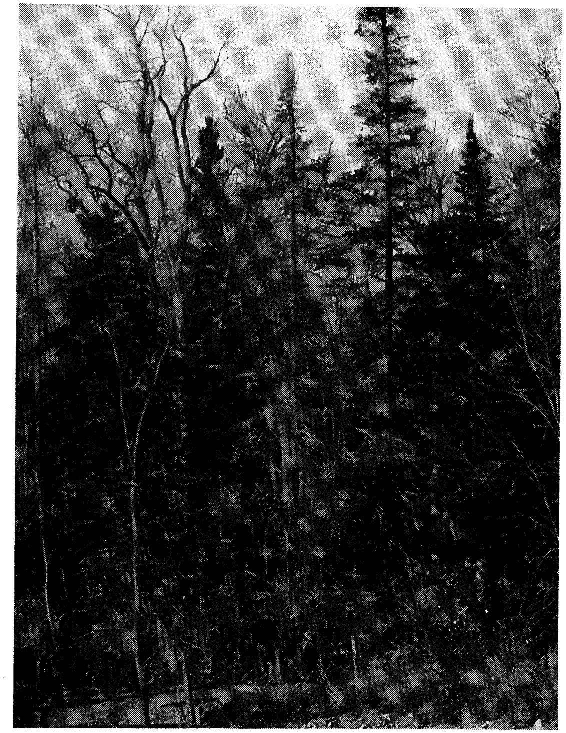


PLATE 8. Bottomlands along Nebagamon Creek. Elm, Balsam, Spruce, White Pine, Basswood, and Quaking Aspen are the major tree species. Sec. 27, T.47N., R.10W.

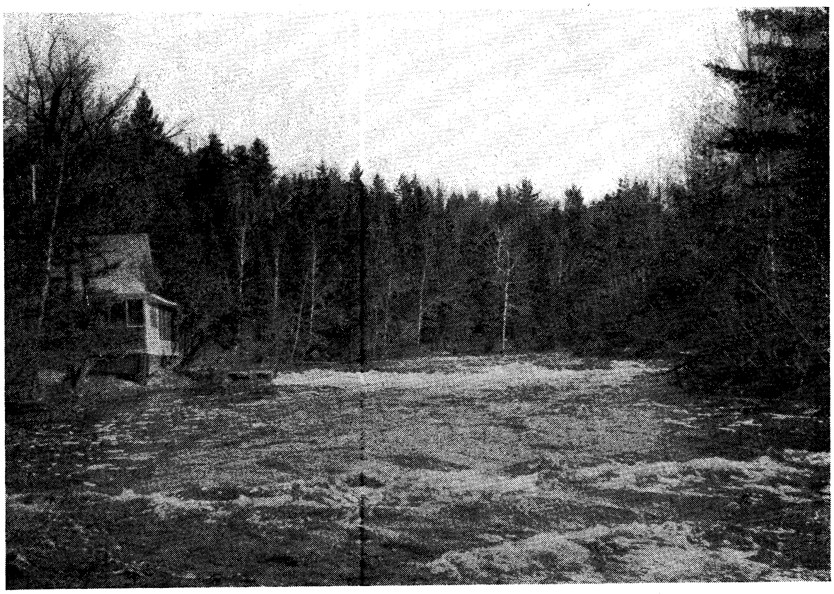


PLATE 9. Rapids west of Waino. Sec. 15, T.48N., R.10W. Forest of mixed Birch, Balsam, White Pine, Elm Poplars. Alder along stream edge. April, 1944.

PLATE 10. Eroding bank below N. P. Johnson Bridge. Sec. 15, T.48N., R.10W. Popple-Birch association on hillslope. April, 1944.

PLATE 11. Section of slumping bank below N. P. Johnsön Bridge showing large mass moving down into stream. Recent drop of more than a foot showed along the line where the man is standing.

PLATE 12. Aspen-Birch association. Brule River, looking north or downstream from Highway 13 bridge. Sec. 34, T.49N., R.10W.

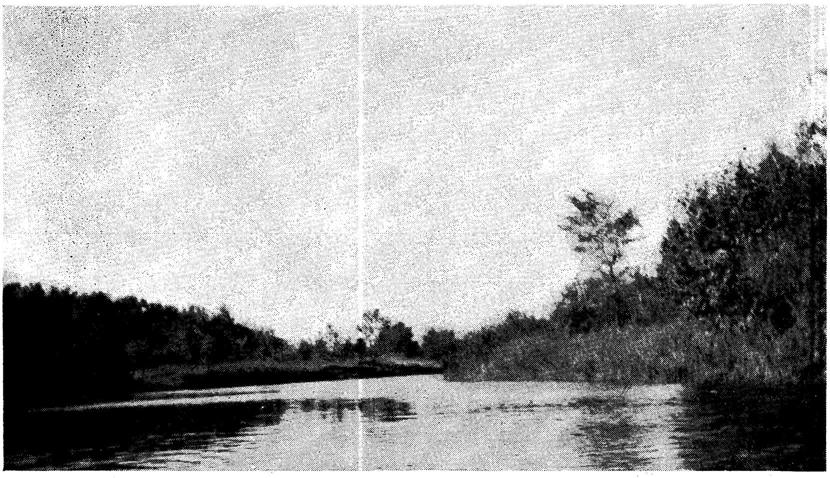


PLATE 13. The lower Brule ⅛ mile above the mouth, Alder swamp and "meadows" fringe the stream. Sec. 10, T.49N., R.10W.

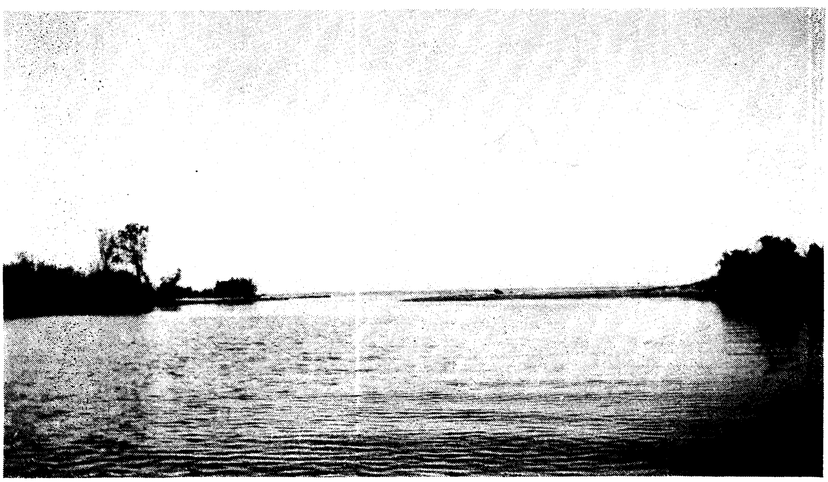


PLATE 14. The mouth of the Brule from the stream side. Note the sandbar almost closing the mouth. Alder, Dogwood and Willow border.

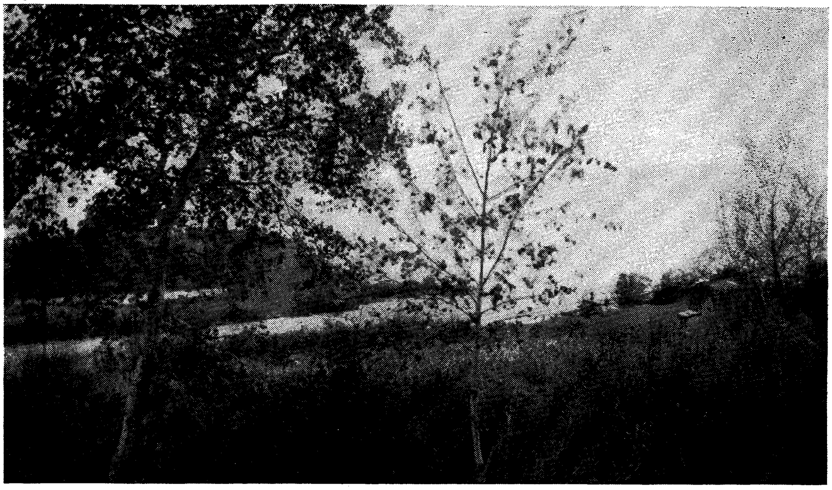


PLATE 15. The mouth of the Brule from the high east bank, Aspen in the foreground. Note the stagnant slough against the west bank in the left of the photo.

THE QUAIL IN EARLY WISCONSIN

A. W. SCHORGER

The quail (*Colinus v. virginianus*) has always been the most popular of American gamebirds. On autumn days, its rapid flight, preceded by an explosive rise, invokes the skill of the sportsman. The quail's gentle, confiding habits appeal to the layman, and the flavor of its flesh to the epicure. The name, bob-white, used by scientists has not gained headway with the masses who are the final arbiters in terminology.

The quail within a period of ten years, 1845-1854, became extraordinarily abundant in Wisconsin. It then declined in numbers so rapidly that during the past 75 years the most that can be said for the species is that it has maintained its existence. There is a fascination in the study of wildlife populations when inquiry is directed to final causes. Taking into consideration all the known influential factors, a decade of favorable winter weather seems to have been of the most importance in producing the peak in the population. Unless we assume that weather has continued to be the important factor, the question of why the quail refuses to undergo more than a sporadic increase remains unanswered. The one certainty is that the factors controlling the quail population are more subtle than was suspected formerly.

ORIGINAL RANGE

Among the bones recovered from the Indian village site at Aztalan, Jefferson County, Somers (1) reported those of the quail. The identification should be checked by a competent osteologist. Theodore Rodolf (2) and Charles Rodolf (3) came to Lafayette County in 1834, when it was in a primitive condition, and both have stated that quail were abundant at that time. Three years later Gen. Smith (4) travelled in southwestern Wisconsin and wrote: ". . . the partridge or quail is not often met with. I saw three or four near some farms and as this bird always follows and attends cultivation, the flocks will certainly increase with the opening of farms and the raising of grain."

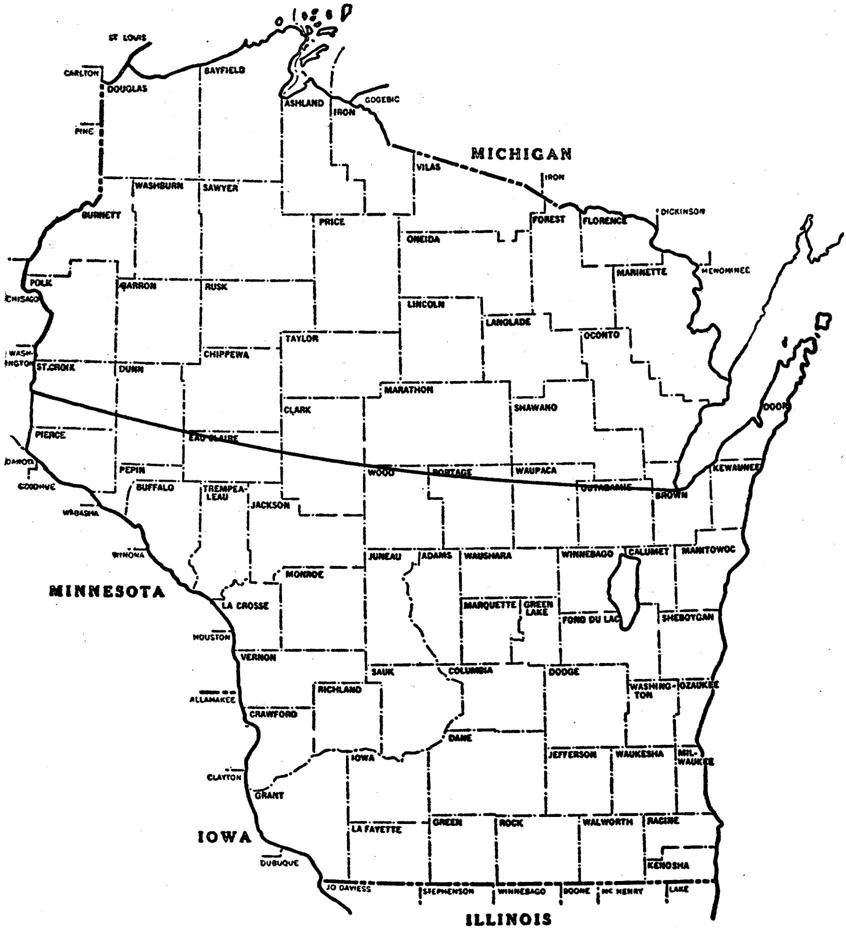


Figure 1. Probable original range of the quail in Wisconsin.

The quail at times must have been distributed widely throughout the open areas of the state. (Fig. 1.) Featherstonhaugh (5) ascended the Fox River in 1835 and found the "plaintive quail" in the southwestern corner of what is now Winnebago County. Hank Tourtolatt, an Indian trader, in the spring of 1849, made a claim at Weyauwega, the first for the Waupaca River. He spent the summer "catching fish and shooting quails." (5a) The Menominee Indians, in October, 1847, received their payment at Pauwaygan [Poygon] Lake, twenty-five miles northwest of Oshkosh and ten miles from the habitation of any white men. They furnished for the occasion large quantities of game including quail (5b). In June, 1829, Mrs. Mary Bristol (6) attended a wedding at Grand Kaukaulin (Kankauna, Outagamie County). She mentions quail as part of the wild meat served for supper. H. Pratten (6a) listed the quail for northern Wisconsin and Minnesota but this is of no assistance in determining the range since he is indefinite on localities. The last survey was made in 1849.

The quail is not a conspicuous bird and would be overlooked easily by the casual observer, particularly during the summer. It is therefore not surprising that conflicting statements are encountered. Keyes (7) came to Jefferson County in 1837 and stated that at that time there were no quail or rabbits, due presumably to the presence of wolves and foxes. Cravath, (8) writing of the winter of 1839-40 at Whitewater, states also that quail were unknown then; however, Mrs. Freeman L. Pratt, (8a) who came to Whitewater in 1837, mentions that they were then plentiful and that quail-pies were served at the raising of the frame of a flour mill in June, 1839. It is also stated that in the spring of 1840 "much sport was to be found in the pursuit of the smaller species of game, such as quails, grouse, . . ." (9) A British traveller (10) shot some quail near Aztalan in the fall of 1841.

The quail, as a Wisconsin bird, was mentioned by Lapham (11) in 1844. Major Tenney (12) came to Madison in 1845 when it was common practise to hunt quail and prairie chickens on the square of the capitol. Quail were present in the town of Taycheedah, Fond du Lac County, in 1838, when the first settlers arrived (13). Within a few years they became numerous. In the fall of 1851, Capt. Mackinnon (14) drove from Sheboygan to Fond du Lac. Quail were among the birds "constantly exposing themselves." The Titus family settled about 1853 in the wooded section east of Fond du Lac, when quail were numerous "but so easily approached by the hunter that they soon grew fewer in number (15)." Ficker (15a) came to the town of Mequon, Ozaukee County, in the fall of 1848. He wrote that the "partridges are not much bigger than the German quail. . . ."

The presence of quail was certainly not dependent on agriculture. Quarles (16), in his letters from Southport (Kenosha) in 1837-1843, does not mention the quail but only the kinds of game killed with his rifle. He wrote in 1838 that it is about three years since the first settler arrived. Mrs. L. T. Fowler (17) came to the town of Bristol, Kenosha County, in 1837, when "quail and prairie chicken were abundant." Another immigrant (18) wrote from Southport on December 19, 1842, that game, including quail, was plentiful. It was said of the town of East Troy, Kenosha County, in 1845: "Small tracts of land were under cultivation but the autumnal fires still swept through the woods. . . . Then the sweet wild plums grew in the thickets where covies of quail were hidden (19)."

Quail were found at Waukesha by Chapman (19a) when he arrived in the spring of 1841. Breck (20) flushed several covies of quail near Nashotah in November, 1846, and mentions that in 1841 there were few settlers inland from Lake Michigan.

Beginning with 1846, quail are mentioned as abundant in several localities. Near Milwaukee the species was "never so abundant," and it is added: "The increase of Quails in particular seems to keep pace with the rapid growth of our population and the spread of the settlements." In October they were shot in the center of the town (21). It was now common in Walworth County (22). Quail were abundant in August, 1847, at Madison (23) and Watertown (24), and they were hunted at Prairie du Chien (25). Their abundance in the Milwaukee (26) market "would excite an enthusiasm among eastern epicures." In a letter dated December 19, 1848, Bühler (27) mentions the rapid increase in the number of quail at Prairie du Sac, many being shot and netted in the cornfields. There were only six resident families at this place in 1840.

Extension Northward

The statement of Barry (28), made in 1854, that the quail was "distributed in immense numbers over the entire state" is much too broad. It is not certain that the original range in the Mississippi Valley extended above La Crosse. The following interesting note was printed at Hudson, St. Croix County, in July, 1855: "In riding across the prairies, a few days since, in a westward direction from this place, we frequently started up a bevy of quails from the road-side. Judging from the numbers we saw, we conclude that next fall sportsmen will find quails here in great plenty, a desirable recent addition to the game of this section of the country." In August, they were listed among the birds obtainable in "unlimited numbers" (29). If quail were so plentiful there in the summer of 1855, it is beyond belief that they did not occur some years earlier.

Quail were mentioned as quite plentiful at Wausau (30) in 1868. They arrived at Ashland (31) in 1874, and at Superior (32) in 1882. An Ohio hunter, familiar with the species, reported seeing a flock of thirteen on November 14, 1891, near Florence, Florence County (33).

Period of Abundance

Quail became plentiful by 1846. In 1852 they were brought into Madison (34) "by the bushel"; and at Prairie du Chien (35) they were never so plentiful. Emery (35a), who came to the town of Rutland, Dane County, in 1852, said: "I have seen thousands of quails (Bobwhite) come into my father's yard to get the seeds from his millet hay." During this year Hoy (36) wrote that the quail, within a few years, had become remarkably numerous. They were so abundant by 1853 as to invade Madison (37) in force, flying against buildings and breaking windows. All the old muskets were brought into action. Some of the citizens were so intolerant as to object to being shot in the back. Quail were so plentiful in central Wisconsin that it had "ceased to be sport to shoot them" (38). In Milwaukee they usurped the place of wild pigeons, and were used for trap shootting (39). Waukesha (40) had "huge quantities" of quail and prairie chickens.

The peak in population was reached in 1854. Quail were as abundant as ever at Janesville (41) in spite of the number trapped the year previous; and more numerous than usual at Watertown (42) and Jefferson (43). At Madison (44), "quail are now found in every grove, and a good shot can readily bag 50 to 75 in a day." They were plentiful even as far north as Green Bay (45).

Despite the shipment of enormous numbers of quail during the fall and winter of 1854-55, they were still abundant in 1855. In January it was said: "Quails have never been in greater abundance in Wisconsin. . . ." (46) They were plentiful in the fall at Milwaukee (47), and were shot in the heart of the city. They were plentiful also at Elkhorn (48), Waukesha (49), Watertown (50), and Hudson (29). Quail could be shot "almost anywhere" at Madison (51), while the following forceful statement appeared at Jefferson: "We saw about a million—say nine hundred thousand—in a short trip the other day. We found one quail-trap full, and let the poor things out." At Portage there were brought in "rabbits, quails, etc. beyond enumeration" (53).

It is difficult to conceive of the former abundance of quail. They were so numerous at times at Milwaukee that there were "on an average, three bevies to every ten acre lot" (54). It was said that at Madison "a ten-minutes walk enables you to put up your first bevy of quails while every succeeding five minutes furnishes a fresh covey" (55). The narrow strip of land between the lakes at Madison was a funnel through which passed great numbers of birds during the irruptions. The following facetious account is not as exaggerated as it seems: "Yes, in early days, if you wanted a meal of quails—all you had to do was to take a club and let fly once or twice among the tall grass in the park, then go about with a wheelbarrow and gather up the slaughtered ones. . . . At the time Col. A. A. Bird kept the United States hotel . . . quails were known to enter the kitchen through open windows, in their flight. One afternoon it is said the cook captured nearly a thousand. . . ." (56).

COMMERCE

Quail were caught at Janesville during the winter of 1842-43, showing that trapping began very early in the agricultural history of the State (57). Roberts (58) came to Lafayette County in 1846. He has described the use of the tunnel trap, a favorite means of taking quail in the Mississippi Valley. This trap, popular in Europe during mediaeval times, was doubtlessly introduced by the French colonists. When snow covered the ground, baited traps of various types were very effective. Poor transportation facilities for a time limited the sale of quail in large numbers for export without the commonwealth, except from the lake ports. The accompanying map (Fig. 2) shows that railroads tapped but a small portion of the state prior to 1855. The arrival of a railroad was followed immediately by a great increase in the traffic in quail and other game.

The first mention of a large shipment of quail is by Hoy (59). In the fall and winter of 1849-50, C. A. Orvis of Racine shipped two tons of quail to the city of New York. One morning in

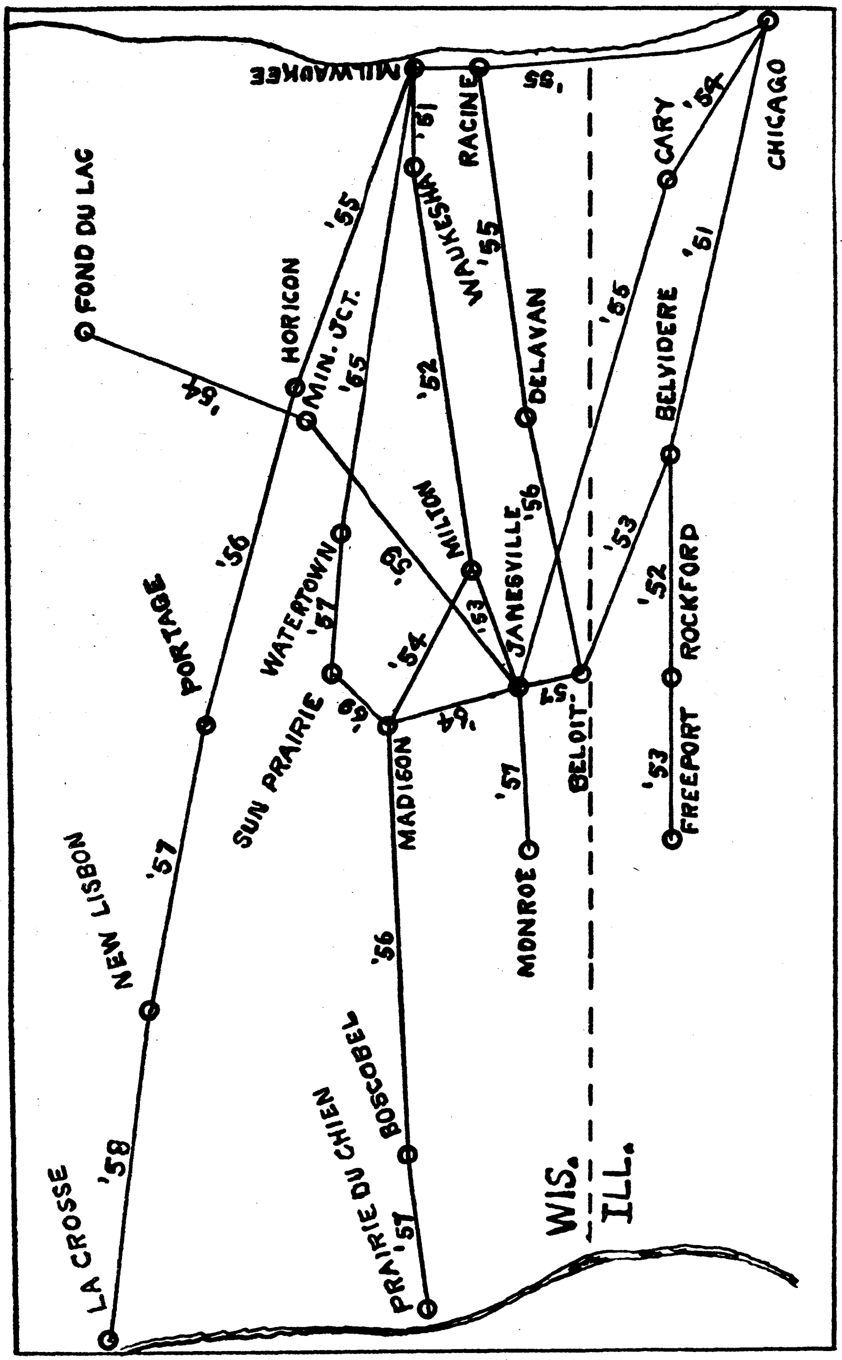


FIGURE 2. Dates of railroad construction in Wisconsin and northern Illinois.

November, 1852, 1,500 quail, some of them alive, were brought to Milwaukee where they were sold at 25 cents a dozen (60). In January of this year, 39 cents a dozen was offered at Janesville (61). Joseph Clason, of Beaver Dam, in February, 1853, hauled to Milwaukee a load of game in which were 100 dozen quail that had been trapped by his son (62). The traffic had become sufficiently large that in 1852 a state law was passed prohibiting the capture and sale of quail except from the first Tuesday in October to February first.

The railroad from Milwaukee to Janesville was completed in 1853. The number of quail trapped and sent east from Janesville, the winter of 1853-54, was "fearful" (63). It was anticipated that fewer would be trapped during the fall and winter of 1854 as the transactions had become unprofitable. Most of the birds were taken illegally. The sellers were at the mercy of the large buyers in the cities and were forced to take the prices offered. Nevertheless large numbers were shipped from Janesville and Beloit. The prices, 87.5 cents to one dollar a dozen, offered the trappers during the legal season, show a great increase. One dealer shipped 500 dozen from Beloit (64).

A Mr. Lee of Milwaukee started for New York on January 20, 1854, with 500 dozen quail. The total number shipped from this port during the season was over 2,860 dozen (65). There was a strong protest against trapping that was said to be done by the "idle and vagrant." This is not a fair statement as the prices paid during the legal season were highly attractive to farmers and professional trappers alike.

The exportation reached a peak in the season 1854-55. Quail continued to arrive in Milwaukee by rail in January, and even long after the legal season had passed. The number shipped east was "enormous" and fears were expressed that this gamebird would become extinct (66). In fact, it was deplored that the traffic persisted the year round. The shipments from Beloit amounted to 12 tons. This is equivalent to 55,000 birds as the average weight was stated to be 7 ounces (68). A shipment of 20,000 quail from Janesville was received in Philadelphia in January, 1856 (68a).

The Decline

The reduction in the number of quail was due to a combination of trapping and adverse weather. The winter of 1854-55 was severe and this was followed by the exceptionally hard winter of 1855-56. The decline was not sudden. During the winter of 1855-56, tons of quail and other game were hanging in the yard of the Capital House at Madison (69). However, while quail sold for 40 cents a dozen at Lancaster, they were neither plentiful nor cheap in Milwaukee (70). In January, 1857, there was a protest against the tons of quail that reached Milwaukee. The market was glutted (71). A Chicago dealer, in December, 1856, received a consignment of 214 dozen from Fond du Lac, Wisconsin. The high price of $2.25 a dozen, wholesale, prevailed (72).

In the fall of 1857, compared with former years, quail were reduced greatly in number at Janesville. (73) The sight of a flock in the Capital Park at Madison elicited the comment that the species was becoming quite rare in the vicinity of large towns (74). They were unusually scarce this season in the Milwaukee markets (75).

The winter of 1857-58 was mild. In the fall of 1858, quail were very numerous at Prairie du Chien (76). In December, the Milwaukee market was again glutted with them. The weather at the end of this month was so unfavorable for keeping game that quail could be purchased as low as 50 cents a dozen (77).

There were few quail at Madison (78) in the fall of 1860 in spite of the mildness of the preceding winter. They were, however, reported abundant at Horicon, (79) Oxford, (80) and Burlington (81). Quail increased gradually, and were numerous locally, until the winter of 1865-66; but their numbers did not begin to compare with those for the years 1845-54. In 1861, they were not nearly as numerous as formerly at Shullsburg. (82) Ruffed grouse were stated to be more plentiful than quail in 1866 in Wisconsin, though "ten years ago the quail whistled from every fence-corner" (83).

Madison is chosen to show the rapidity of the decline. Quail had recovered sufficiently by the fall of 1863 as to be seen almost daily in the Capital Park (84). In 1870 it was said: "These delicious birds, once so plentiful here, are very rarely found in this vicinity now. We have seen none in the market this fall until today, when Oppell had a lot of them brought from abroad. . . ." (85). A year later the presence of a covey was an item of note (86). For 1879, we read: "A Sun Prairie farmer tells us, a few days ago, he stirred up a flock of quails, thirteen in number, and shot eight. We had thought that there was not one quail in Dane County" (87).

During this time the quail disappeared almost completely from the border of Lake Michigan. In the fall of 1879, a hunter shot a quail near Milwaukee. It was the only one seen during the season (88). They were very scarce this year also at Waukesha (89). The quail was considered a bird of the past at Milwaukee in 1882, though a few years previously they could be found quite plentifully two to four miles south or west of the city (90). Willard (91), writing in 1883, had never found a quail in Brown County; also, it was not found at this time at Shiocton by Grundtvig (92) though he was assured by others of its presence. Hoy (59) mentioned in 1885 that it had been two years since he had seen a quail at Racine.

A few quail were reported present in Manitowoc County, and also in Sheboygan County, in the fall of 1898, for the first time in many years (93). Prior to 1868, there were hundreds of quail in the town of Scott, Sheboygan County. None were seen during the following 30 years. They were thought to have disappeared because a "wild bean"* upon which they fed became scarce with settlement of the country.

The close of the century found a temporary increase in the population, particularly in the Mississippi Valley. In 1895 there were more quail at Eau Claire than for many years (94). They were "abundant" in 1896 at Prairie du Chien (95), and more numerous than usual at Trempealeau (96), Black River Falls (97), and Stevens Point (98). Though quail had been scarce at the latter place for years, several flocks invaded the town October 9 to 12. The increase continued through 1900. They were to be found everywhere in the country districts at Prairie du Chien for the first time in many years (99). This year Hough (100) found only a few quail at Waupaca but remarked that for several years they had been moving steadily northward from that place. In 1902, Schoenebeck (101) stated that the species had become common in Oconto County within the past ten years.

The general statement may be made that from one decade to another, since 1870, the quail population has remained relatively stationary.

---

* Prof. N. C. Fassett suggested *Lathyrus palustris*.

EMIGRATION

The former periodic irruption or emigration of quail on an extensive scale was a very interesting phenomenon. During the movement, that took place usually in September and October, quail entered towns, flew against houses, and crossed wide rivers. The habit was developed to the highest degree in the North Central states. Van Dyke (102), as late as 1891, wrote of the quail in Minnesota: "In the early part of the fall, . . . the quail generally have a crazy spell, during which they gather into large flocks, travel quite a distance and even go into town and butt their brains out against houses."

It is not known if quail irruptions occurred under primitive conditions. They may have taken place and yet not have been recognized. Audubon, as is well known, observed quail cross the Ohio River periodically during his residence in Kentucky. One writer (103) mentions a congestion of quail, in the autumn of 1840, on the bank of the Mississippi at Quincy, Illinois. Here the river was approximately a mile wide. He states that the autumnal migration, or change of quarters, was well known. Another observer (104) mentions that at Louisville, Kentucky, "quails migrate here from Indiana and elsewhere every three or four years, and wherever you can find an elbow of the river, they are very plenty, as they go to these projections to cross the river, and many a one meets a watery grave in the attempt." In the fall of 1839, "some 500 or 1,000" were encountered at the junction of the Ohio and Mississippi (105).

There is little definite information on the extensiveness of the emigrations or the distances travelled. In the fall of 1846, quail emigrated in "myriads" from Iowa to Illinois, while four years previously the movement was in the opposite direction. Large numbers were encountered the entire distance of 30 miles between Bloomington, Iowa, and Davenport. The observer wrote: "We saw every hundred yards, flocks numbering from twenty to two hundred. They seemed half deranged; they run into town, fill the streets, and even the barns, for they break numberless windows in their flight." In attempting to cross the Mississippi, a weary flock dropped upon a steamboat but "countless numbers must perish" (106).

A movement of quail in 1866 across the Ohio from Indiana to the vicinity of Louisville, Kentucky, began September 15 and was still in progress on October 26. It extended as far down the river as Owensboro, so that the front of the advance was approximately 80 miles (107). A mile seems to be about the limit of a sustained flight. Yorke (108), on three occasions, observed quail in flight across the Mississippi where it was at least a mile wide. In one instance only five or six of a flock of fifteen reached the bank.

The behaviour of quail during the fall movement has been graphically described by a Milwaukee sportsman:

> "Another western peculiarity of this bird is its annual visit to large cities and villages in the fall. During the fine weather of Autumn while food is in the greatest abundance on stubble, in stack and in the high road, the quail seeks our closely inhabited places, and may be heard and seen all day. In the morning, he is not so often seen, but just after noon he begins to show himself and make himself heard. He gets on top of houses and stores, and pipes most lustily. He drops into the smallest back yards and gardens, piping, and rambling about as if he wished to call your attention to him. He even parades the crowded streets in large bevies, and actually spends the whole afternoon loafing about the principal streets and all the yards and gardens. . . .
>
> "Towards sunset he becomes excited, crazy as a speculator . . . he often makes pounce at a house, hits it and knocks himself down. . . . Even after dark he continues this game, and you may sometimes hear him *take* a house late in the evening, and you can pick him up at its base in the morning, as dead as a herring.
>
> "Why he does all this, we cannot say, but every boy knows he does it, and nine-tenths of the juveniles in the eager chase after him in the Autumn, run over your grounds and often demolish half your garden and shrubbery. Nor is this chase so unsuccessful as you might suppose. When pursued by the boys he often runs under boards, bushes, woodpiles or rubbish, and is taken by the hand, and often when driven by them from this covert rushes madly against house or fence, and is taken up dead. These vagaries are of annual occurrence, some years the fit of insanity only lasts a few days, and sometimes it lasts for weeks.
>
> "Yet, while he thus visits our villages, he seems to remain as abundant in the country. We have left a village filled with piping quails, and yet found one or more covies in every stubble field, and have seen them in the road picking up the wheat dropped by the wagons.

> "These habits he may have elsewhere, but we have never noticed them except at the West, and know he is not so inveterately addicted to them in the Atlantic States, if he is at all." (109)

About 1840, quail abounded in fall in the streets and gardens of Chicago. Owing to their small size, they were "not much molested by gunners" (110). In 1854 and 1855 large numbers of quail were killed in the streets of Watertown and Madison by boys using only sticks and stones (111). There were protests at this time at Madison, Kenosha, and Racine against the common practise of shooting quail in the streets (112). Sportsmen were shooting quail on West Water Street, Milwaukee, on November 4, 1854, "something novel for a city with a population between 30 and 35,000." (113) Nevertheless, they subsequently invaded this city each fall from 1859 to 1862 (114). In the fall of 1863, hundreds of quail and prairie chickens flew over or entered the city of La Crosse (115). Quail came into the Capital Park in the center of Madison as late as 1865 (116).

There is little doubt that the habit of quail to emigrate or irrupt, when a certain density of population was attained, was a powerful factor in producing the huge numbers that existed in Wisconsin in the decade prior to 1854. A sportsman wrote from Racine, July 18, 1849: "The winter—a real polar one—thinned out the Quails a good deal, but still there will be abundance according to your ideas, and if, as I expect will be the case, they should come in the fall from the South, abundance even according to ours" (117). The fall movement was clearly defined. It is surprising to find that a spring movement took place also, supposedly: "The quail is a permanent resident of this state, though after the stock has been thinned off by a very severe winter, we have known vacancies filled by emigration from the South, both in the succeeding spring and the fall after it." The spring influx generally occurred, the fall always, so that it was unnecessary to import birds after a severe winter (118).

There is little information on how far north the large irruptions of quail extended. In the fall of 1850, hundreds of quail arrived at Sheboygan Falls during a sleet storm, to the mystification of the inhabitants. They remained about the town for months (119). The most puzzling of quail records is given by Kneeland (120). His observations were made from August, 1856, to June, 1857, at Portage Lake, Upper Peninsula of Michigan. A few years previously quail were unknown there but at this time they were not uncommon on Keweenaw Point. The quail travels largely on the ground during irruptions and it is wholely improbable that birds from Wisconsin would cross the wooded wilderness of the Upper Peninsula. Any quail on Keweenaw Point must have been imported. Due to the heavy snowfall characteristic of the region, the chance of their survival for a single winter is remote.

The mass movement of quail has never had a satisfactory explanation. The theory that the species was once migratory, and that a vestige of the old instinct remains (121), is inadequate. Wild turkeys and other animals performed similarly without being in the strict sense migratory. It is unknown whether a flock of quail travelled ten, a hundred, or more miles. Recent banding studies made in Oklahoma have shown that it is not uncommon for quail to wander in fall and winter distances of three to 26 miles from the summer range (121a). Without doubt the distances covered during irruptions were considerably greater. It seems that a certain density of population stimulates an innate solicitude for adequate winter quarters and sets the birds in motion.

Due to the invasion of towns and frequent self-destruction against buildings, it was popularly believed that in autumn quail became crazy and partially blind (122). Quail assemble usually by running, less often by flying. When they were dispersed over the streets, gardens, and buildings of a town, the structures kept them in bewilderment. On the morning of September 7, 1855, six members of a flock of quail flying through the village of Whitewater failed to avoid a store and were killed (123). Muir (124) saw quail killed by flying against his home near Kingston, Green Lake County, when suddenly startled. Several additional examples could be cited. Quail flush with explosive violence and with little regard for direction. Once launched, their short wings render them incapable of turning with sufficient rapidity to avoid an object of unnatural dimensions.

Effect of Agriculture

There was a deep-seated tradition in the middle west that quail were unknown to the Indians and that they were added to the fauna by immigration or introduction. Imlay (125), for example, wrote that quail were unknown in Kentucky when the first settlers arrived. He makes the fantastic statement that the birds came over the Appalachian mountains "by following the trail of grain which is necessarily scattered through the wilderness."

Regarding the quail in Illinois in 1854, Kennicott (126) makes this puzzling comment: "Very abundant throughout the state. Introduced within twenty years." It is difficult to believe that he meant that the quail was not native to the state. Hubbard (127) spent the winter of 1818-19 at an Indian trading-post near modern Hennepin, Putnam County, Illinois. Quail and prairie chickens were abundant but were not considered respectable food. By 1837, quail were being trapped by the "hundreds in a day" and sold in the city markets (128). This year they were plentiful at Bloomington, and in 1841 sold at 25 cents a dozen (129).

The quail was indigenous to Cook County. The following note appeared in the Chicago *Journal*, September 11, 1848: "But speaking of quails—a number of years ago, and before half the present population of Chicago ever dreamed there was such a place there were none of them in this region, a severe previous winter having completely exterminated them. In view of this . . . Gordon S. Hubbard, who was then wintering at the South, brought up with him in the Spring a cage or box full of these birds for breeding, and hence springs the present profusion . . ." Capt. Levinge (130) shot quail near Chicago in 1838. A severe winter like that of 1842-43 could have reduced the population to a point where the quail would appear to be extinct. It is hardly possible that a few imported birds could have produced the number present by 1848.

There were no quail at Rockford, Illinois, according to Thurston (131), when he arrived in 1837. They appeared shortly after the first settlers. On the other hand, in 1833, when the adjoining county of Stephenson was first settled, game, including quail, was in abundance (132).

There is ample evidence that quail increased greatly simultaneously with a certain stage in the development of agriculture. Cabot (133) was told that they had increased eight-fold within the recollection of the informer. He states: "I myself saw numbers of quails in the main street [Chicago] and on the houses, and was assured that they sometimes entered the shops. The cause is simply the increase of food." The following quotation is in a similar vein: "For twenty years after the settlement of Northern Illinois, the deer, the grouse, and the quails increased in numbers every year. . . . The quails were constantly on the increase from 1840 to 1850" (134). Thurston (131) has written that at Rockford quail were present in "countless numbers from 1844 to 1854." Boys traded dressed quail for ammunition at a maximum value of 18 cents a dozen. During the winter of 1852-53, the time when the railroad reached Rockford, barrels of quail were brought from Stephenson County for shipment east. As will be shown later, the peak in the quail population was reached during a series of favorable winters and it is probable that this factor was far more important that the food supply.

When quail began to decline, the cause was attributed to over-shooting or trapping, the state of agriculture being left out of consideration, usually. Baldwin (135) stated that quail have "largely decreased" since the settlement of La Salle County, Illinois. Quail were past their peak near Fond du Lac prior to the Civil War; yet, according to Titus (15), it was not until this war opened that the settlers had sufficient land under cultivation to make a "frugal but fairly comfortable living."

Southwestern Wisconsin developed slowly in spite of early occupation. Evans (135a) wrote: "My first impression of Platteville (1846) was that of a village located in a dense forest. . . . At this early date most of the land was uncultivated; both prairie and timber were in primitive condition. . . . There were few farms then; just a vast prairie between here and Shullsburg." In 1854 it was said of Dane County: ". . . perhaps one-eighth is under cultivation embracing about 1,600 farms. . . ." (135b) The three southwestern counties, Grant, Lafayette, and Iowa, had improved only 20 per cent of their areas by 1860. (136) It is difficult to believe that so slight an extent of agricultural development could have affected greatly either an increase or decline of the quail. The ratio of wild to cultivated land would appear ideal. All stages of land improvement could be found at this time in the southern portion of the state, yet the quail never recovered.

It should be mentioned that the most pronounced increase in quail took place in the *prairie* regions of the Upper Mississippi Valley. Many thousands of these birds were sent to eastern markets from Wisconsin, Illinois, and Iowa (137). Under primitive conditions quail had great difficulty surviving a winter on the open prairie unless the weather was exceptionally mild. It was not, however, absent from the prairie in summer. Levinge (130), in September, 1838, found quail in the tall grass a few miles west of Chicago. In Wisconsin, Goss (138) found quail nesting on the prairie miles from a tree or bush.

The quail is essentially a border bird, and as King (139) has said occupied the "borders of groves, hazel patches and open fields." Even in the absence of snow the customary autumnal burning of the prairies by the Indians deprived the birds of food and cover over large areas. Marsh (140) mentions that in De Kalb County, Illinois, in 1849, the quail wintered in the hazel thickets at the edge of the woods as there was no cover beyond.

Prior to agriculture, the quail was restricted mainly to the borders of streams and woods. A strip of hazel separated the prairie from the timber, and whenever the latter encroached upon the prairie, the hazel led the advance. It is evident therefore that both habitat and quail population were strictly limited. The advent of agriculture was soon followed by an apparently optimum ratio of wild to cultivated land. Reduction of burning permitted a rapid advance of hazel and other types of brush, while the building of fences and the planting of hedges increased greatly the protective cover. Cultivation produced grain and weed seeds, which in combination with cover, permitted the quail to take over lands that were formerly uninhabitable the year round.

Introductions

It was thought unnecessary, in 1856, to introduce quail since winter losses were repaired by immigration from the south. (109) It is said that quail were introduced into Minnesota in 1845 (141), but no early plantings seem to have been made in Wisconsin. There were occasional attempts to care for the birds during the winter (142).

Some Tennessee quail released at Ripon froze to death during the winter of 1884-85 (143). In 1886, birds imported from Texas were liberated at Oskosh (144). Their subsequent history is unknown. About 20 pairs were freed at Whitewater in the spring of 1890 (145).

The almost complete disappearance of the species along Lake Michigan led to numerous attempts at reëstablishment. Some quail imported from New Orleans were released at Racine in the spring of 1887 (146). A few birds were introduced at Plymouth about 1892 (147). Seven dozen Kansas quail were liberated at Sheboygan in 1892, but the expected increase did not take place (148). Two Rivers was quite persistent in its efforts. A private attempt was made in 1894 to raise birds from Texas stock. The local gun club liberated 120 birds from Kansas in the spring of 1895, and several hundred were released in 1897. (149)

Sportsmen at Sturgeon Bay, in 1899, set free 140 quail received from Kansas. Since further stocking was discussed the following year, there is doubt that the birds survived (150); however, in 1903, the quail were said to have multiplied rapidly. (151) Great optimism was shown by the release of quail at Washington Island in the spring of 1902. Their existence was in doubt by the spring of 1904 (152).

Quail were introduced at Palmyra, Jefferson County, in 1897 (153), while hundreds were liberated at Prairie du Chien by Col. J. T. Barnum in the years prior to 1898 (154). It is stated that at this time Gustav Pabst released large numbers of quail in various parts of the state (155). Southern quail, liberated near Lake Koshkonong, survived the winter contrary to expectations (156). It is very doubtful if any of the importations have had a perceptible influence, racially or numerically, on the native stock.

Weather

It has been recognized for a long time that the most lethal enemy of the quail is severe weather. Crèvcoeur (157), in 1782, mentioned a severe winter in the east that reduced the species to near extinction. Hoy (59) wrote of a winter at Racine during which hundreds of quail froze to death in groups of ten to fifteen while roosting. The mortality caused by cold and deep snow is stressed by Muir (124a). One of his neighbors was watching some quail when "they actually fell down and died." Mrs. S. Littlefield (157a) mentions a severe winter that killed quail in Sheboygan County and that she actually saw them drop dead.

The first Wisconsin winter mentioned in connection with quail mortality is that of 1842-43. It was long known for its low temperatures and deep snows. There was sleighing from the 10th of November to about the same date in April. A thaw in January followed by rain produced a crust on the snow, making the worst possible conditions for game birds. Quail were nearly exterminated. A gentleman at Janesville purchased from trappers 100 quail that were liberated the following spring (57). There followed a succession of mild winters until that of 1848-49, giving the quail a chance to become plentiful. During the latter winter, snow and sleet killed "thousands" in Iowa (158) and reduced considerably the number in Wisconsin (117).

Quail had increased so rapidly in Wisconsin along the Mississippi River by the spring of 1854 that they were expected to "swarm" should the following winter be mild (159). This hope was not realized as the winter was severe. A storm in December drove large numbers into the settlements around Jefferson (160) where they were trapped easily.

The winter of 1855-56 was very severe throughout the northern and eastern states. The deep snow by December had driven the quail into the farmyards. They were numerous at Kilbourn (Wisconsin Dells) until the cold weather of January, 1856, when they disappeared (161). A letter from Belvidere, Boone County, Illinois, states that few quail lived through the winter. There was a better survival, supposedly, in Wisconsin "on account of having woods for shelter" but that even there quail were few in comparison with other years (162). They were said to have been nearly exterminated in Grant County and that it was many years before they were numerous again (163).

The belief persisted that a warm winter would restore the population. One writer states that though the winters of 1854-55 and 1855-56 "have thinned his numbers deplorably, but a single warm winter will bring him to us in abundance, and a couple of them in extra abundance. . . ." (109). Unfortunately the winter of 1856-57 was also severe on quail (164), so that there were three successive killing winters. The winter of 1857-58 was mild and to it was attributed the presence of numerous quail at Prairie du Chien in the fall of 1858 (165). It was not considered good sportsmanship to shoot quail until the autumn of 1859 since until that time they had not become sufficiently plentiful. (166)

The nature of the southern Wisconsin winters from 1840 to

1900 is described in general terms in Table I. A detailed analysis of each winter would extend this paper to unjustifiable length. The statement, "quail killed," has been used only when it is supported by literature references for the particular winter. The factors governing winter survival are varied and complex. Quail that are well fed have an excellent chance of living through the winter (167), but during rigorous weather birds in seemingly good condition may perish (168). When the body weight drops below 70 per cent of normal, through cold or lack of food, quail are particularly vulnerable to subzero temperatures. February and March are usually the critical months. A covey that survives in weakened condition until March may be exterminated by a single snowstorm, while a drifting snow that becomes crusted may be fatal at any time.

It is easy to understand why some of the earliest settlers reported quail absent or scarce when it is realized that potentially 1833-34, 1834-35, and 1837-38 were killing winters. Each of these winters had one month during which the mean temperature was 9 or 10 degrees. There was an insufficiently long run of favorable weather to permit a large increase in the population. Beginning with the winter of 1843-44 and extending through that of 1853-54, a period of 11 years, there was a remarkable succession of mild winters, the only interruption being that of 1848-49. This series of mild winters has never been duplicated. It is evident why the peak in population was possible in 1854.

TABLE I. Character of Southern Wisconsin Winters, 1840-1900

1840-41	Mild
1841-42	Very mild.
1842-43	Very severe. Deep snow with crust. Quail killed.
1843-44	Mild.
1844-45	Very mild.
1845-46	Mild.
1846-47	Comparatively mild. Deep snow.
1847-48	Exceptionally mild. Little snow.
1848-49	Severe. Deep snow and ice. Quail killed.
1849-50	Mild. Little snow.
1850-51	Mild. "Moderate open winter."
1851-52	Comparatively mild. Heavy snow in March melted rapidly.
1852-53	Mild. Little snow. "An open winter."
1853-54	Comparatively severe. Cold with deep snow the end of January. February mild.
1854-55	Severe. Quail killed.
1855-56	Very severe. Quail killed.
1856-57	Severe. Quail killed.
1857-58	Mild.

1858-59 Mild.
1859-60 Mild. "Open."
1860-61 Comparatively severe. Deep, drifted snows in January.
1861-62 Severe. Exceptionally heavy snow fall.
1862-63 Very mild.
1863-64 Severe. Heavy snow.
1864-65 Severe.
1865-66 Severe. Rain, cold, drifted snow.
1866-67 Mild.
1867-68 Severe, "Steady cold."
1868-69 Comparatively severe. Deep snow.
1869-70 Exceptionally mild.
1870-71 Mild.
1871-72 Comparatively severe. Numerous snowstorms.
1872-73 Very severe. "Hardest on record." Quail killed.
1873-74 Comparatively severe. Deep snows.
1874-75 Very severe. Quail killed.
1875-76 Very mild.
1876-77 Comparatively severe. Cold with deep, drifted snow in January.
1877-78 Very mild. "Open winter."
1878-79 Comparatively mild. Low temperatures in January.
1879-80 Very mild. "Exceptionally fine."
1880-81 Severe. Exceptionally heavy snowfall. Blizzards. Quail killed.
1881-82 Very mild.
1882-83 Severe. Extreme cold and deep, crusted snow. Quail killed.
1883-84 Severe. Quail killed.
1884-85 Very severe. Very cold in January and February. Quail killed.
1885-86 Severe.
1886-87 Very severe. Blizzards.
1887-88 Severe. Drifted and crusted snow.
1888-89 Mild. "One of the mildest on record."
1889-90 Very mild.
1890-91 Mild.
1891-92 Comparatively mild.
1892-93 Very severe.
1893-94 Mild.
1894-95 Severe.
1895-96 Mild.
1896-97 Mild.
1897-98 Mild.
1898-99 Comparatively severe. Quail killed.
1899-00 Mild.

The question may be raised whether food or weather was the more important factor in producing the peak in population in 1854 and the subsequent decline. The commerce in quail that became extensive about 1852, and was pursued vigorously for many years, was contributory to the decline, especially since quail could be trapped so easily in severe weather. It is reasonably clear, however, that weather played the important role. The birds, after the series of three severe winters beginning with 1854-55, never again approached their former numbers. Food must have been as ample as formerly during the three mild winters starting with 1857-58, but the population was so depleted that there was only a limited recovery. Similar series of three favorable winters occurred only three additional times before the end of the century. When there was a succession of six hard winters such as that between 1882-83 and 1887-88, it is surprising that the species survived.

It is stated by Gerstell (170) that the quail stands near the bottom of the list of gamebirds in its ability to withstand lack of food; and that even under *favorable food conditions* there is a high mortality due to environmental extremes. Artificially propagated quail, confined individually without food, showed the following survival time: 1.9 days at 0° F. with an air movement of 5.8 miles per hour; and 2.5 days at the same temperature with no movement of the air. Due to conservation of heat, the chances of survival in a bevy are increased greatly. A group of 10 birds, owing to the opportunity to huddle closely while roosting, showed an average survival of 4.1 days at 0° F. and no air movement.

Quail roost usually upon the ground in a compact circle. There are exceptions. The following note was made at Madison, March 23, 1930: "About 6 inches of snow fell last night. . . . At 2:45 found 5 quail (there might have been more) roosting in a clump of spruce trees near the old sand pit. They were about 15 feet from the ground. About 200 yards up the same road, found 8 quail roosting in a grapevine tangle about 12 feet from the ground. This roost was quite open but offered good protection against large owls." I have never, however, found an elevated roost during severe weather.

The argument that quail, after attaining a certain abundance, may as well be shot, since they are sure to approach extermination during the next cold winter, is an old one in Wisconsin (168). While there is some truth in this assertion, it produces a dilemma. The normal bevy of 15 to 20 birds has the best chance of survival. If it is reduced to 4 or 5 birds prior to a hard winter, the chance of the remnant surviving is much more remote. It is improbable that many of the reduced coveys would combine for the winter since in most regions the coveys are too widely separated.

There is no prospect that quail will become numerous in Wisconsin in the near future. The effects of weather are largely beyond management. Cover continues to deteriorate. Where it is not removed deliberately, its effectiveness is reduced greatly by grazing. Dairying and the raising of stock are injurious to both cover and the food supply. It is evident, therefore, that the improvement of present conditions for quail are for the most part not subject to control.

ADDENDA

Editor D. J. Powers (*Wisconsin Farmer* 9, 1857, p.231) states that approximately 25,000 quail were sent from Madison to Chicago the winter of 1855-56. He thinks that an estimate of 500,000 quail sent to eastern cities from Milwaukee and Chicago would be low.

Howard Bosworth (*Forest and Stream* 56, April 13, 1901, p.287) knew of one or two places in the valley of the Wisconsin River where he could have killed 75 quail a day in the fall of 1901.

Quail were first observed at Schilling Station, Clark County, in the fall of 1901 (Greenwood *Gleaner* Oct. 18, 1901).

A. H. Pape liberated quail in 1899 in Waupaca County (New London *Republican* Sept. 22, 1903), and in the spring of 1903 a few were set free in Burnett County (Grantsburg *Sentinel* Nov. 12, 1903).

LITERATURE CITED

1. A. N. Somers, *Pop. Science Monthly* 42 (1892) 203.
2. T. Rodolf, *Wis. Hist. Coll.* 15 (1900) 345.
3. C. Rodolf. In: History of Grant County, Wisconsin. Chicago, (1881) p. 800.
4. Gen. William R. Smith. Observations on the Wisconsin Territory. Philadelphia, (1838) p. 24.
5. G. W. Featherstonhaugh. A canoe voyage up the Minnay Sotor. London. Vol. 1 (1847) p. 180.

5a. "The Upper Wolf, Wis." Vol. 6, No. 8, Wisconsin Local History. Wis. Hist. Soc.

5b. Watertown *Chronicle* Nov. 3, 1847.

6. Mrs. Mary Bristol, *Wis. Hist. Coll.* 8 (1879) 303; 15 (1900) 236.

6a. H. Pratten. In: D. D. Owen, Report of a geological survey of Wisconsin, Iowa, and Minnesota. Philadelphia, (1852) p. 623.

7. E. W. Keyes, *Wis. Hist. Coll.* 11 (1888) 424.
8. Prosper Cravath. Early annals of Whitewater. Whitewater, (1906) p. 40; *cf.* Whitewater *Register* Sept. 11, 1858.

8a. *Ibid.*, p. 178.

9. Whitewater *Register* Nov. 13, 1858.
10. Anon. Life in the west. London, (1842) p. 275.
11. I. A. Lapham. A geographical and topographical description of Wisconsin. Milwaukee, (1844) p. 76.

12. H. A. Tenney. In: D. S. Durrie, History of Madison. Madison, (1874) p. 163.
13. Martin Mitchel. History of the county of Fond du Lac. (1854) p. 80.
14. Capt. L. B. Mackinnon. Atlantic and transatlantic: sketches. N. Y. (1852) p. 136.
15. W. A. Titus, *Wis. Mag. Hist.* 19 (1936) 415.
15a. C. T. Ficker, *ibid.*, 25 (1942) 349.
16. J. V. Quarles, *ibid.*, 16 (1933) 297-320.
17. Mrs. L. T. Fowler, *ibid.*, 18 (1935) 397.
18. F. S. Stone. History of Racine County. Chicago. Vol. 1 (1916) p. 421.
19. W. H. M. A reminiscence. Burlington *Free Press* Sept. 26, 1882.
19a. Silas Chapman. Early Waukesha days. Waukesha *Freeman* July 10, 1890 [1].
20. James L. Breck. Life. New York, (1883) p. 60.
21. Milwaukee *Sentinel* Aug. 17 and Oct. 7, 1846.
22. D. McLeod. History of Wiskonsan. Buffalo, (1846) p. 238.
23. Madison *Argus* Aug. 3, 1847.
24. Watertown *Chronicle* Aug. 18, 1847.
25. A. S. H. *Porter's Spirit of the Times,* 17 (Sept. 11, 1847) 333.
26. Milwaukee (w) *Wisconsin* Aug. 18, 1847.
27. Jacob Bühler, *Wis. Mag. Hist.* 16 (1923) 325.
28. A. C. Barry, *Proc. Boston Soc. Nat. Hist.* 5 (1854) 8.
29. Hudson *North Star* July 4 and Aug. 8, 1855.
30. Wausau *Pilot* Nov. 14, 1868.
31. Ashland *Press* Sept. 26, 1874.
32. Superior *Times* July 29, 1882.
33. Florence *Mining News* Nov. 21, 1891.
34. Madison (w) *Argus and Democrat* Dec. 7, 1852.
35. Prairie du Chien *Courier* Oct. 20, 1852.
35a. J. Q. Emery. Early history of Rutland. Madison *Democrat* April 18, 1920.
36. P. R. Hoy, *Trans. Wis. Agr. Soc. for 1852,* (1853) 357.
37. Wisconsin *State Journal* Oct. 8, 1853.
38. Appleton *Crescent* Oct. 22, 1853.
39. *Porter's Spirit of the Times,* 22 (Jan. 22, 1853) 583.
40. Waukesha *Press.* In: Juneau *Gazette* July 29, 1853.
41. Janesville *Democratic Standard* Aug. 9, 1854; Madison *Argus and Democrat* Dec. 29, 1854.
42. Watertown *Chronicle.* In: Madison *Argus and Democrat* Oct. 19, 1854.
43. Jefferson *Jeffersonian.* In: *Ibid.*, Nov. 6, 1854.
44. "Badger," *Porter's Spirit of the Times* 24 (Nov. 18, 1854) 476.
45. Green Bay *Advocate* March 23; Nov. 16, 1854.
46. Milwaukee (d) *Wisconsin* Jan. 31, 1855.
47. *Ibid.*, Aug. 25, 1855; Milwaukee *American* Oct. 17, 1855.
48. Elkhorn *Reporter.* In: Milwaukee (d) *Wisconsin* July 18, 1855.
49. Waukesha *Plain Dealer* Oct. 16, 1855.
50. Watertown *Democrat* Jan. 4; Aug. 30, 1855.
51. Madison (d) *Argus and Democrat* Oct. 29, 1855.
52. Jefferson *Republican.* In: Madison (d) *Patriot* Dec. 8, 1855.
53. Portage *Badger State* Jan. 4, 1856.

54. Milwaukee (d) *News* Sept. 7, 1856.
55. *Ibid.*, Sept. 14, 1856.
56. Madison *Democrat* Dec. 23, 1881.
57. Portage *Badger State* Dec. 26, 1856; Madison *State Journal* Dec. 27, 1856.
58. S. E. Roberts, Darlington *Democrat* March 27, 1919.
59. P. R. Hoy, *Proc. Wis. Nat. Hist. Soc.* March, 1885, p. 8.
60. Milwaukee *Sentinel* Nov. 26, 1852.
61. Janesville *Democratic Standard* Jan. 21, 1852.
62. Milwaukee *Sentinel* Feb. 2, 1853.
63. Janesville *Democratic Standard* Feb. 1; Aug. 9, 1854.
64. Madison *Argus and Democrat* Dec. 29, 1854.
65. Milwaukee *Sentinel* Jan. 21 and 31, 1854.
66. *Ibid.*, Jan. 20, 1855.
67. *Ibid.*, Feb. 20, 1855; Whitewater *Gazette* Feb. 7, 1856.
68. Beloit *Journal.* In: Milwaukee *Sentinel* Feb. 10, 1855.
68a. E. J. Lewis. American Sportsman. Philadelphia, (1863) p. 64.
69. Milwaukee (d) *News* June 10, 1856.
70. Milwaukee *Sentinel* Jan. 10; Feb. 7, 1856.
71. Milwaukee (w) *Wisconsin* Jan. 28, 1857.
72. Chicago *Tribune* Dec. 20, 1856; Milwaukee *Sentinel* Dec. 22, 1856.
73. Janesville *Gazette* Aug. 10, 1857.
74. Madison (d) *Patriot* Sept. 29, 1857.
75. Milwaukee *Sentinel* Jan. 4, 1858.
76. Prairie du Chien *Courier* Sept. 16, 1858.
77. Milwaukee *Sentinel* Dec. 28, 30, and 31, 1858.
78. Madison (d) *Argus and Democrat* Oct. 12, 1860.
79. Horicon *Argus* Sept. 21; Oct. 19; Nov. 16, 1860.
80. Oxford *Express* Aug. 31, 1860.
81. Burlington *Gazette* Aug. 14, 1860.
82. Shullsburg *Local* Sept. 6, 1861.
83. "Snap Shot," *Wilkes' Spirit of the Times* 15 (Oct. 20, 1866) 129-30.
84. Madison *State Journal* Sept. 25, 1863.
85. *Ibid.*, Dec. 8, 1870.
86. Madison *Democrat* Nov. 1, 1871.
87. *Ibid.*, Dec. 30, 1879.
88. L'Eclair, *Forest and Stream* 13 (1879) 714.
89. H. W. Merrill, *ibid* 13 (1879) 827.
90. "Blue Jay," *Am. Field* 17 (June 24, 1882) 440.
91. S. W. Willard, *Wis. Acad. Sci.* 6 (1885) 189.
92. F. L. Grundtvig, *ibid.*, 10 (1895) 105.
93. Manitowoc *Pilot* Aug. 25, 1898; Plymouth *Review* March 6; May 22; Dec. 25, 1901.
94. Eau Claire *Telegram* Aug. 4, 1895, 1.
95. Prairie du Chien *Courier* Nov. 10, 1896.
96. Trempealeau *Herald* Aug. 28, 1896.
97. Black River Falls *Journal* Aug. 27 and *Banner* Oct. 8, 1896.
98. Stevens Point *Gazette* Oct. 14, 1896, 4, and *Journal* Oct. 17, 1896, 8.
99. Prairie du Chien *Courier* Oct. 23, 1900.
100. E. Hough, *Forest and Stream* 55 (Oct. 6, 1900) 268.

101. A. J. Schoenebeck. Birds of Oconto County. [1902], p. 21.
102. T. S. Van Dyke. Bob-White in Minnesota. *Shooting and Fishing* 10, No. 7 (June 11, 1891) 11-13.
103. H. M., *Porter's Spirit of the Times* 11, No. 8 (April 24, 1841) 90.
104. G. *ibid.*, 11 (March 13, 1841) 19.
105. N. *ibid.*, p. 25.
106. J. G., *ibid.*, 16 (Oct. 24, 1846) 415.
107. "Bang," *Turf, Field and Farm* 3 (Nov. 10, 1866) 295.
108. F. H. Yorke, *Am. Field* 32 (Dec. 14, 1889) 553.
109. Milwaukee (d) *News* Nov. 16, 1856.
110. S. C. C., *Wildwood's Magazine* 2 (1889) 98.
111. Madison *Argus and Democrat* Oct. 19, 1854 and (d) *Patriot* Oct. 12, 1855.
112. Madison (d) *Patriot* Nov. 21, 1854; Kenosha *Telegraph* Oct. 25, 1850; Racine *Advocate* Oct. 14, 1853 and Oct. 16, 1854.
113. Milwaukee (w) *Wisconsin* Nov. 8, 1854.
114. Milwaukee *Sentinel* Oct. 14 and 15, 1859; Milwaukee (d) *Wisconsin* Oct. 17, 1860; *Sentinel* Sept. 19, 1861 and Oct. 10, 1862.
115. La Crosse (w) *Democrat* Oct. 10, 1863.
116. Madison *Democrat* Oct. 12 and 19, 1865.
117. B. and S. Sporting in Wisconsin. *Porter's Spirit of the Times* 19 (Aug. 11, 1849) 295.
118. Milwaukee (d) *News* Nov. 9 and 16, 1856.
119. Anon. Quail or bob-white. Sheboygan Falls *News* April 6, 1892.
120. S. Kneeland. *Proc. Boston Soc. Nat. Hist.* 6 (1859) 237.
121. E. Sandys and T. S. Van Dyke. Upland game birds. London, (1904) p. 25.
121a. L. G. Duck, *J. Wildlife Management* 7 (1943) 367.
122. Anon. Racine, Wis. *Porter's Spirit of the Times* 24 (Oct. 28, 1854) 436.
123. Milwaukee (d) *Democrat* Sept. 19, 1855.
124. J. Muir. The story of my boyhood and youth. N. Y. (1913) p. 133.
124a. *Ibid.* pp. 134 and 152.
125. G. Imlay. A topographical description of the western territory of North America. 2nd. ed. London, (1793) p. 101.
126. R. Kennicott, *Trans. Ill. State Agr. Soc. for 1853-54,* 1 (1855) 586.
127. G. S. Hubbard. Autobiography. Chicago, (1911) p. 63.
128. Illinois in 1837. Philadelphia, (1837) p. 41.
129. E. Duis. The good old-times in McClean County, Illinois. Bloomington, (1874) pp. 311 and 342.
130. R. G. A. Levinge. Echoes from the backwoods. London. Vol. 2 (1846) p. 215.
131. J. H. Thurston. Reminiscences, sporting and otherwise of early days in Rockford, Ill. Rockford, (1891) pp. 104 and 111.
132. A. L. Fulwider. History of Stephenson County, Illinois. Chicago. Vol. 1 (1910) p. 146.
133. J. E. Cabot. In: L. Agassiz. Lake Superior. Boston, (1850) p. 68.
134. C. Game in the west. *Wilkes' Spirit of the Times* 17 (Dec. 28, 1867) 334.
135. E. Baldwin. History of La Salle County, Illinois. Chicago, (1877) p. 529.
135a. J. H. Evans, *Proc. Wis. Hist. Soc. for 1909,* (1910) pp. 234 and 237.
135b. Madison *State Journal* June 6, 1854.

136. J. Schafer. Wisconsin lead region. Madison, (1932) p. 162.
137. T. F. DeVoe. The market assistant. N. Y. (167) p. 164; Milwaukee (d) *Wisconsin* Nov. 28, 1855, [2].
138. B. F. Goss. In: C. Bendire. Life histories of North America birds. Washington. Vol. 1 (1892) p. 3.
139. F. H. King. Geology of Wisconsin. Vol. 1 (1883) p. 457.
140. C. W. Marsh. Recollections 1837-1910. Chicago, (1910) p. 41.
141. Milwaukee *Sentinel* March 18, 1869, [2].
142. Madison *State Journal* Dec. 27, 1856; Palmyra *Enterprise* Jan. 23, 1878.
143. Milwaukee *Journal* Feb. 7, 1885, [2].
144. *Ibid.*, Nov. 1, 1886.
145. Whitewater *Register* April 24; Sept. 4, 1890.
146. Racine *Times* March 11, 1887.
147. Plymouth *Review* July 1, 1903.
148. Sheboygan *Telegram* March 22, 1892; Plymouth *Review* Dec. 2, 1903.
149. Two Rivers *Chronicle* Feb. 27, 1894; Feb. 2 and 20, 1897; Kewaunee *Enterprise* Jan. 22, 1897.
150. Sturgeon Bay *Democrat* April 14, 21 and Aug. 25, 1899; *cf.* Jan. 20, 1899; Jan. 13, 1900.
151. Sturgeon Bay *Advocate* Jan. 18, 1902; Feb. 7, 1903; *Democrat* Oct. 31, 1903.
152. Sturgeon Bay *Democrat* Aug. 23, 1902; *Advocate* March 12, 1904.
153. Palmyra. Viroqua *Censor* Sept. 22, 1897, [4].
154. Prairie du Chien *Courier* Sept. 6, 1898.
155. Plymouth *Review* Aug. 14, 1901, [4].
156. L. Kumlien and N. Hollister. Birds of Wisconsin. (1903) p. 55.
157. J. H. St. John [De Crèvcoeur]. Letters from an American farmer. London, (1782) p. 30.
157a. Plymouth *Review* Dec. 25, 1901.
158. "Short Pete," *Porter's Spirit of the Times* 19 (April 14, 1849) 90.
159. "H. of Wis.," *ibid.*, 24 (May 27, 1854) 176.
160. Jefferson *Jeffersonian*. In: Milwaukee (d) *Democrat* Dec. 21, 1854.
161. Kilbourn *Mirror* Jan. 22, 1856.
162. "Don," *Porter's Spirit of the Times*, n.s. 1 (Dec. 27, 1856) 269.
163. History of Grant County, Wisconsin. Chicago, (1881) p. 473.
164. Janesville *Gazette* Aug. 10, 1857.
165. Prairie du Chien *Courier* Sept. 16, 1858.
166. Milwaukee *News* Sept. 16, 1859, [2].
167. P. L. Errington. The wintering of the Wisconsin bob-white. *Trans. Wis. Acad. Sci.* 28 (1933) 1-35.
168. A. Leopold, *Am. Mid. Naturalist* 18 (1937) 408-416; P. L. Errington, *Wilson Bull.* 51 (1939) 22-37.
169. E. Miller. A century of temperatures in Wisconsin. *Trans. Wis. Acad. Sci.* 23 (1927) 169.
170. R. Gerstell. The place of winter feeding in practical wildlife management. Research Bull. No. 3. Pa. Game Com., Harrisburg (1942).
171. Milwaukee *Sentinel* Feb. 18, 1903.

SMALL MAMMAL CENSUSES NEAR PRAIRIE DU SAC, WISCONSIN

HAROLD C. HANSON
Research Assistant, Department of Wildlife Management*
University of Wisconsin

INTRODUCTION

Each winter since 1930 the gamebirds and predators on a seven square mile area in Westpoint Township, Columbia County near Prairie du Sac have been censused. The results of these censuses will be summarized in a forthcoming paper by Errington. In order to fill the gaps in our knowledge concerning the populations of animals not heretofore censused, the writer, during the years 1941 and 1942, made censuses of mice and shrews, cottontail rabbits, fox and gray squirrels, winter birds, and nesting songbirds. This paper summarizes the data obtained on populations of mice, shrews, and cottontail rabbits. It also includes notes on four little-known Wisconsin mammals: pygmy short-tailed shrew (*Cryptotis parva parva*), least weasel (*Mustella rixosa allegheniensis*), harvest mouse (*Reithrodontomys megalotis pectoralis*), and the pine mouse (*Pitymys pinetorum scalopsoides*).

Fifteen quadrats in 12 cover types were censused between September 21 and October 29, 1941: Grain stubble (two fields); Alfalfa (two fields); Bluegrass—sweet clover two fields); *Carex stricta bog*; Smartweed—foxtail; Short-grass prairie relic; Sandy field (primarily panic grass); Juniper bluff; Red oak and red cedar pasture; Whitebirch—prickly ash; Red and white oak woodlot (severely grazed); Red and white oak woodlot (moderately grazed).

MATERIALS AND METHOD

Quadrats employing snap traps have been used by a number of authors (Bole 1939, Townsend 1935, Williams 1936). Live trapping and banding have been used with notable success by

* Now Assistant Game Technician, Illinois Natural History Survey, Urbana, Illinois.

Burt (1940) and Blair (1940 a, b, c) while censuses by means of nest boxes have yielded much information not obtainable by either of the other two methods (Nicholson 1941).

Because of the large number of cover types that had to be sampled in a brief period, it was decided that quadrat trapping with snap traps would be most suitable. That snap traps when properly employed can obtain adequate estimates of small mammal populations has been shown by Goodnight and Koestner (1942), who made a field comparison between live traps and snap traps, and found that the two techniques were of about equal value. They found that snap traps gave the approximate total population in three days, while live traps took two or three days longer.

Previous investigators (see Burt 1940, 36-39) have estimated small mammal populations on the basis of the catches they obtained from quadrats only a fraction of the size of the home range of any one individual.

In this work, unless otherwise specified, quadrats 300 feet square containing 121 traps spaced ten yards apart were used. Each quadrat was trapped for four nights. This is a modification of the method used by Burt (*op. cit.* 12-14). He found that quadrats from two to five acres, containing live traps similarly spaced, usually caught most of the shrews and mice in four successive nights of trapping.

Before cool weather set in, crickets proved to be very troublesome in eating the bait, which consisted at first of a mixture of rolled oats and peanut butter. By experimentation it was found that a moist crumbly mixture of millet, rolled oats, and peanut butter was better because the millet withstood the depredations of the crickets, and thus remained available to the mice.

Regardless of the size of quadrat used, small mammals whose home ranges border the quadrat area are likely to be taken (Dice 1941). Some adjustment must be made for catches of these bordering individuals when calculating density. The author believes the most equitable method of determining the coverage of snap trap quadrats is that suggested by Dice (1938); that is, to consider the area censused to be the area of the quadrat itself, plus an additional distance beyond its periphery equal to the radius of the home range of the species in question. In this paper each quadrat is assumed to have drawn upon peripheral zones as follows:

Blarina brevicauda	75 ft.	(after Burt)
Reithrodontomys megalotis	50 ft.	(arbitrary)
Peromyscus maniculatus	75 ft.	(after Blair 1940a)
Peromyscus leucopus	50 ft.	(after Burt)
Microtus pennsylvanicus	60 ft.	(after Blair 1940c)
Microtus ochrogaster	60 ft.	(arbitrary)
Pitymys pinetorum	60 ft.	(after Burt)
Mus musculus	75 ft.	(arbitrary)

These censuses are first discussed quadrat by quadrat. A later discussion deduces habitat preferences for each species. Additional notes on individual species are included in the latter section.

A few quadrats were inhabited by both species of *Peromyscus.* Because these mice are difficult to separate before adulthood, the identifications are doubtful for a few of the immatures taken.

Calculations of the number of mice per acre usually produced decimal figures. When these involved only a fraction of a mouse per acre, they can not be rounded off without distorting the species ratio. Hence, all densities have been left in decimals, but it should be understood that this does not imply accuracy to one decimal.

Status of the Rodent Cycle in 1941

Mice were generally abundant in all habitats censused in the fall of 1941. During the fall of 1942, according to a farmer on the Prairie du Sac area, mice were far more numerous in his fields than during the previous year. Field experience by the author and other Wisconsin workers leaves little doubt that the small rodent population "crashed" some time between late in the winter of 1942-43 and early spring. Repeated trapping during that spring and summer in hayfields, bluegrass areas, sand prairies, and waste places yielded but a few specimens. However, *Peromyscus leucopus* was found in fair numbers in a wooded ravine in the Baraboo hills. This leads the author to suspect that this species may not be cyclic, or if it is cyclic, that its numbers do not fluctuate as violently as field-inhabiting species.

COVER TYPES AND POPULATIONS

Grain Stubble

Two grain stubble-fields were censused. The catch taken from the two fields reflected the character and density of the cover; Field I having sparse stubble and a poor growth of weeds, had a population of only 1.7 mice per acre, while Field II, having a fertile black soil which supported a dense growth of weeds, yielded 5.2 mice per acre. Table I suggests that as grain stubble-fields became increasingly weedy, there is a corresponding increase in the rodent population, particularly of the genus, *Microtus*. Thus besides reducing crop yields through competition, weeds may also be the indirect cause of crop losses because of the high rodent populations they seem to encourage.

TABLE I. Number of mammals caught, calculated density per acre, and composition of population of two grain stubble-fields, September 21-28, 1941.

Species	No. mammals caught		Calculated density per acre		Composition by per cent of population	
	Field I	Field II	Field I	Field II	Field I	Field II
Reithrodontomys megalotis	2	2	0.5	0.5	30	10
Peromyscus maniculatus	2	7	0.4	1.5	23	29
Microtus ochrogaster	1	6	0.2	1.5	13	29
Mus musculus	3	8	0.6	1.7	34	32
Total	8	23	1.7	5.2	100	100

Bluegrass—Sweet Clover

The quadrat used in Field I was 300 feet square, while Field II with an area of 4.25 acres was trapped in its entirety. Since the latter field was bordered by woods on three and one-half sides, it was possible to trap it to exhaustion before an influx of mice through the one opening to an adjoining field could seriously affect the catch. During the four census nights, eighty mice were caught and in the following three nights only an additional fifteen mice were secured. However, to make the census figures for all cover types comparable, the population figures given in Table II are based on the standard four-night trapping period.

There was a greater proportion of bluegrass and a more luxurious growth of weeds in Field II, thus accounting for the proportionately greater catch of field voles, *Microtus ochrogaster*, which reach their highest populations in dense cover. A correspondingly lower population of prairie deer mice (*Peromyscus maniculatus*) also reflects this cover difference, as they are known to prefer habitats having a more open ground surface.

Woodland deer mice are computed as a part of the total field inhabiting population, since it was evident that portions of the fields bordering the woods were important parts of their home ranges.

TABLE II. Number of mammals caught, calculated density per acre, and composition of population of two fields of bluegrass and sweet clover, Oct. 2-11, 1941.

Species	No. mammals caught		Calculated density per acre		Composition by per cent of population	
	Field I	Field II	Field I	Field II	Field I	Field II
Blarina brevicauda	3	5	1.0	1.1	12	6
Reithrodontomys megalotis	1	4	0.3	0.9	4	5
Peromyscus maniculatus	7	7	2.3	1.6	27	9
Peromyscus leucopus	5	4	1.7	0.9	21	5
Microtus ochrogaster	6	60	2.0	14.1	24	75
Mus musculus	3		1.0		12	
Total	25	80	8.3	18.6	100	100

Alfalfa

Field I was censused with a quadrat 300 by 300 feet and Field II with a quadrat 300 by 240 feet. The census figures for these two fields in Table III suggest that an average alfalfa field supported seven to eight mice per acre in the fall of 1941. Again it is evident from a comparison of the rodent populations for Fields I and II (Table III) that a field supporting a fairly high *Microtus* population is generally inhabited by a correspondingly lower prairie deer mouse (*Peromyscus maniculatus bairdi*) population.

TABLE III. Number of mammals caught, calculated density per acre, and composition of population of two alfalfa fields, September 23—Oct. 5, 1941.

Species	No. mammals caught		Calculated density per acre		Composition by per cent of population	
	Field I	Field II	Field I	Field II	Field I	Field II
Reithrodontomys megalotis	4	5	1.2	1.7	17	23
Peromyscus maniculatus	6	4	1.8	1.1	25	15
Microtus ochrogaster	2	8	0.6	2.5	8	34
Microtus pennsylvanicus		2		0.6		9
Mus musculus	12	5	3.6	1.4	50	19
Total	24	24	7.2	7.3	100	100

Carex stricta Bog

The total small mammal population of this bog (Table IV) compares very closely with that obtained for alfalfa fields. Its population was characterized by relatively low populations of non-microtine species and the presence of a shrew, which species, like voles, were found to be most abundant in dense cover.

The entire bog of 1.5 acres was trapped.

TABLE IV. Number of mammals caught, calculated density per acre, and composition of population of a *Carex stricta* bog, October 16-19, 1941.

Species	No. mammals caught	Calculated density per acre	Composition by per cent of population
Blarina brevicauda	1	0.6	8
Reithrodontomys megalotis	1	0.6	8
Peromyscus maniculatus	3	2.0	28
Microtus ochrogaster	3	2.0	28
Microtus pennsylvanicus	3	2.0	28
Total	11	7.2	100

Smartweed—Foxtail

This habitat occupied a small basin at the foot of a steep dry hill (populations on this hill are discussed under *Prairie Relic*) and was censused in its entirety as it had an area of only 2.1 acres. Due to the fact that this site was inadequately tiled, drainage from the surrounding fields often made it too wet to cultivate in the spring. The central portion had been ploughed the previous spring, but had to be abandoned, and a dense growth of yellow foxtail and ragweed marked this sector at the time of the census. Beggar's tick (Bidens) and smartweed (Polygonum) were the most abundant plants. Newly planted timothy, a mature stand of alfalfa, and a cornfield adjoined three sides of the basin while on the fourth side northeast it merged with the *Carex stricta* bog previously discussed.

During the census period, October 16-19, the nearby cornfield was cut and shocked, which may have increased the catch. The catch of house mice was so spectacular (see Table V) that I believe it to be unlikely that this disturbance affected the results to any great degree.

House mice were so abundant in this 2.1 acre plot it seemed improbable that four nights of trapping could have completely exhausted the resident population. To test this possibility a fifth night of trapping was carried out and eleven more house mice, three voles, two prairie deer mice, and a harvest mouse were caught.

The top-heavy population of house mice in this habitat is a striking illustration of how "animal weeds" may overrun the land side by side with plant weeds. Undoubtedly the magnet which attracted the high rodent population was the abundant food supply, the ground being thickly strewn with seeds of foxtail grass, ragweed, and smartweed. In contrast to this situation was the "hostility" of the relatively undisturbed adjoining *Carex stricta* bog. In spite of the extreme density of house mice on this quadrat none were taken in the central portion of the bog (Table IV).

TABLE V. Number of mammals caught, calculated density per acre, and composition of population of a smartweed—foxtail habitat, October 16-19, 1941.

Species	No. mammals caught	Calculated density per acre	Composition by per cent of population
Reithrodontomys megalotis	5	2.4	5
Peromyscus maniculatus	12	5.7	12
Microtus ochrogaster	4	1.9	4
Microtus pennsylvanicus	1	4.7	9
Mus musculus	73	34.0	70
Total	95	48.7	100

Short-grass Prairie Relic

Many areas like this one are found in southwestern Wisconsin on steep westerly-facing hillsides. The five domiant plants composing this relic were: *Andropogon scoparius Sporobolus heterolepis, Aristida basiramea, Amorpha canescens,* and *Aster sericeus.* Because of the topography, it was necessary to lay out the traps in the form of a triangle that spread down fanwise from the peak of the hill. Consequently there was a relatively large amount of edge across which mice from the different surrounding cover types might have drifted. For this reason the census figures in Table VI are not strictly comparable with those given for the other types. The area covered by the traps was 0.8 acre but the actual coverage was assumed to be one acre.

As might be expected the prairie deer mouse (*Peromyscus maniculatus*) was the dominant species in this relic. The woodland deer mice (*Peromyscus leucopus*) were taken from amongst a thicket of wild grape and bittersweet on an outcropping of limestone in the center of the census area. The genus *Microtus* was conspicuously absent, possibly because the cover was neither dense nor succulent enough for their requirements. The great bulk of this large catch of deer mice were immatures and young adults.

In spite of my limited data, I believe the original prairie was capable of supporting a fairly high small rodent population. This belief is supported by the findings of Smith (1940) working in Oklahoma. He says that: "Although somewhat less food is available in climax prairie, excellent cover is present and a large population of rodents is found."

TABLE VI. Number of mammals caught, calculated density per acre, and composition of population of a short-grass prairie relic, October 17-20, 1941.

Species	No. mammals caught	Calculated density per acre	Composition by per cent of population
Reithrodontomys megalotis	1	1.0	2
Peromyscus maniculatus	24	24.0	56
Peromyscus leucopus	13	13.0	30
Mus musculus	5	5.0	12
Total	43	43.0	100

Sandy Field

Continuous farming of an inadequate topsoil had reduced this field to shifting sands. It is now slowly returning to a modified prairie. At the time of the census, scattered clumps of panic grass (*Panicum Scribnerianum*) were the dominant cover. Prairie lespedeza (*Lespedeza capitata*), a species of puccoon (*Lithospermum croceum*), and spiderwort (*Tradescantia reflexa*) also occurred. The field is planted to pines, but only ten per cent of the quadrat supported trees over three years of age. The eight- to ten-year-old trees have not yet modified the surrounding ground cover.

Though cover was at a minimum, prairie deer mice proved to be surprisingly abundant (Table VII).

TABLE VII. Number of mammals caught, calculated density per acre, and composition of population of a sandy field, October 7-10, 1941.

Species	No. mammals caught	Calculated density per acre	Composition by per cent of population
Reithrodontomys megalotis	1	0.3	8
Peromyscus maniculatus	8	2.3	62
Mus musculus	4	1.1	30
Total	13	3.7	100

Juniper Bluff

Depressed juniper (*Juniperus communis depressa*), arranged in a somewhat checker-board fashion, together with prairie relics form one of the unique plant associations on the Prairie du Sac area. This type is found on the extremely dry and westerly-facing slopes overlooking the Wisconsin River. Though cattle-grazing had caused the invasion of such weeds as evening primrose, mullen, and hoary vervain, a number of prairie species still flourished. Among the latter were: little bluestem grass (*Andropogon scoparius*), St. John's wort (*Hypernicum*), prairie bluebell (*Campanula*), and lead plant (*Amorpha canescens*). This habitat was the only one censused in which both species of *Peromyscus* were distributed rather evenly throughout the quadrat (Table VIII). The author has not encountered a reference in the literature to any other habitat freely populated by both species of deer mice.

The census plot was only 240 by 240 feet due to the configuration of the available area.

TABLE VIII. Number of mammals caught, calculated density per acre, and composition of population on a juniper bluff, October 15-18, 1941.

Species	No. mammals caught	Calculated density per acre	Composition by per cent of population
Reithrodontomys megalotis	2	0.7	6
Peromyscus maniculatus	14	4.0	31
Peromyscus leucopus	20	7.7	58
Mus musculus	2	0.7	5
Total	38	13.1	100

Red Cedar—Red Oak Pasture

This woodlot was composed of an open stand of red cedar and red oak occurring in about equal numbers, with a few scattered depressed junipers. The ground cover was sparse, made up chiefly of an intermixture of bluegrass, a panic grass and an occasional clump of little bluestem grass. A few small scattered patches of prickly ash and black raspberry were all that remained of the shrubs. Among other herbs and weeds present were wild bergamot, prairie clover (*Petalostemum*), prairie lespedeza, St. John's wort, hoary vervain and mullen.

The drastic effect of long continued grazing of woodlots on small mammal populations is evident in Table IX below. The only apparent reason for the woodmouse population holding up was the excellent places of retreat afforded by the litter of needles under the cedars and amongst the depressed junipers.

TABLE IX. Number of mammals caught, calculated density per acre, and composition of population of red cedar—red oak pasture, October 2-5, 1941.

Species	No. mammals caught	Calculated density per acre	Composition by per cent of population
Peromyscus leucopus	11	3.4	92
Mus musculus	1	0.3	8
Total	12	3.7	100

White Birch-Prickly Ash

White birch and prickly ash were the two chief woody species growing on a north-facing slope that was censused in late October. At one time an even-aged stand of red oak timber had occupied the site, but had been cut over some years previous to the time of the census. After the cutting occurred the slope had evidently been pastured by cattle. Under their selective browsing these two species, unpalatable to cattle, gradually assumed dominance.

Since the leaves of neither the birch or ash tend to build up a heavy layer of leaf mold, this cover type offered little attraction to small mammals. Thus the small mammal population of this woodland was unusually low (Table X). The three shrews were taken near old rotten stumps of oak trees.

Table X. Number of mammals caught, calculated density per acre, and composition of population of a white birch—prickly ash woodlot, October 24-27, 1941.

Species	No. mammals caught	Calculated density per acre	Composition by per cent of population
Blarina brevicauda	3	0.8	31
Peromyscus leucopus	5	1.8	69
Total	8	2.6	100

Red and White Oak Woodlot
(severely grazed)

The low mammal density found in this woodlot (Table XI) indicates that constant grazing by cattle may be disastrous to small mammal populations. Cattle had eradicated almost every shrub in this woods and the resultant packing of the topsoil had probably excluded the locally rare pine mouse (*Pitymys pinetorum*). Even the woodland deer mouse population was markedly low. Fox squirrels still remained abundant in this woods, and probably benefitted by the lack of cover.

TABLE XI. Number of mammals caught, calculated density per acre, and composition of population of a red and white oak woodlot (severely grazed), Oct. 24-27, 1941.

Species	No. mammals caught	Calculated density per acre	Composition by per cent of population
Blarina brevicauda	1	.2	4
Glaucomys volans	1	..	..
Peromyscus leucopus	18	5.3	96
Total	20	5.5	100

Red and White Oak Woodlot

(moderately grazed)

This woodlot differed from the one discussed above mainly as to the degree of grazing to which it had been subjected. Prickly ash and a species of *Rubus* were the only remaining shrubs of any abundance. A thick layer of leaf mold was believed to explain the survival of pine mice in this woodlot, since this species in Wisconsin has been recorded only from woods in which litter remained. The woodland deer mouse population (Table XII) was similar in density to that which Burt found in an oak-hickory woodlot (11 per acre in November) in Michigan. Flying squirrel populations are not calculated on an acreage basis, as little is known of their mobility, but the presence of a greater number of den trees is thought to account for their greater abundance in this woods.

HABITAT PREFERENCES

Pygmy Short-tailed Shrew—*Cryptotis parva parva* (Say)

The author is aware of only one previously published record reporting this species from Wisconsin. This record consists of the remains of an individual found in an owl pellet collected at Prairie du Sac. (Errington, Hamerstrom, and Hamerstrom, 1940). Intensive fieldwork may reveal that it is more widely distributed and common in Wisconsin than the lack of records would indicate.

The single specimen in the author's collection was found dead on the Sauk Prairie on December 15, 1942, by Albert Gastrow of Prairie du Sac. It had been killed by a red fox, as the trail sign clearly indicated, and then had been tossed aside. The finding of this specimen on prairie is in agreement with its preference for dry habitats.

TABLE XII. Number of mammals caught, calculated density per acre, and composition of population of a red and white oak woodlot (moderately grazed), Oct. 25-28, 1941.

Species	No. mammals caught	Calculated density per acre	Composition by per cent of population
Blraina brevicauda	2	0.4	4
**Glaucomys volans*	2		
Peromyscus leucopus	30	8.8	89
Pitymys pinetorum	2	0.5	5
Mus musculus	1	0.2	2
Total	37	9.9	100

* A third flying squirrel was caught on the fifth night.

Short-tailed Shrew—*Blarina brevicauda brevicauda* (Say)

Short-tailed shrews on the Prairie du Sac area are apparently chiefly limited in their distribution to areas of bluegrass and woodlands having numerous fallen logs and a thick layer of leaf mold (Table XIII). In these situations they inhabit the runways made by themselves and by the resident mouse population, and in all likelihood are dependent on them for protection, as well as for insect food or an occasional mouse. Hence, shrew populations are probably relatively secure from horned owl predation. ("Represented in 2.7% of the total pellets and stomachs [examined]"—Errington, Hamerstrom, and Hamerstrom, 1940). Predation likely occurs when they make short excursions away from these sheltered trails.

TABLE XIII. Populations and relative abundance of short-tailed shrews in five cover types, October 2-28, 1941.

Cover Type	Calculated density per acre		Composition by per cent of population	
	Field I	Field II	Field I	Field II
Bluegrass-Sweet Clover	1.0	1.1	12	6
Carex stricta	0.6		8	
White Birch-Prickly Ash	0.8		31	
Severely grazed woods	0.2		4	
Moderately grazed woods	0.4		4	

Least Weasel—*Mustela rixosa allegheniensis* (Rhoads)

Records of the least weasel in southern Wisconsin are too few to enable one to deduce the pattern of its distribution in this portion of the State. Swenk (1926), in the most recent review of the species, lists the following Wisconsin records: Pierce Co., Prescot 1; Racine Co., Burlington 1; Sauk Co., Sumpter township, 2; Merrimac 1. After his paper was published, remains of another specimen was reported in an owl pellet from Stoughton, Dane Co., by Errington, Hamerstrom and Hamerstrom (1940). Phillip Wright of the University of Wisconsin is known to have secured two in the University Arboretum. During the winter of 1943-44 a third specimen was taken in the arboretum by Robert A. McCabe, biologist in charge. I am indebted to him for furnishing his data on this specimen.

The data on five more least weasels recently taken in Sauk Co. are given in Table XIV. These specimens were obtained from farmers by Mr. Ed Ochsner of Prairie du Sac, and at least four of the five were killed by the farmers when removing corn shocks from the fields.

TABLE XIV. Data on six additional least weasels taken in Wisconsin.

Collector's Number	Locality	Date	Sex	Weight	Total Length	Tail	Hind Foot
638	Eastern Sauk Co.	About Mar. 20 '43	♂	60 gms	198	34	24
652	Eastern Sauk Co.	About Apr. 3 '43	♂	45* gms	182	29	22
686	Eastern Sauk Co. Honey Creek	Nov. 10-14 '43	♂		193	26	23
651	Eastern Sauk Co.	About Mar. 25 '43	♀	48.3 gms	184	27	22
653	Eastern Sauk Co.	About Apr. 3 '43	♀	36* gms	165	23	19.5
1	Dane Co. University Arboretum	Apr. 9, '43	♀			23	20

* These weights are low as the specimens were eviscerated when received.

Descriptions of the pelage of these six specimens are given below:

Individual (Collector's Number)

638 Entirely white except for brown hairs on the distal half of tail.
652 Entire back and sides brown; ventral portion of the body white, the white extending slightly higher on the head and neck region and present on the dorsol side of the toes of the fore legs.
686 Pelage entirely white including the tip of the tail.
651 Pelage midway between the white of winter and the brown of summer. The brown limited to the dorsal ⅖ of the body and extending down the dorsal sides of the fore and hind legs and tail. A white patch above the nose and extending around the eyes as a circumorbital ring; a larger white patch in front of each ear. Ears brown, slightly tipped with white. Sides of neck white and numerous white hairs intermixed with the brown of the back where it joins the white sides.
653 Similar to No. 652.
1 Similar to No. 652.

Harvest Mouse—*Reithrodontomys megalotis pectoralis** **Hanson**

A local reconnaissance was made on the Sauk prairie, in addition to the censuses in Columbia County, to gather further information regarding the habitat preferences of the harvest mouse. One of the cover types trapped in Sauk County was a tall stand of ragweed in a sandy fallow field. On entering this field two harvest mice were observed running about. One of these mice was captured by hand, while subsequent trapping yielded an additional three. As no other species of mice were caught in that field, it would appear that the harvest mice like a partial over-head canopy and a relatively herb-free, hard-packed ground surface that permits freedom of movement. Their apparent preference for the cultivated counterpart of this ecological niche, alfalfa fields, is evident from Table XV. They were also more abundant in this habitat relative to the total population than in any of the other cover types.

This mouse is fairly common about Prairie du Sac. Hence, it is surprising that specimens had not been reported from Wisconsin prior to 1941. Errington (1932) and Errington, Hamerstrom, and Hamerstrom (1940) did not report it in owl pellets collected from the Prairie du Sac region. This species was, however, frequently recorded in owl pellets that they studied from

* A paper by the author relating to the discovery of this species in Wisconsin and its distribution and taxonomy has been published by the Chicago Museum of Natural History. See *Literature Cited.*

Des Moines and Ames, Iowa—localities that lie well within the previously known range of the harvest mouse.

The author examined roughly 100 owl pellets collected on April 1, 1942, from a Scotch pine plantation on the Sauk prairie, Sauk County, in which five long-eared owls had wintered. In these pellets were found skulls of 77 *Microtus*, 25 *Peromyscus*, and 17 *Reithrodontomys*, thus indicating that the harvest mouse was freely taken by long-eared owls.

TABLE XV. Population and relative abundance of harvest mice in eight cover types, September 21-October 20, 1941.

Cover Type	Calculated density per acre		Composition by per cent of population	
	Field I	Field II	Field I	Field II
Stubble	0.5	0.5	30	10
Alfalfa	1.2	1.7	17	23
Bluegrass-Sweet Clover	0.3	0.9	4	5
Foxtail-Smartweed	2.4		5	
Carex stricta bog	0.6		8	
Sandy field	0.3		8	
Prairie relic	1.0		2	
Juniper bluff	0.7		6	

Prairie Deer Mouse—*Peromyscus maniculatus bairdi* (Hoy and Kennicott)

The prairie deer mouse was probably the most abundant native mouse on the Prairie du Sac area in the fall of 1941. Like the harvest mouse, this species seemed to prefer situations where the immediate ground cover varied from light to moderate densities. This is shown by the fact that they attained a fairly high density in a sandy field having as its chief cover scattered plants of panic grass. Other species of mice seem to be unable to populate, at least in any densities, such xeric and exposed habitats. As pointed out by Johnson (1926), the prairie deer mouse has probably increased in abundance and extended its range as a result of cultivating the land; and investigations will probably show that prairie deer mice are confined to early stages of the prairie succession on uncultivated lands. The distribution of this species on the Prairie du Sac area supports these contentions (See Table XVI).

TABLE XVI. Population and relative abundance of prairie deer mice in eight cover types, September 21—October 20, 1941.

Cover Type	Calculated density per acre		Composition by per cent of population	
	Field I	Field II	Field I	Field II
Stubble	0.4	1.5	23	29
Alfalfa	1.8	1.1	25	15
Bluegrass—Sweet Clover	2.3	1.6	27	9
Foxtail—Smartweed	5.7		12	
Carex stricta bog	2.0		28	
Sandy field	2.3		62	
Prairie relic	24.0		56	
Juniper bluff	4.0		31	

Woodland Deer Mouse—*Peromyscus leucopus noveboracensis* Fischer

Woodland deer mice were trapped in every census area that supported a few trees or shrubs. One female had made her nest for five new-born young in a paper wasp nest hanging in a clump of hazel-bush. At least a portion of the habitat in cover of a woody nature seemed requisite to satisfy some demand in this mouse.

A female, which had her young in a nest of corn silk inside of a corn-shock, was the only individual encountered a considerable distance from timber or brush. Johnson (*op. cit.*) also reports capturing a wood mouse in a cornfield a quarter of a mile from the nearest woodland. However, some individuals which have home ranges along the borders of woods range out into

TABLE XVII. Population and relative abundance of the woodland deer mouse in seven cover types, October 2-28, 1941.

Cover Type	Calculated density per acre		Composition by per cent of population	
	Field I	Field I	Field II	Field II
Bluegrass—Sweet Clover	1.7	0.9	21	5
Short grass prairie relic	13.0		30	
Juniper bluff	7.7		58	
Red-oak—Red cedar pasture	3.4		92	
White birch—Prickly ash	1.8		69	
Red and White Oak Woodlot (Severely grazed)	5.3		96	
Red and White Oak Woodlot (Moderately grazed)	8.8		89	

adjoining fields (Blair). While trapping the bluegrass-sweet clover fields a number of wood mice were taken (Table XVII), but these were generally caught in traps less than 35-40 feet from the forest edge.

Field Vole—*Microtus ochrogaster* Wagner

The northern and western limits of the range of this species in the midwest is still in need of careful exploration. Field investigations by the author in central and western Wisconsin and in southeastern Minnesota have suggested the possibility that the range of *Microtus ochrogaster* is coincident with that of the harvest mouse, *Reithrodontomys megalotis pectoralis*, in this region.

It was observed that *Microtus ochrogaster* was the common vole at the localities where harvest mice occurred, while localities that did not yield harvest mice also failed to yield *M. ochrogaster*; replacing this vole in the same ecological niche was the meadow vole, *Microtus pennsylvanicus.*

Microtus ochrogaster may be the most abundant vole over the uplands and sand prairies of the driftless region. It proved to be the only vole common to the upland fields in Westpoint Township, Columbia County, and on the Sauk prairie, Sauk County, both on the eastern border of the driftless area. In western Clark County, Schmidt (1931) found *Microtus ochrogaster* only on sandy plains and slopes of sandstone mounds where there was no heavy covering of grass; *Microtus pennsylvanicus* was taken in hayfields, pastures, and other well-watered habitats.

Records of the field vole from western Wisconsin are limited, but they indicate that this species occurs there freely. Allen (1936) mentions obtaining specimens of the field vole in Vernon County. In the fall of 1942 the writer trapped a number of these voles, as well as three harvest mice, from an upland alfalfa field east of La Crosse in La Crosse County during one night of trapping.

According to Thwaites (unpublished map 1944) the western limits of the driftless area are now recognized as extending not beyond the tops of the Mississippi River bluffs on the Minnesota side. Since data available suggests that the harvest mouse, *R. m. pectoralis*, is found only in or on the periphery of the driftless region (Hanson 1944), it was of especial interest to find a grain stubble-field in a valley near Hokah, Houston County, Minnesota, which was inhabited by both species of voles as well as harvest mice. Allen (1936) also reports finding both species of *Microtus* in a similar valley near Caledonia, Houston County. However, at three localities a few miles west of Hokah and well beyond the edge of the driftless area, the writer was unable to trap either the harvest mouse or the field vole. At these localities (two near Spring Grove, Minnesota, and one 14 miles southwest of Preston, Minnesota) *Microtus pennsylvanicus* and *Peromyscus maniculatus* were the only species of mice obtained.

The field vole and harvest mouse are apparently absent from northeast Iowa (Allamakee and Winnesheik Counties) where *Microtus pennsylvanicus* is abundant as Dr. Sherman Hoslett of Luther College, Decorah, Iowa, was unable to secure an example of this species during an intensive five-year study of the mammals of these two counties. Thus, judging from the evidence available, it seems that the ecological or geological factors determining the distribution of the harvest mouse in the southeast Minnesota-northeast Iowa region may also be operative in the case of *Microtus ochrogaster.*

Cory (1912) notes that prairie voles are commonly found in clover and alfalfa fields, a preference the Prairie du Sac census supports. Stubble-fields become increasingly inhabitable to this species as quackgrass and other weeds gain a foothold, but maximum densities are attained in bluegrass areas (Table XVIII).

TABLE XVIII. Population and relative abundance of the field vole in five cover types, September 21-October 19, 1941.

Cover Type	Calculated density per acre		Composition by per cent of population	
	Field I	Field II	Field I	Field II
Grain stubble	0.2	1.5	13	29
Bluegrass—Sweet clover	2.0	14.1	24	75
Alfalfa	0.6	2.5	8	34
Carex stricta bog	2.0	0.0	28	0
Smartweed—Foxtail	1.9	0.0	4	0

Meadow vole—*Microtus pennsylvanicus pennsylvanicus* (Ord)

The only habitat to yield more than two stray meadow voles was a *Carex stricta* bog. Several other specimens were obtained from a another bog a few miles east of the Prairie du Sac area. Since this species was found commonly only in *Carex stricta*, it seems possible that it could become *locally* extinct through draining and the gradual drying up of these bogs.

TABLE XIX. Population and relative abundance of the meadow vole in three cover types, October 2-19, 1941.

Cover Type	Calculated density per acre	Composition by per cent of population
Alfalfa	0.6	9
Carex stricta bog	2.0	28
Smartweed—Foxtail	4.7	9

Pine Mouse—*Pitymys pinetorum scalopsoides* (Audubon & Bachman)

Pine mice collected in northern Clark County, Wisconsin, by Franklin Schmidt were recently recognized as a new subspecies by Hartley H. T. Jackson (1941). Since the two individuals collected by the author are not in a pelage comparable with the type series from Clark County, the Columbia County specimens are assumed to belong to the race *scalopsoides*. Additional specimens of pine mice have been taken in western Dane County (Blue Mounds) by Phillip Wright (University of Wisconsin collections). Excepting mention of a specimen from Lynxville, Crawford County, (Jackson *op. cit.*) no other published records are available to reveal the distribution of this species elsewhere in the state.

The habitat requirements of the pine mouse in Wisconsin are apparently very specific as all records of this species to date are from oak forests having a heavy carpet of litter and leaf mold. Elsewhere in its range, according to Hamilton (1938), it has been found in such diverse situations as sphagnum bogs and rocky hills about caves. Hamilton (*op. cit.*) quotes Poole as having found pine mice in Pennsylvania on an area having "light sandy alluvial soils supporting scattered trees and shrubs."

One of the two specimens taken on the Prairie du Sac area was trapped above ground at the base of an oak tree, while the other was caught in a trap set in an opened runway in the leaf mold.

TABLE XX. Population and relative abundance of the pine mouse in a red and white oak woodlot, October 25-28, 1941

Cover Type	Calculated density per acre	Composition by per cent of population
Red and White Oak Woodlot (moderately grazed)	0.5	5

House Mouse—*Mus musculus musculus Linnaeus*

House mice attained their greatest densities in cultivated fields where they often were the most abundant species. When their numbers about farm buildings were taken into consideration, there can be little doubt that they were the most numerous mammal on the Prairie du Sac area. Because of their general abundance in fields far from any farm buildings, it is difficult to understand their comparative absence in owl pellets. One reason may be that owl pellet studies usually represent the late winter and early spring months, a period when house mice particularly seek buildings for refuge; another may be that the first spell of severe cold weather greatly reduces the field inhabiting populations.

The high density of this species found in the prairie relic was probably due to an influx of individuals from the nearby area of smartweed and foxtail which had an extremely high house mouse population (Table XXI). However, it should be noted that they were *relatively* uncommon in this undisturbed area.

TABLE XXI. Population and relative abundance of the house mouse in nine cover types, September 21-October 20, 1941.

Cover Type	Calculated density per acre		Composition by per cent of population	
	Field I	Field II	Field I	Field II
Grain stubble	0.6	1.7	34	32
Alfalfa	3.6	1.4	50	19
Bluegrass—Sweet Clover	1.0		12	
Smartweed—Foxtail	34.0		70	
Sandy field	1.1		30	
Short grass prairie relic	5.0		12	
Juniper bluff	0.7		5.3	
Red Oak—Red Cedar pasture	0.3		8.0	
Red and White Oak woodlot (moderately grazed)	0.2		2.0	

Cottontail—*Sylvilagus floridanus mearnsi* (Allen)

Method and Materials.—The method used to census cottontail rabbits was first employed by Durward Allen (1938-1939) in Michigan. It consists of trapping and banding the largest number of rabbits possible and securing a shot sample of the population on the census area. From the ratio of banded to unbanded rabbits in the sample to the total number banded, the actual population is determined. This technique has been used by Lincoln as an adjunct to estimating continental waterfowl populations.

Forty "Pennsylvania type" box traps, as described by Gerstell (1937), were used for the census. All rabbits caught were banded with ear tags which proved to be very satisfactory. Carrots were found to be the best bait as they did not spoil quickly in mild weather and were not as attractive to mice as ear or shell corn.

Census Area.—The census area consisted of approximately 65 acres of woods and brushy cover on the south slopes of Blackhawk ridge, and an area of second growth timber and brushlands adjoining its western base. The observed tendency of wintering cottontails in southern Wisconsin to avoid cold windy slopes made it unnecessary to extend the trap lines on to the north slopes of the ridge. This latter area was not considered a part of the winter range when computing the population. A brief description of the cover types on the census plot and their acreages are summarized below:

Cover Types	Acreage
Ungrazed woods with an abundant understory of shrubs	14
Grazed woods containing scattered thickets of prickly ash, blackberry and red cedar	21
Second-growth oak woods with a poor understory of shrubs	13
Heavy bluegrass, with scattered shrubs, young oaks and stump sprouts (5 small areas)	16
Short grass prairie relic	1.5
Total	65.5

Trapping Operations.—Due to the diversity of the cover types, weather conditions, and the irregular distribution of the rabbit populations in the various coverts, trap movement proceeded in no orderly fashion; instead, the traps were shifted from place to place whenever their efficiency in catching unbanded rabbits suffered a marked drop. In addition to these variables in the procedure, one sector of the census area was trapped continuously during most of the census period. The number of traps used varied, and their efficiency was never 100% as mice sometimes ate the bait or sprung the traps. A summary of the trapping operations is given in the table below:

Trapping Periods	Traps in Use		Trap nights
Nov. 23-Dec. 7	30		420
Dec. 7-Dec. 22	38		532
Jan. 9-Jan. 13	13		52
Jan. 13-Feb. 13	37 (av.)		1148
		Total	2100

A total of 71 rabbits were caught and of these four died in the traps. The number of repeats was small because of the frequency of trap movement. Of the 22 rabbits that repeated, a few were caught as many as three times, making the total number of repeats twenty-nine.

Sampling.—Shooting was believed to be the most efficient means by which an adequate sample of the rabbit population could be secured in the shortest period of time, thereby reducing any error resulting from movements of rabbits into or out of the census area during the sampling period. It was also thought that shooting would obtain a more representative sample than live trapping which might be more apt to take an undue number of rabbits having the trap habit. The latter point, however, still requires further testing. Other sources of error that are present in this technique of censusing have already been discussed by Allen (*op. cit.*) and Dice (1941).

During the first shoot on February 14, a crew of eight secured only three rabbits. The sampling was continued until March 22, but it was with the greatest difficulty that a sample of twenty-one was secured.

Populations.—Twelve of the twenty-one rabbits shot carried bands. As the total number of rabbits banded was known (71, minus three that died in traps), the solution of a simple ratio gave the approximate total population on the census area.

$$\frac{(71-4)}{x} \cdot \frac{12}{21} \qquad 12\,x = 1407 \;. \qquad x = 117$$

In the course of the fieldwork, remains or indications of old kills of 11 rabbits were found. This number added to the 117 implies a peak fall population of at least 128 rabbits on the 65 acres of brushlands and woods, or a density of 2 rabbits per acre. However, the average density for the entire winter would be somewhat less.

ACKNOWLEDGEMENTS

This study was begun under a fellowship from the Wisconsin Alumni Research Foundation, and was completed under a grant from the American Association for the Advancement of Science, awarded through the Wisconsin Academy of Science. During the fieldwork I had the able co-operation of Albert Gastrow of Prairie du Sac, who was censusing other species for the Wisconsin Conservation Department. His keen observations and skill at "reading sign" contributed much to this study.

LITERATURE CITED

ALLEN, DURWARD

1938. Ecological studies of the vertebrate fauna of a 500 acre farm in Kalamazoo County, Michigan. Ecol. Monog., 8: 348-436.

1939. Michigan cottontails in winter. Journ. Wildlife Mgmt., 3: 307-322.

ALLEN, PHILLIP F.

1936. *Microtus ochrogaster* in Minnesota. Journ. of Mamm., 17: 291.

BLAIR, W. FRANK

1940. A study of prairie deer mouse populations in southern Michigan. Amer. Mid. Nat., 24: 273-305. 6 tables, 4 figures.

1940. Notes on home ranges and populations of the short-tailed shrew. Ecology, 21: 284-288.

1940. Home ranges of the meadow vole in southern Michigan. Journ. Wildlife Mgmt., 4: 149-161. 1 figure.

BOLE, B. P. JR.

1939. The quadrat method of studying small mammal populations. Cleveland Museum of Natural History, Scientific Publications 5 (4) Dec., 15-77.

BURT, WLLIAM HENRY

1940. Territorial behavior and population of some small mammals in southern Michigan. Misc. Pub. No. 45, Museum of Zoology, Univ. of Mich. 1-58. 2 plates, 8 figures, 2 maps.

CORY, CHARLES B.

1912. The mammals of Illinois and Wisconsin. Field Museum of Natural History, Pub. 153, Zool. Ser., XI, Chicago.

DICE, LEE R.

1941. Methods for estimating population of mammals. Journ. Wildlife Mgmt., 5: 398-407.

ERRINGTON, PAUL L.
1932. Food habits of southern Wisconsin raptores. Condor, 34: 176-186.

ERRINGTON, PAUL L., FRANCES HAMERSTROM AND F. N. HAMERSTROM, JR.
1940. Great horned owl and its prey in north central United States. Agr. Exp. Sta., Iowa State College of Agriculture and Mechanical Arts, Research Bul. 277: 757-850. 12 tables, appendix.

GERSTELL, RICHARD
1937. Management of the cottontail rabbit in Pennsylvania. Part II. Pa. Game News, No. 2, 8: 8-10, 32. 1 figure.

GOODNIGHT, CLARENCE J. AND KOESTNER, E. J.
1942. Comparison of trapping methods on an Illinois prairie. Journ. of Mamm, 23: 435-438.

HAMILTON, W. J., JR.
1938. Life history notes on the northern pine mouse. Journ. of Mamm., 19: 163-170.

HANSON, HAROLD C.
1944. A new harvest mouse from Wisconsin. Field Museum Natural History, Zool. Ser.

HOSLETT, SHERMAN S.
1940. Unpublished doctorate thesis on the mammals of northeast Iowa. Univ. of Mich., Ann Arbor.

JACKSON, HARTLEY H. T.
1941. A new pine mouse, genus *Pitymys*, from Wisconsin. Proc. Biol. Soc| Washington, 54: 201-202.

JOHNSON, M. S.
1926. Activity and distribution of certain wild mice in relation to biotic communities. Journ. of Mamm., 7: 245-277.

NICHOLSON, ARNOLD J.
1941. The homes and special habits of the wood-mouse. (*Peromyscus leucopus noveboracensis*) in southern Michigan. American Midland Naturalist, 25: 196-223.

SCHMIDT, F. J. W.
1931. Mammals of western Clark County, Wisconsin. Journ. of Mamm., 12: 99-117.

SMITH, CHARLES CLINTON
1940. Succession on abandoned eroded farmland. Ecol. Monog., 10.

SWENK, MYRON H.
1926. Notes on *Mustela campestris* Jackson, and on the American forms of the least weasel. Journ. of Mamm., 7: 313-330.

THWAITES, F. T.
1944. Unpublished map of the driftless area. Univ. of Wis.

TOWNSEND, MYRON T.
1935. Studies on some of the small mammals of central New York. Roosevelt Wildlife Annals, 4, No. 2: 1-120. 22 figures, 8 plates, 4 maps.

WILLIAMS, ARTHUR B.
1936. The composition and dynamics of a beech-maple climax community. Ecol. Monog., 6: 318-408. 16 figures.

THE LAKE STURGEON, *ACIPENSER FULVESCENS* RAFINESQUE, IN LAKE WINNEBAGO, WISCONSIN

EDW. SCHNEBERGER AND LOWELL A. WOODBURY
Wisconsin Conservation Department, Madison, Wisconsin

Fishing for lake sturgeon, *Acipenser fulvescens* Rafinesque, has been permitted for many years in the waters of Lake Winnebago, Wisconsin. For the past three years the open season has been from February 1 to March 1 with spearing as the only legal method of fishing. The legal minimum length is 30 inches and a season's bag limit is five fish. The regulations provide further, that each person spearing sturgeon must purchase a special tag for each fish. In order to collect data on the annual harvest, creel census blanks on addressed and stamped postal cards were furnished each person purchasing these tags. The blanks provided space for the fishermen to record the length, weight, and sex of each fish caught.

Lake Winnebago, the largest inland lake within the borders of the state of Wisconsin, is located in the east central part of the state. It is elongate, with a major axis of about 28 miles lying in a north-south direction and a minor axis of about 10 miles lying in an east-west direction. The lake has a maximum depth of about 21 feet and an average depth of about 15 feet (Juday 1914).

Most of the spearing for sturgeon is done in two areas along the eastern shore, one near Calumet Harbor and the other near Stockbridge Harbor. A limited amount of spearing is also done along the western shore near Neenah-Menasha, Wisconsin.

Schlumpf (1941) described sturgeon spearing in some detail and it is from his article that the following summary of the techniques was made.

Spearing is done from portable shanties placed on the ice one-half to four miles from shore and over the large mudflats which are the feeding grounds of the sturgeon. A rectangular hole about three by five feet is cut in the ice and the shanty moved over the hole. The spearing is done in 13 to 16 feet of water. Broken pieces of pottery or white plates are often dropped in the water so that the bottom is more easily seen and the distance can be more readily estimated when a fish swims into the area. Usually decoys intended to attract the sturgeon are suspended about the hole in about ten feet of water. A variety of decoys, ranging from oranges, lemons and ears of corn to skillfully carved wooden images of sturgeon, is used. The spear is so constructed that the spear and handle are detachable, although used as one unit. Props are attached to both the spear head and handle. When a "hit" is made the handle becomes detached from the spear and the fisherman can then "play" the fish on the rope.

Materials and Methods

The creel census data, as mentioned earlier, were obtained by furnishing each person who purchased a sturgeon tag with a blank to which to record his catch. These cards were distributed for the 1941, 1942, and 1943 seasons.

An estimate of the total take was made on the basis of the assumed proportionality, viz:

$$\frac{\text{Number of persons purchasing tags}}{\text{Number of persons reporting catch}} \times \begin{matrix}\text{Number of fish}\\ \text{reported caught}\end{matrix} = \begin{matrix}\text{Total}\\ \text{catch}\end{matrix}$$

Further information, especially with reference to food habits, length, weight, and age, was desired. Accordingly, Mr. Homer E. Keane, an employee of the Wisconsin Conservation Department, was detailed to Lake Winnebago during the 1942 sturgeon season, to collect the heads, viscera, and accompanying data of as many sturgeon as possible. The heads were collected so that the otoliths could be obtained for age determinations.

For several reasons this assignment was not as simple as it seems. Many of the fishermen were secretive about their success fearing that the "news" might attract too many other fishermen to the vicinity of their particular fishing spot. Other successful fishermen did not wish to part with the head of the fish stating that they used it in the preparation of a special soup. Nevertheless a total of 49 sturgeon heads and 11 alimentary tracts was collected.

A description of the otolith and the methods employed in the preparation of the otolith for reading is given under the section on Ages.

RESULTS OF CREEL CENSUS

A summary of the data on creel census work is found in Table I. Scrutiny of the table will show that the computed total take was 788 fish in 1941, 467 fish in 1942, and 238 fish in 1943, or a fairly proportionate decline. The cause of this decline is not clear but depletion cannot be cited as a definite cause since there are many factors that govern the take of sturgeon. Unfortunately it was impossible to obtain the unit effort expended by the fishermen. There were, however, 110 less fishermen in 1942 and 320 less in 1943 than in 1941, the year of the greatest catch. It is conjectured that in 1943 less effort was expended than in 1941 because of the general labor shortage and fishermen had in general less free time to spend fishing. In addition the winter

TABLE I. Summary of creel census reports on sturgeon spearing in Lake Winnebago for the years 1941, 1942, and 1943.

	1941	1942	1943
Number persons purchasing tags	829	719	449
Number reporting catch	162 (19.5%)	77 (10.7%)	290 (66.3%)
Number reporting 0 fish	78	43	188
Number reporting 1 fish	47	25	64
Number reporting 2 fish	15	6	29
Number reporting 3 fish	14	0	5
Number reporting 4 fish	5	2	1
Number reporting 5 fish	3	1	2
Total number sturgeon reported caught	154	50	155
Computed total take of sturgeon	788	467	238
Average number sturgeon / fishermen (reported)	0.95	0.65	0.53
Average number sturgeon / fishermen (computed)	0.95	0.66	0.52

was quite severe and travel on the ice was difficult because of the deep snow. The season of 1942 was generally considered as a poor year because the ice did not form until late in the winter and the water remained turbid during most of the season.

The sucessfulness of a season is likewise reflected to some extent in the size of fish reported. In 1942, the largest fish was

88 pounds while in 1941, five fish which weighed over 100 pounds each were reported. Their weights were 104, 105, 105, 112, and 135 pounds. In 1943, the largest fish reported weighed 120 pounds and the next largest weighed 90 pounds.

AGES OF LAKE WINNEBAGO STURGEON

Harkness (1924) in his study of the sturgeon used the otoliths or earstones in determining age. Scales usually employed for this purpose in the teleost fish are not present on the sturgeon and according to Harkness the vertebrae could not be used because they failed to show annular markings. The opercles and pectoral fins were examined by us, but these structures likewise showed no annular markings. Therefore, in view of these findings, the otoliths were employed in the determination of age in the present study.

The otolith is a small, curved, roughly triangular piece of calcareous matter. In the specimens examined the length varied from 7.5 to 12.3 millimeters. The composition varies from solid homogenous calcareous material to a conglomeration of small conical particles. The annular markings appear as more or less definite dark bands or lines continuous across the otolith and separated by finer broken lines. Some otoliths could be read with comparative ease, others could not be read at all, while still others could be read up to a certain age but not beyond. An attempt was made to determine the number of annuli by examination under a binocular microscope with the otolith immersed in the glycerine. The attempt was unsuccessful as the annuli could be distingished only with difficulty and could not be counted accurately. Several other immersion fluids of high refractive index were tried but all proved unsatisfactory.

An attempt was made to reduce the thickness of the otolith on a geologist's "thin section" wheel but due to the curvature of the specimens this method could not be used. After much trial and error a method of preparation was evolved that gave excellent results and resulted in a permanent mount that showed the annuli present in a satisfactory manner. This method is described in the following paragraphs.

The otolith was removed from a glycerine solution, drained, and then passed through 95 per cent alcohol, clove oil and xylene, remaining about five minutes in each liquid. Following this de-

TABLE II. Length, weight, sex, and age of sturgeon from Lake Winnebago, Wisconsin, taken during February, 1942.

Length (inches)	Weight (pounds)	Sex	Age (years)
42	19	Male	16
43	20	Male	..*
43	22	Male	16
45	19	Male	19
46	20	Male	21
46	26	Male	15
46	29	Male	16
47	28	Male	14
47	32	Male	18
48	23	Male	18
48	27	?	19
48	45	Female	21
49	31	Male	20
49	32	Male	26
50	20	Male	..*
51	28	Male	18
51	30	Male	15
51	33	Male	21
51	35	?	19
52	40	Male	..*
52	41	Male	18
52	38	Male	19
53	44	Male	18
54	29	Female	22
54	42	Male	22
54	45	Female	27
55	33	Female	12+
56	40	?	16
56	30	Female	24
57	48	Female	23
58	45	Male	18
59	47	Male	21
59	50	Male	21±
60	54	Male	31
60	58	Female	25±
60	68	Male	24
60	70	Female	24±
62	81	Female	40±
63	55	Female	26
63	82	Female	31
64	71	Female	22+
65	74	Female	24
66	78	Female	22+
67	78	Female	11+
..	45 ?	......	23±
..	..	......	27
..	46	Male	18

* Otolith unreadable with any certainty.
± Age near this value but exact figure uncertain.
\+ Age greater than this value by indeterminate amount.

hydration and clearing the otolith was placed in melted xylene-free balsam until all xylene carried in with the specimen had boiled off. It was then mounted on a slide concave, face downwards, in a drop of melted balsam and allowed to cool.

With a small file and a sharp knife the otolith was then thinned down by filing and scraping on the convex side until microscopic examination of the concave surface showed clearly the annular markings.

The dry balsam was then dissolved off in xylene and the otolith mounted in fresh balsam under a cover glass with the concave side upwards.

The otoliths were read with a compound microscope at a magnification of 50 diameters and checked on a binocular microscope at various magnifications. They could not be read on a micro-projection machine of the type ordinarily used for scales.

Out of a total of 49 heads, 47 pairs of otoliths were obtained of which the ages of 35 were determined. The remaining 12 possessed various degrees of readability. The ages ranged from 14 to 40 $\pm$ 3 years. Due to the scantiness of the data and the small numbers of fish in each year-class the average rate of growth of each year-class could not be computed. The smallest fish, 42 inches in length, was a male, 16 years old. The youngest fish was also a male, 47 inches long, and was 14 years old. The data indicates that the females grow at a slightly higher rate and to a larger size than the males. The youngest female was 21 years old and was 48 inches long. A 22 year old female was 54 inches long. Table II gives the available data on length, weight, sex, and age of all specimens whose otoliths were examined.

The available data do not show the age at which maturity is reached. The fish collected, however, were well above the minimum legal length of 30 inches since the smallest specimen collected was 42.5 inches long. Harkness (1924) however, stated:

> "In all fish which were less than 22 years of age it was impossible to determine the sex by macroscopic examination of the reproductive organs. In older fish the sex was readily determined. It is interesting to note that between the ages of 20 and 25 years great changes occur in the outward appearance of the sturgeon. The snout becomes shorter and blunter; the sharp points of the shield disappear; the shields themselves become smoother, and some apparently are entirely resorbed. Without doubt these

changes are associated with the attainment of sexual maturity which is reached apparently at about 22 years of age. Although a female may become sexually mature at this age, it is not until after the age of about 30 years that she begins to produce a large number of eggs. Therefore, the taking of fish of 30 years or less diminished greatly the production of fry and is likely to result ultimately in the complete depletion of the sturgeon."

COMPARATIVE GROWTH OF LAKE WINNEBAGO AND LAKE NIPIGON STURGEON

As the age-length data on the sturgeon of Lake Winnebago from our data and from Lake Nipigon (Harkness' data) were somewhat scanty a direct comparison of length at the same age was not practicable due to the small number of age groups represented in both samples.

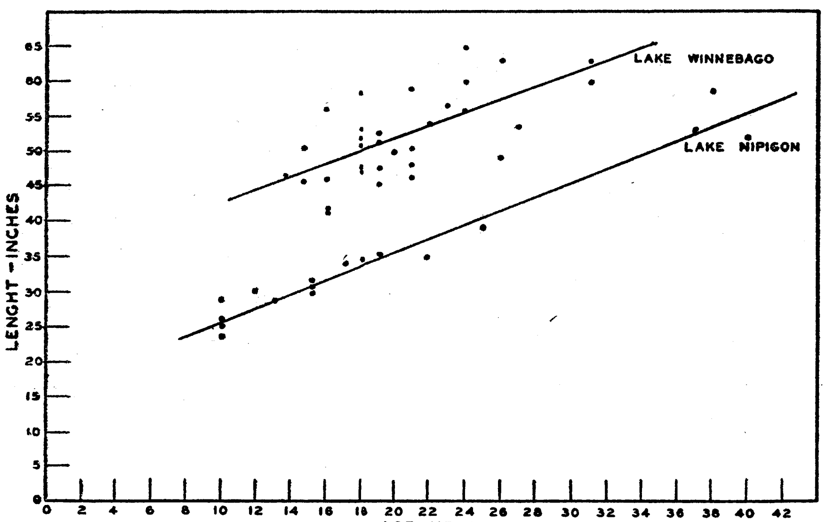


FIGURE I.—RELATIONSHIP OF LENGTH TO AGE OF STURGEON FROM LAKE WINNEBAGO COMPARED WITH THOSE FROM LAKE NIPIGON, CANADA.—CURVES COMPUTED BY THE METHOD OF THE LEAST SQUARES.

In our data the definite ages varied from a minimum of 14 to a maximum of 31 and the relationship of length to age over this range approximated a straight line. The age-length data for the Lake Nipigon sturgeon over this same range, and for a distance on each side also approximated a straight line. A straight line was therefore computed by the method of least squares for both our data and those of Harkness (Figure 1). The equations were as follows:

L = 34.06 + 0.8902 A M (Lake Winnebago)
L = 16.49 + 0.9798 A N (Lake Nipigon)
Where L = length in inches and A = age in years.

The Lake Winnebago equation was computed for the age range 14 to 31 years and the Lake Nipigon equation for the length range 10 to 40 years. A total of 33 pairs were used in computing the Lake Winnebago curve and 18 for Lake Nipigon.

TABLE III. Comparison of computed values of length for sturgeon of the same age from Lake Winnebago and from Lake Nipigon.

Age (years)	Length (inches)	
	Lake Winnebago	Lake Nipigon
14	46.5	30.2
15	47.4	31.2
20	51.9	36.1
25	56.3	41.0
30	60.8	45.9
31	61.6	46.9

Table III shows the computed age-length values at intervals over the range 14 to 31 years. The comparison indicates that the Lake Winnebago fish grow somewhat faster than the Lake Nipigon group. If this is true, it might be expected that the age of maturity for the Lake Winnebago population is less than that of the Lake Nipigon fish. Considerable more data are needed on this point.

FOOD HABITS AND PARASITES

Analysis of the stomach contents indicated that during February the sturgeon were feeding almost entirely on chironomid larvae. Only a small proportion of other organisms such as leeches and small mollusks were found. Table IV gives the results of the stomach examinations.

Dr. C. A. Herrick, University of Wisconsin parasitologist, was invited to examine the heads and alimentary tracts for parasites. With the exception of a few trematodes found in three of the tracts, the fish were free of parasites.

TABLE IV. Results of examination of sturgeon stomachs taken from Lake Winnebago, Wisconsin, during February, 1942.

Length (inches)	Weight (pounds)	Sex	Stomach contents	
			Volume (Cubic Centimeters)	Organisms
43	20	..	130	Chironomid larvae, occasional leeches, numerous pisidium and small snails.
43	20	Male	190 10	Chironomid larvae Leeches
52	41	Male	2	Chironomid larvae
54	46	Female	305	Chironomid larvae
59	55	Male	460	Chironomid larvae
60	59	Female	400	Chironomid larvae
62	81	Female	200	Chironomid larvae
66	74	Female	725	Chironomid larvae
66	78	Female	20	Chironomid larvae
69	54	Male	250	Chironomid larvae
..	..	..	250	Chironomid larvae

ACKNOWLEDGEMENTS

The authors take this opportunity of expressing their sincere thanks to the many fishermen who furnished specimens for study and returned the census cards; to Dr. C. A. Herrick, Professor of Zoology of the University of Wisconsin, who examined the specimens for parasites; and various conservation department personnel who assisted in various phases of the project.

SUMMARY

1. On the basis of the creel censuses conducted it is estimated that 788, 467, and 238 sturgeon were removed from Lake Winnebago during the 1941, 1942, and 1943 spearing seasons.

2. Otoliths were collected for age determinations and a method of preparing them for study is given.

3. The ages ranged from 14 to 40 ± 3 years. The smallest and youngest fish was 14 years old, 47 inches long and weighed 28 pounds. The largest fish was 62 inches long, weighed 81

pounds and was 40 ± 3 years old; the exact age could not be determined with certainty. The females were slightly larger than the males.

4. Analysis of the food found in the alimentary tract indicates that the sturgeon feed mainly on chironomid larvae during February.

5. The specimens collected were relatively free of parasites.

Literature Cited

Juday, Chancey
1914. The inland lakes of Wisconsin. The hydrography and morphometry of the lakes. Bull. No. XVII, Sci. Ser. No. 9., Wis. Geol. and Nat. Hist. Survey, Madison, Wisconsin

Harkness, W. J. K.
1924. The rate of growth and the food of the lake sturgeon (*Acipenser rubicundus* Le Sueur). Univ. of Toronto Studies, Pub. Ontario Fish. Res. Lab., 18: 15-42.

Schlumpf, Charles A.
1941. The spearing of sturgeon in Lake Winnebago. Wis. Cons. Bull., 6: 33-36.

THE BUR OAK OPENINGS IN SOUTHERN WISCONSIN

A. B. Stout

The New York Botanical Garden

A Typical Oak Opening.—Bur oak openings were the principal timbered lands over a considerable part of southern Wisconsin when this region was homesteaded about one hundred years ago. Today only a few remnants of these once numerous natural parks still survive. One of these, about 50 acres in extent and still in good preservation, is situated a few miles to the north of the village of Albion in Dane County. A similar grove now of smaller area is located about a mile to the southwest. The illustrations (Plates 1 and 2), from photographs taken in this grove in 1941, show the stately grandeur and the rugged beauty of natural stands of this type of tree growth.

In this particular oak opening the trees are, I believe, all bur oaks (*Quercus macrocarpa* Michaux); but in some of the other oak openings of the area and especially on the belt of moraines there were trees of the white oak (*Quercus alba* L.). These oaks are all broad-topped and so spaced that seldom are the branches of two trees interlocked. Also they are rather uniform in size. There are no young trees or shrub growth anywhere in this grove nor has there been such growth here for at least one hundred years. Between the trees there is the firm turf of native grasses that has never been disturbed by cultivation. The entire area of this grove is almost level, as are the reaches of formerly prairie land that lie adjacent to the grove and which continue for some distance immediately to the east and the northeast. But many of the openings of the region were on the more rolling and undulating uplands. A small, shallow, and rather sluggish stream (Saunders Creek) flows close to the south of this oak opening and along its banks, both above and below the grove, there are flat marshy grasslands that are often of considerable extent and occasionally there are areas of tamarack swamp. These lowlands and their water-table are, as a rule, only slightly below the general level of the uplands. Marshes are abundant throughout much of the prairie-oak opening area that was glaciated and on which the drainage is geologically still young.

It seems to the writer that the trees in this grove are scarcely any larger today than they were fifty years ago. The present owner, Mrs. D. L. Babcock, is the daughter of Jacob Langworthy who in the year 1842* became the owner of the farm which includes this grove. She has resided on this farm for 85 years and her recollection is that the character of this oak opening has remained unchanged during all this time. It is known that "prairie fires" burned over this area both before and for some time after the arrival of the early settlers. Storms have broken down or uprooted some of the trees; but except for the removal of such trees no wood has been cut in the grove. About 50 years ago nearly 100 of the trees were blown down at one time and during a storm in 1941 nearly 30 trees were uprooted. The counts that have been made of the annual rings of growth of these trees indicate that the present age of most of the trees is at least 200 years. The owners have taken an unusual and commendable pride in this grove that has prompted them to keep it intact. For about 90 years its area has been pastured by cattle and horses and for some of this time by sheep but never by swine.

Oak Openings in Wisconsin.—The Babcock Oak Opening as it stands today is typical of the groves which once covered a considerable part of an extensive area in Wisconsin. This region extended across the entire southern boundary of the state. Northward its width from east to west decreased, with irregular border limits, until it terminated near Rush Lake. Roughly the entire area in Wisconsin comprised about 5,000 square miles and it formed a broad-based wedge that projected northward into and almost through a wide belt of more dense forest growth in which oaks were, and still are, the dominant species.

Dane County, in the southeast corner of which is the township of Albion, is situated near the center of the area of oak openings. Rock County lies partly adjacent to Dane County and south of it. These two counties were quite typical of the best developments of the prairie-oak opening vegetation in Wisconsin.

---

* The first four white settlers in the town of Albion arrived during the summer and autumn of 1841.

Plate 1. View near the border of the Babcock Bur Oak Opening, looking eastward across an area of former prairie. In the distance a woodland of second growth is in sight. Photo in 1941 by the author.

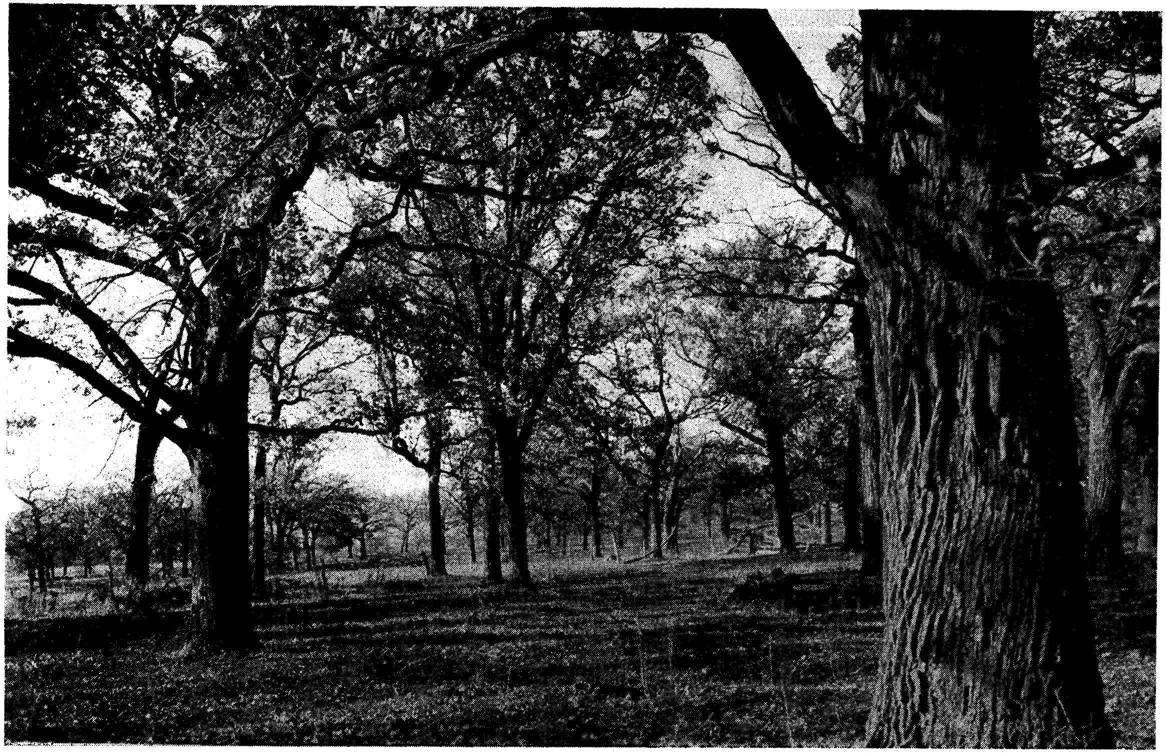


PLATE 2. View looking westward across a section of the Babcock Bur Oak Opening near Albion, Wisconsin. Photo in 1941 by the author.

Early Records for Dane County.—The notations with the early land surveys of Dane County record that the areas of forest growth were mostly scattering oak trees which were referred to as oak openings. In describing "the face" of Dane County, Lapham in 1846 states that "there are no considerable portions that can be called timber land, it being almost entirely oak openings or prairie." A "History of Dane County" (5), published in 1880, makes both general statements regarding the entire county and rather definite statements for each township in respect to the character of the native vegetation. Some of these statements may be quoted here.

> "The prevailing timber of Dane County is small oak, occurring in patches or groves, constituting what is known as oak openings" (p. 309).—"Bur Oak. This is perhaps the most ornamental of our oaks. Nothing can exceed the graceful beauty of these trees, when not crowded or cramped in their growth but left free to follow the laws of their development. Who has not admired these trees in our extensive bur oak openings" (p. 128).
> The statements for several of the townships may be quoted. (For Albion (36 square miles): "The northeast part is mostly prairie; the southeast, oak openings; the northwest, openings and marsh; and the southwest are openings, except sections 19 and 30, which are marsh." — For Dunkirk Township adjacent at the west of Albion: "The lands in this town are diversified by oak openings, prairie and marsh." — For the township of Rutland next west of Dunkirk: "The larger part of the land is openings, while little, if any, may be termed prairie. The soil is rich and productive. There is a lake known as Island Lake which in early times was considered a curiosity. It has an island near the center of about three acres. This was once thickly wooded with good rock maple trees with no others within twenty miles." — For the township of Oregon, third to the west of Albion: "The surface in most places is beautifully undulating, while in other places it is called hilly. It is principally covered with bur oak, among which stood large white and red oaks, and occasionally a large shellbark hickory. The entire town was covered with a sweet and nutritious grass, called blue joint.* As this grass was burned every fall, and there was no underbrush of timber, a two-horse

* Evidently the name "blue joint" here refers to *Andropogon furcatus* Muhl. For this species Shantz and Zon (15) give the common name "bluestem" and later Shantz (20) gives the name "big bluejoint." The species *Calamagrostis canadensis* also known as "bluejoint" was abundant in the marsh meadows of Dane County.

wagon could be driven through these openings with ease. As these annual fires prevented the roots of the timber from growing near the surface, the land was broken for the same price for breaking prairie, hence it was claimed the oak openings combined all the advantages of prairie and timberland." — For Blue Mounds, second township from the south in the western tier of five townships and about 30 miles from Albion: "The timber supply of the town of Blue Mounds is perhaps as varied as can be found in any locality in the county, there is oak in variety, black walnut, butternut, hickory (bitter and sweet), poplar and other timbers." — For the town of York in the extreme northeastern corner of the county: "The land of this town is oak openings, with occasionally marsh, there being no prairie within its borders." — For Black Earth in the northwestern corner of the county and second township north of Blue Mounds: "Section 24 is mostly marshy land, the remainder of the town being oak openings, with little if any prairie." — For Berry Township which joins Black Earth: "This country, in its native condition was timbered principally with oak, there being heavy growths of white oak in the high lands, and bur oaks in the bottom lands." — For the township of Madison near the center of the county: "The land is undulating, generally covered with oak openings."

The native forest vegetation over the other 26 townships was quite like that of the nine townships for which the reports are quoted. The eastern and western boundaries of the county did not extend into the region of denser oak forest, but within the confines of the county there were somewhat isolated areas of such timber at the time when the areas were first settled. For several of the townships, however, there are statements in this publication of 1880 which refer to the changes in the character of the timber that had already occurred since the area was settled, and these will be noted later in this article.

Early Records for Rock County.—Of the native vegetation in Rock County, which lies to the south of Dane County, there are rather adequate statements in an early publication (2) that appeared in 1856. Some of the most pertinent of the statements will be quoted.

"This county is about equally divided between prairie and oak openings. The trees are so scattering that men frequently make farms without felling—only girdling them —besides the openings are annually burnt over, like the

> prairies. On Rock River is a belt of timber and openings. Groves are interspersed through the prairies at intervals, besides which, points of openings jut into the prairie at different places, thus rendering the outlines of the prairie unequal, and at the same time bringing wood and timber within a short distance to all its settlers; in fact few men on the prairie live more than three miles from timber."

The record for several of the townships may be given here. Of the five northern townships of Rock County, the middle one, Fulton, lies adjacent to and directly south of Albion. For this township:

> "It has several small and beautiful prairies. The timber is of large growth, suitable for sawing and building purposes." There are records of sawmills at the villages of Fulton, Newville and Edgerton in this township at this early date (1856). — For the township of Rock, the third directly below Albion: "That part upon the east side of the river is nearly all prairie, but that upon the west side is mostly timber, some of it being very good, though the greater part being oak openings."

Records similar to these noted above could be quoted for the counties or portions of them which lie to the east and to the west of Rock County and to the immediate north of Dane County.

The Oak Openings in Relation to the Native Vegetation of Wisconsin.—A brief but very excellent description of the "classes" or "groups" of the main natural associations of plant life in Wisconsin together with a map of their extent and distribution was presented by Chamberlin (4). In discussing the "oak group" Chamberlin (pages 177-181) makes the following statement:

> "This is most nearly related and most closely associated with the prairie group. The prairies are rarely contigious to any other form of aboreous vegetation. — The group as here constituted includes both the 'oak openings' or 'oak orchards,' and the denser oak forests. There are sufficient reasons, however, for separating them into two classes, as they indicate different, though allied, agricultural capabilities. The oak openings are most nearly related to the prairies, while the oak forests graduate to the following classes." The "classes" here referred to are designated "The Oak and Maple Group," "Maple Group," "Maple and Beech Group," and "The Hardwood and Conifer Group," which are, in part at least, included in the northern arm of what is now termed the northeastern hardwood forest.

Thus the bur oak openings comprised almost pure stands of the one species, *Quercus macrocarpa* (with a sprinkling of *Q. alba* especially on the higher lands) and they constituted the most characteristic arboreal association that was in direct contact with the prairie. The belt of oak openings extended between the prairies and the denser deciduous forests, in which there was, and still is, a mixture of various species of trees, especially red oak (*Quercus rubra*), shellbark hickory (*Carya glabra*), large-toothed aspen (*Populus grandidentata*) and such shrubby underbrush as hazel nut (*Corylus americana*) and panicled cornel (*Cornus paniculata*). The transition from oak openings to the denser oak forest involved interpolations, intergradations, and some intermingling of the two types of timber.

It may be noted that both the oak openings and the denser oak forest of the oak group as described by Chamberlin combine to form in Wisconsin and Minnesota the northern element of what has more recently been termed the "oak-hickory association" and that this constitutes the western margin or zone of the still more extensive "oak or southern hardwood forest." It has been stated that this entire oak forest "is probably the largest hardwood forest in the Temperate Zones of the World" (15). Of the character, location, migration and extent of this forest there are numerous publications, especially those by Shantz and Zon (15) and Shantz (20).

The Vanishing of the Prairies and the Oak Openings in Wisconsin.—The fertile prairie lands were ready for the plow of the settlers. But on many of the homesteads in Dane County and in neighboring counties the acreage was mostly oak openings and many of the trees were removed or at first merely killed by girdling to provide land for cultivation. For a time some of the oak openings were utilized as pasture lands for cattle, horses, and sheep, especially if there were no lowland meadows in a farm. Between the scattered trees of the oak openings the native grasses flourished and provided excellent grazing land.

Previous to 1900 many public gatherings, on such holidays as Decoration Day and Fourth of July, and community picnics were held in an oak opening where the checkered shade of the trees contributed much to the comfort of all. But the extension of cultivated farmland steadily reduced the area of the oak openings. To some extent the needs for timber for building homes, for the construction of rail fences, and for firewood contributed to the removal of the grand old trees of bur oak and white oak.

Natural Reforestation by Second Growth.—While the bur oaks were rapidly being decimated and the areas of oak openings were disappearing in the region about Albion, as elsewhere in southern Wisconsin, there was a most remarkable spread and increase of new or "second growth" stands of "black oaks." This noteworthy and conspicuous natural reforestation entirely changed the character of the arboreal population in this particular area during the years between 1850 and 1890. Here this second growth was almost entirely composed of *Quercus rubra* L. and *Q. coccinea* Muench. Thus a survey of the flora of Madison and vicinity (7) published in 1892 at a time when the second growth forests were well advanced contains the following statements:

> "*Quercus rubra* L. forms a considerable element in the older forests of the region" and "*Q. coccinea* Wang. forms the chief element in the oak forests of the region." *Quercus alba* was reported to be present in "all woodlands of the county" and to be next to *Q. coccinea* in abundance. *Quercus macrocarpa* was reported to be "represented in all parts of the region by small clumps or single individuals of medium sized trees." These authors mention the presence of only one other species of oak (*Q. bicolor*, Willd.) in Dane County and they make no mention of the oak openings which had formerly been abundant about Madison.

This second growth of timber appeared as seedlings which were often in such numbers that they formed thickets over many upland areas that were not cultivated or heavily pastured. Often the second growth invaded oak openings and filled in about the old trees of bur oak and white oak. As a result, in a span of some 40 years, nearly every large farm in the area about Albion possessed at least one "woodlot" of close-standing "black oaks" of which many were no more than 12 inches in diameter at the level of the ground. Some of these woods covered an acreage in which there had previously been no, or at least few, black oaks to serve as parent seed trees. But scattering trees of these oaks and areas of rather dense woods which contained black oaks were interpolated within the area dominated by oak openings, especially near certain streams and lakes.

Thus the second-growth oak forest composed of the so-called black oaks became the principal natural association of tree growth about Albion where the oak openings had formerly been abundant. Perhaps the largest acreage of this second growth was in existence here about 1880-1890. It was the rule that the trees stood close together with no growth of grass between them. Especially after 1890 many of these woodlands were cut over for firewood or were entirely cleared. But fine stands of this timber still exist. One such woodlot is shown against the horizon in the middle of the view of Plate 1.

Scattered through many of the second-growth woods there were, and still are, towering monarchs of white oak and somewhat lower trees of the bur oak whose knarled trunks were usually from three to four feet in diameter. These had existed here when the site was an oak opening. In these trees the red-tailed hawks build their nests. The larger branches and trunks are often hollow and in such cavities the screech owls nest, and the abundant fox squirrels and the less frequent and more secretive flying squirrels make their homes.

The writer can attest that in these woods near the village of Albion, as well as in the oak openings, he has rarely observed, about one of the bur oak trees, any younger trees that could have grown from its acorns. However when second-growth woods were cut over and not severely pastured a "third-growth" reproduction often contained some seedling reproduction of both white oak and bur oak.

There has been some seed reproduction of both bur oak and white oak during the period of second growth in localities where conditions favored such reproduction. One such area recently studied by Chavannes (21) is located in the northwestern corner of Dane County a few miles distant from the townships of Black Earth and Barry in an area of the early oak openings. This particular woodland covers sixty acres. The timber surrounds several small areas of hillside prairie the largest of which (Beech's prairie) covers only one half of the area. Bur oak trees surround this island of relic prairie, and next to them is a stand of white oak in a part of which there is a recent growth of linden. Of both the bur oak and the white oak there are old wide-spreading trees as much as 250 years old which once formed an oak opening. Now younger trees of the bur oak stand in a concentric distribution about the plot of prairie and there are also younger trees of the white oak. The study reveals that the growth of the other arboreous species, such as linden, aspen and sumac, is an invasion during the past one hundred years. No doubt there are now many areas of second growth in the region of the oak openings in which there have been recent reproductions from the seed of *Quercus macrocarpa* and *Q. alba*. But it is certain that such reproduction has been relatively much less over the entire area than the reproduction of other woody species, especially of the so-called black oaks now found in the area.

Records of the Second Growth.—Mention of this development of second growth was made in some of the publications already quoted. In the History of Dane County (5) in the report of the township of Blooming Grove (second in the diagnonal northwest from Albion) there are the following statements:

> "In an early day there was but little timber in this town in common with localities adjacent and what there was was used with the utmost prudence. Some of the farmers sowed locust seed to raise timber, but nature soon supplied the want and now there is enough and to spare of white, black, and red oak and other kinds."

Another record for the town of Perry in the southwest corner of Dane County and the sixth township directly to the west of Albion is of special interest:

> "Largely rolling prairie, northeast part is principally rolling prairie. The southern part on the other hand, being made up more of bluffs and low-lying bottoms. The town in its native state was covered with brush and grubs, there being scarcely enough timber to supply the wants of the farmers, but now there is an abundance of young timber, the growth of the last thirty-five years. It consists of white, black, and red oak, including other kinds indigenous to this part of the country."

The development of second growth in the prairie-oak opening area in Wisconsin has been noted in numerous technical publications of which one by Sargent (6) will here be quoted:

> "The forest area has somewhat increased in the prairie regions of the state since its first settlement and the consequent decrease of destructive prairie fires. The growth of trees has gradually spread from the bottom lands of the streams to the hills, and the oak forests on the uplands have gradually encroached upon the prairie, losing

their open, park-like character by the appearance of a young growth which has sprung up among the old trees."

That this increase of forest involved the spread and to some extent the introduction of black oaks rather than the reproduction of the original species of bur oak and white oak was later recognized by Sargent (9) in the following statements which refer to a wide area of the Mississippi basin as well as of Wisconsin:

> "Forests of oaks, too, have spread over regions in the basin of the Mississippi where prairies existed before the white man checked the Indian fires which year after year had swept them bare of trees. The oak forests of the middle and southern states, although increasing in area, are deteriorating, however, in composition, the white oaks being gradually overpowered by the less valuable black oaks, whose bitter acorns are left to germinate by hogs which pasture in the forest and devour the sweet acorns of the white oaks."

This statement of the fact that there was a rapid and selective reproduction of the black oaks applies to the developments in Dane County noted above, but here the selective feeding on acorns by hogs was never more than a most rare and incidental occurrence.

Considerable attention has been given to the factors involved in the reproduction and migration of species of *Quercus*. Gleason (13, p. 120) discusses these matters but decides that the determination of these factors is not sufficient to explain the distribution and migration of the oaks in Illinois. More recently Korstian (17) has determined many of the factors which affect the production and the germination of the acorns and the survival of the seedlings of several important species of oak, and he has made application of this data to silvicultural methods. But it is not fully evident how such factors operate in natural selective and adaptive reproduction in which the inherent characters of various species of oaks are involved.

It may be stated (a) that this extension of the forest was the latest period in the general western advance of the oak forest which had long been in progress in the Mississippi Valley; (b) that this was at first favored by the cessation of prairie fires; and (c) that the natural advance of the forest was then checked and the area of the natural oak-hickory belt of timber much reduced by the extension of agriculture. An excellent discussion of "The Vegetational History of the Middle West" together with a bibliography has been presented by Gleason (14).

The Natural Range and Variations of the Bur Oak.—The species *Quercus macrocarpa* is distributed over a wide area of the United States and Canada and in its population there are noteworthy diversities in botanical characters, in habits of growth that exhibit adaptations to habitats, and in associations with other species of plants.

Trees of the bur oak are found over the entire range of the southern hardwood forest and also over a considerable part of the northeastern hardwood forest as these are mapped in the Atlas of American Agriculture (15). The climax in the stature of trees of this species is reached in the rich bottomlands of southern Indiana and Illinois in the southern hardwood forest where individual trees reach a height of 170 feet and a trunk diameter of 6-7 feet (9).

Throughout most of their range the trees of the bur oak are scattered among trees of other species and the associations involve a considerable number of species. So general is this habit that one writer (22) makes the following statements:

> "Bur oak never grows in dense stands, but as individuals or in groups associated with other bottomland trees such as pin oak, white oak, basswood, willow, cottonwood, black walnut, the hickories, elms and soft maples. It grows well on rich, moist bottomlands and on lower slopes, preferring areas where water is available but not excessive. Of relatively slow growth, it reaches great ages and is not considered mature before 200 to 300 years."

In its mid-western range the bur oak reaches the western limits of the tall grass prairies in western Nebraska—about 600 miles directly to the west of the bur oak openings of Dane County, Wisconsin. Pound and Clements (10, p. 148) report on the bur oak in this region as follows:

> "*Quercus macrocarpa* is the sole species of oak which grows over the entire state. It extends from the bluffs of the Missouri to the canyon sides of the foothills. The individuals exhibit the greatest variation in different habitats. In the deep forests of I and II* '*Quercus macro-*

* Refers to the "Wooded Bluff" and the "Prairie" regions in Nebraska.

> *carpa*' is a tall commanding tree, which is usually the principal element in the formation. Northward along the Missouri the bur oak steadily decreases in size in forest formation and becomes a conspicuous object along the tops of the high dry bluffs. The front of the bluffs of both the Niobrara and the Republican is covered almost exclusively with individuals of this species. At the base of the bluffs they are usually small trees, 3-5 meters high. But toward the top they decrease regularly in size, and become diffusely branched, so that the tops of the bluffs are covered with a dense thicket of low straggling bushes, 5-10 decimeters high."

It is evident from these statements that in 1898 the stands of bur oaks in Nebraska were quite different from those of the oak openings in Wisconsin. They were much more diverse in habits of growth and there was much greater natural reproduction. Weaver and Kramer (19) report in 1932 that in Nebraska "in many places the bur oak is invading the grassland" and that "most of this migration and invasion has occurred in the 70 years since the early settlement of eastern Nebraska and the cessation of prairie fires." They describe and illustrate (see their Figure 2) as typical of the "forest margin in eastern Nebraska" a "pure open stand" of bur oaks mostly 50 to 65 years old that were rather widely spaced (10 to 40 feet) but yet standing somewhat closer together than are the trees of the Babcock grove at Albion, Wisconsin. These authors report for the root system characteristic of the bur oaks in Nebraska that (a) there is a rapid growth and deep penetration (as much as 3-5 feet the first summer) of the roots of seedlings; (b) that as trees mature the skeleton of larger roots is wide spreading, and much branched, and hence occupies a very large volume of soil; and (c) that fine much-branched rootlets clothe this framework. It is noted that this widely spreading, well-branched root system compensates for the low water content of the soil, provides a means of successful competition against grasses and shrubs, and contributes to a competition between trees of the bur oak that results in the somewhat wide spacing noted even in pure stands.

Further to the north of Nebraska the bur oak extends into the area of the short grass prairie and here in the cold dry areas of Dakota and eastern Montana plants that are classed as *Quercus macrocarpa* become merely low shrubs, and in the most northern range of this species at Berens River in Canada the members are described as bushes.

Oak Barrens.—Trees of the bur oak occasionally form the chief arboreous vegetation on sandy areas where the soil is much less fertile than the soils of the bur oak openings of Dane County. In the volume of Minnesota Plant Life, MacMillan (11) makes the following statement:

> "The bur oaks in Minnesota, together with the black oaks, form oak barrens. These wastes, covered with grotesquely branching trunks, form picturesque forests in the central part of the state."

But MacMillan (8, 11) makes no mention of any remnants of the oak openings in Minnesota in the zone of the hardwood belt that was in contact with the prairies.

In his "Notes on the Big Woods" of Minnesota, published in 1875, Winchell (3) states that the western boundary of this forest

> "is not well marked, the trees gradually becoming thinner and smaller, and more and more restricted to the valleys of the streams, till the country is changed to a treeless prairie. Around the outskirts of the woods small oaks and aspens constitute almost the only arboreal vegetation." His only mention of oak openings is in the statement that "There is a species of oak that appears like red oak (*Quercus rubra* L.) that frequents the outskirts of the Big Woods. It is sometimes associated with the bur oak in the openings."

In his studies of the vegetation of the inland sand deposits of Illinois, Gleason (13) also describes a bur oak association which occupied the depressions between sand ridges. The bur oak was the principal tree, but trees of white oak and shellbark hickory were also present. The stand of trees was somewhat close and the trees were rather young (see his Figure 1, Plate XVI). In this sand area Gleason found in 1910 that the trees which were invading the prairies were black oaks, chiefly of the species *Quercus velutina*. There were in this area no oak openings of the type of the Babcock grove in Wisconsin. In the discussion of the Barrens of Illinois, Indiana and Iowa, Gleason (13) notes that these areas are characterized by a sparse low growth of scrub oak (*Quercus velutina*), hazel and wild plums.

It should be noted here that the "oak openings" near Toledo, Ohio, which were described by Moseley (18) also occupy a sandy area partly covered with low sand dunes, that although several species of Quercus were found on the area the bur oak was not present, and that this particular association is more like the oak barrens than the bur oak openings in Wisconsin.

The Ecological Status of the Bur Oak Openings.—Several features of the oak openings in Wisconsin are characteristic and conspicuous: (a) the trees are of nearly the same age and of good tree-like stature; (b) the trees were scattered or separated in a park or orchard-like disposition with dense sod of grasses between them; and (c) there had been for many years no reproduction from seed of the trees and no invasion by other woody species.

The trees in these bur oak openings, judging from those now in the Babcock grove, date back to about 200-250 years ago, a rather short and recent period of time when the entire interval of the post-glacial history of the area is considered.

Various writers have supported the view frequently expressed from an early date and already referred to in this article, that the prairie fires of the Indians were an important factor in destroying tree growth in the belt adjacent to the prairies and that one result of this was the development of the oak openings. Gleason (14) has supported this view and described the probable process as follows:

> "The fires destroyed seedling trees at the west margin of the forest, preventing further advance in that direction. It is doubtful if they penetrated far into the forest, but by destroying the undergrowth and killing the more susceptible species, they gradually reduced the forest to the park like condition known as oak openings" (14, pp. 80-81).

According to this view the oak openings in Wisconsin and in neighboring states were remnants of an earlier and more dense marginal forest of which the older of the bur oaks and white oaks withstood destruction by fires.

But in the Babcock grove the character of the grove has remained quite unchanged since the last prairie fires swept the area. During this time in the area of this grove there continued to be no seed reproduction of the bur oaks already there; but there was also relatively little reproduction of bur oaks and white oaks over the entire area.

What became of all the acorns produced in this Babcock grove during the past one hundred years? From the general evidence at hand, especially summarized and presented by Korstian (17), large numbers were eaten by rodents and weevils; perhaps few germinated and had even a chance to live in competition with the sod; and finally it may be that seedlings of the bur oaks and of any invading woody species were destroyed in the browsings of cattle, horses and sheep. It would seem that the facts in this situation, as well as those for the decided selective reproduction of black oaks over white oaks, could yet be determined by direct observation and experimentation, and also that the matters of reforestation warrant such study.

It may be noted that the association of a dense sod of grasses with a scattering distribution of trees is a somewhat unstable and obligate relationship. An increase in the stand of the trees will eliminate the grass beneath the canopy of the branches. But the dense sod of grass roots and rhizomes make it difficult for seedlings of hardwoods to become established.

The rather robust growth of the bur oaks in the oak openings of Wisconsin is no doubt due to the fact that the trees have developed on rich fertile land that has received adequate rainfall for tree growth. The area of the tall grass prairies bulges eastward into southern Wisconsin and over most of Illinois. Over a considerable part of this area the amount of rainfall has in recent time become favorable to forest growth and the oak forests which were advancing to the west had in 1850 already become a belt of considerable width. The oak-hickory portion of the oak forest belt covered (a) much of the fine farm land of Ohio and Indiana, (b) portions of southern Michigan and southern Wisconsin, (c) parts of Minnesota, Iowa and Illinois, and (d) portions of other states to the southwest.

Northward in Minnesota the entire oak belt became a narrow strip along the western edge of the Big Woods and in its marginal contacts with the prairie there was rapid decrease in the size of the trees (3). This decrease in the stature of the tree growth was quite general and continuous along the entire western fringes of forest in the Mississippi Valley and northward in Canada. Here several hundred miles to the west of the Wisconsin oak openings there was not only sparse and scattered distribution of woody species but also much reduction in stature.

That other species besides bur oak and white oak may dominate "openings" is to be recognized. Sargent writing in 1882 and 1883 (6), states that the original forests of the oak belt in Ohio and Indiana had already been "largely removed in the developments of agriculture." For Illinois he reported that the forest growth of the prairie region "was confined to the narrow river bottoms and occasional open park-like groves of bur, scarlet, red, black jack or post oaks, known as 'oak openings'." While many areas of this timber in Illinois have now disappeared, as elsewhere in the Mississippi Valley, some areas of them still exist. In his report on the flora of the Chicago area published in 1927, Pepoon (16, p. 47) shows a photograph of a typical bur oak opening and states that this type of association was at that date characteristic of the bur oaks on the ancient lake benches of the area.

Although trees of the bur oak are found as far south as central Texas, it seems that in that region other species of oak are most frequent in the "open forests" and "cross-timbers" which are adjacent to the dry prairies [Sargent (6), p. 540]. Also in Indiana territory the timberlands that are interspersed with the prairies are mostly post oak (*Quercus stellata* Wang.: *Quercus obtusifolia* Michaux.) and black jack oak (*Quercus marylandica* Muench.) and in their most western range there is the stunted growth of these species which is characteristic of the "cross-timbers." But these species disappear to the north near the Cimarron River [Sargent (6), p. 543] and in Kansas and Nebraska the bur oak becomes the most abundant species of tree. Several hundred miles to the eastward the black jack oak (*Quercus marylandica*) reaches its northern limit on the sand prairies of central Illinois on areas where the bur oak is not present (12).

The Matter of Terminology.—Under the term "opening" Webster's *New International Dictionary*, Second Edition, 1842, gives the following definition: "A thinly wooded space, without underbrush, in the midst of a forest, or grove; as oak-openings." But the bur oak openings in Wisconsin were not in the midst of a forest; they were most often surrounded by or bordering on prairie grassland.

In the *Century Dictionary and Cyclopedia* (1900) there is the following definition:

> "Opening. 5. A clear, unobstructed or unoccupied space or place; specifically, in the United States, a tract over which there is a deficiency of forest, trees being not entirely wanting, but thinly scattered over the surface, as compared with their abundance in an adjacent region. The word is most frequently used with this meaning in Wisconsin and neighboring states on the west and as the scattered trees are frequently oaks (*Quercus nigra,** jack-oak, and *Q. obtusifolia,*** post oak, are the most common species) such openings are often designated as *oak openings*. Similar tracts in the more southern states, especially in Kentucky, are called *barrens* and *oak barrens*."

There follows a quotation from Cooper's novel, *The Oak Openings,* in which there is mention of the bur oak. The two species of *Quercus* mentioned in the quotation above are the principal oaks of the Cross-Timbers area in Texas and Oklahoma, but neither was present in the extensive oak openings in Wisconsin nor is now found in the state.

It appears that the term "oak orchard" employed by Chamberlin (4) has had rather limited use in the literature of oak openings, and that the terms "park" and "grove" have rather wide applications which include other types of tree growth. The term, chaparral (15, especially Figures 6 and 7), is especially applied to broad-leaved woodlands of the southwest which range from "an impenetrable thicket of low shrubs to open oak stands" some of which may somewhat resemble the oak openings of Wisconsin but are entirely composed of different species.

Since the oak openings of Wisconsin constituted a somewhat definite type of prairie grassland and oak forest association in which the bur oak was more abundant than the white oak it seems suitable to apply the term "bur oak openings."

A Commemoration of the Oak Opening in Literature.—The bur oak openings received special mention and distinction in the historical novel *The Oak Openings* which was written by James Fenimore Cooper in 1848. The scene of the beginning of the story in the year 1812 was in a bur oak opening on the banks of the Kalamazoo River in Michigan. The description is as follows:

> "The country was what is termed 'rolling,' from some fancied resemblance to the surface of the ocean, when it

* = *Quercus marylandica* Muench.

** = *Quercus stellata* Wang.

is just undulating with a long 'ground-swell.' Although wooded, it was not, as the American forest is wont to grow, with tall straight trees towering toward the light, but with intervals between the low oaks that were scattered profusely over the view, and with much of that air of negligence that one is apt to see in grounds, where art is made to assume the character of nature. The trees, with very few exceptions, were what is called the 'burr-oak,' a small variety of a very extensive genus; and the spaces between them, always irregular, and often of singular beauty, have obtained the name of 'openings,' the two terms combined giving their appellation to this particular species of native forest, under the name of 'Oak Openings.'

"These woods, so peculiar to certain districts of country, are not altogether without some variety, though possessing a general character of sameness. The trees were of very uniform size, being little taller than pear-trees, which they resemble a good deal in form; and having trunks that rarely attain two feet in diameter. The variety is produced by their distribution. In places they stand with a regularity resembling that of an orchard; then, again, they are more scattered and less formal, while wide breadths of the land are occasionally seen in which they stand in copses, with vacant spaces, that bear no small affinity to artificial lawns, being covered with verdure. The grasses are supposed to be owing to the fires lighted periodically by the Indians in order to clear their hunting-grounds."

This excellent description of an oak opening was based entirely "on the evidence of documents" furnished to Cooper by the "bee hunter" who was an important character of the novel, and later a well-known citizen of Michigan, General Benjamin Boden.

In the concluding chapter of the novel *The Oak Openings*, Cooper tells of his journey during the summer of 1848 from his home near Cooperstown, N. Y., to Kalamazoo. This, he states, was "an occasion which offered to verify the truth of some of our pictures, at least by personal observation." The portion of this journey from Detroit to Kalamazoo was by railroad and of the natural scenery Cooper makes comment as follows:

"The whole country was a wheat-field, and we now began to understand how America could feed the world. Our road lay among the 'Openings' much of the way, and we found them undergoing the changes which are incident to the passage of civilised men. As the periodical fires had now ceased for many years, underbrush was growing in lieu of the natural grass, and in so much those groves are less attractive than formerly; but one easily comprehends the reason, and can picture to himself the aspect that these pleasant woods must have worn in times of old."

At Kalamazoo, Cooper found that "Those who had laid out this village, some fifteen years since, had the taste to preserve most of the trees" and that the houses and grounds were "pleasant to the eye, on account of the shade, and the rural features they present." But in this year of 1848 Cooper evidently saw few surviving trees of the bur oak openings that existed in the area about the Château au Miel 36 years earlier and evidently he did *not* find *any* sizable area of the oak openings still in a natural condition. But at this time there were thousands of acres of such oak openings in Wisconsin.

In regard to the present status of bur oak trees in the area about Kalamazoo the writer has received the following statement from the Forestry Department of the City of Kalamazoo: "The Forestry Department reports no real stand of bur oaks in this vicinity. Scattered trees are found throughout the city, perhaps the largest group being that of eight or ten in Bronson Park. Formerly groves of bur oaks were found near Kalamazoo including a large stand near Oshtemo on route U. S. 12."

The total area of the prairies and of the oak openings in southern Michigan was relatively small in comparison to the area in southern Wisconsin but evidently the character of the bur oak openings was quite the same in both regions.

Concluding Remarks.—The early records are particularly complete and accurate for the main facts regarding the character, location, and extent of the bur oak openings in Wisconsin. Their relations and ecological status in the so-called oak-hickory belt which constitutes the western margin of the extensive eastern forests of North America are now well recognized.

For perhaps a hundred years before the advent of the white settlers into southern Wisconsin the oak opening prairie association was a somewhat static feature in the midst of a region where there had been dynamic changes in post-glacial plant migrations. Both the prairie and the forest are decidedly static and self-sustaining and the two tend to be mutually exclusive. In the bur oak openings these two sharply contrasted types of vegetation are combined in a somewhat balanced and static relationship that is indeed noteworthy and of special interest.

But the coming of the white man spelled the doom of the oak openings. The land they occupied was fertile, there was sufficient timber for the immediate needs of the settlers, yet the stands of the trees were so sparse that the clearing involved relatively little labor. Within fifty years most of the oak openings were converted into fields of corn, wheat, oats, and tobacco or were filled in by the second growth which was mostly of invading black oaks. At the present time, after another fifty years, there exist only few scattered remnants of the once numerous bur oak openings. Of these the Babcock grove now occupies about fifty acres and is still in an excellent state of preservation. It is the memory of the grandeur and the beauty of the extensive groves, of which this is a remnant, that has prompted this epitome which perhaps may be considered an obituary of the bur oak openings in Wisconsin.

LITERATURE CITED

1. 1846. Wisconsin, its geography and topography. By I. A. Lapham.
2. 1856. History of Rock County. Edited and compiled by Orrin Guernsey and Josiah F. Willard. Published by the Rock County Agricultural Society and Mechanics' Institute, Janesville.
3. 1875. Notes on the Big Woods. By N. H. Winchell, in Annual Rep. State Hort. Soc.
4. 1877. Geology of Wisconsin, 2: Part 2. By T. C. Chamberlin. The map of the native vegetation of Wisconsin, Plate No. IIA, bears the date 1882.
5. 1880. History of Dane County, Wisconsin. Western Historical Society.
6. 1884. Report on the forests of North America. By Charles S. Sargent. In Tenth Census of the United States, Vol. 9.
7. 1892. On the flora of Madison and vicinity. Trans. Wis. Acad. Sci., 9: 45-135. By L. S. Cheney and R. H. True
8. 1892. The metaspermae of the Minnesota valley. By Conway MacMillan.
9. 1895. The silva of North America, Vol. 8. By Charles S. Sargent.
10. 1898. The phytogeography of Nebraska. By Roscoe Pound and Frederic E. Clements.
11. 1899. Minnesota plant life. By Conway MacMillan.
12. 1907. A botanical survey of the Illinois River Valley sand region. Bull. Ill. State Lab. of Nat. Hist., 7: 149-194. By H. A. Gleason.
13. 1910. The vegetation of the inland deposits of Illinois. Bull. Illinois State Lab. Nat. Hist., 9: 23-174. By H. A. Gleason.
14. 1923. The vegetational history of the Middle West. Annals Ass'n. Am. Geographers, 12: 39-85. By H. A. Gleason.
15. 1924. Atlas of American Agriculture, Part I. Section E. By H. L. Shantz and Raphael Zon.

16. 1927. An annotated flora of the Chicago area. Bull. 8. Nat. Hist. Survey. By H. S. Pepoon
17. 1927. Factors controlling germination and early survival in oaks. Bull. No. 19, Yale School of Forestry. By Clarence F. Korstian.
18. 1928. Flora of the oak openings west of Toledo. Prod. Ohio Acad. Sci., 8: 81-134. By Edwin L. Moseley.
19. 1932. Root system of *Quercus macrocarpa* in relation to the invasion of prairie. Bot. Gazette, 94: 51-85. By J. E. Weaver and Joseph Kramer.
20. 1938. Plants as soil indicators. Yearbook of U. S. Dept. of Agriculture, pp. 835-860. By H. L. Shantz.
21. 1940. The steep prairies of southern Wisconsin and their invasion by forest. By Elizabeth Anna Chavannes. An unpublished thesis in the records of the University of Wisconsin, loaned to the writer by Prof. N. C. Fassett. The investigation was financed by the Alumni Research Foundation of the University of Wisconsin.
22. 1941. Knowing your trees. By C. H. Collingwood.

SOME AQUATIC AND SUB-AQUATIC PLANTS FROM THE REGION OF GLACIAL LAKE WISCONSIN

JOHN CATENHUSEN

This paper records some of the aquatic and sub-aquatic plants occurring on the bed of Glacial Lake Wisconsin (Fig. 1) and contains notes on rare or interesting species. Of special interest are several plants of the Atlantic coastal plain which occur in this region. The remaining species have been listed here chiefly as a matter of record. Since they are all native to the region it was deemed worthwhile to record them because of extensive plantings of aquatic plants (obtained from commercial seed distributors) by the Resettlement Administration in 1936 and 1937 and in more recent years by the Fish and Wildlife Service.

Collections were made during the month of August of the years 1938 to 1940 incidental to a study concerning the bog vegetation of the region. The study was made possible by grants from the Alumni Research Foundation of the University of Wisconsin. Grateful acknowledgment is made to Professor N. C. Fassett for many helpful suggestions. All plants collected were checked against records of plantings made by the organizations mentioned above to make certain that they were native to the area. Expressions of relative abundance refer only to their status in the region.

Glacial Lake Wisconsin was formed by the damming of the pre-Glacial Wisconsin River by the advancing ice sheet. After the ice melted away, the lake was drained by the east fork of the Black River. After the lake was drained, peat bogs formed in the low places, while red and white pine stands developed on the interspersed sand islands and sandstone ridges.

About 1900 the entire area was cut through by a network of drainage ditches. Much of the area was drained completely. Several severe fires followed the artificial drainage, burning deep basins into the peat and destroying much of the native vegetation. Those aquatic plants which survived occurred in protected

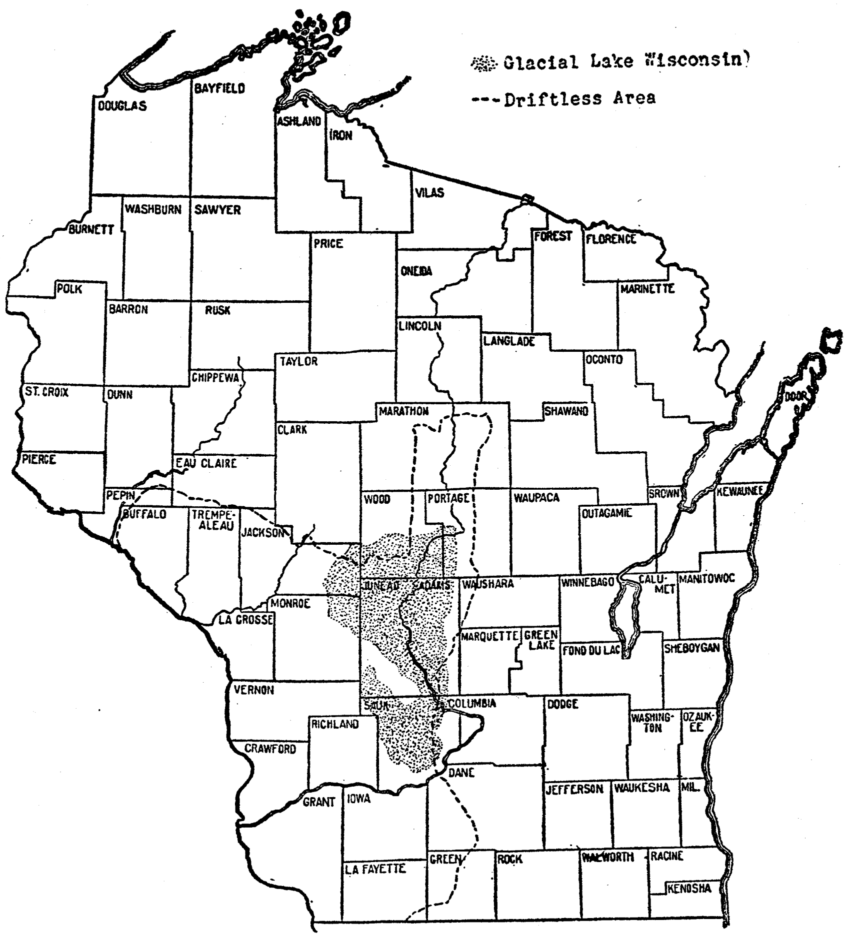


Figure 1.- Glacial Lake Wisconsin

FIGURE 1. The graph shows the number of tons of lime sold annually from 1904 to 1940 by Wisconsin producers. The solid line indicates the total amount of lime sold while the two broken lines show the amount sold for the specific purposes indicated. Note that as the total production declined a smaller percentage has been sold for building purposes.

cranberry reservoirs or migrated to the artificially constructed ditches. In 1933 and the years following, dams and dikes were constructed in an effort to raise the water-table to its original level. Flowages were created above the dikes, and shallow pools were formed in the burned-out peat basins. The past few years have witnessed an invasion of these pools and flowages by the aquatics restricted for years to the ditches and cranberry reservoirs.

TYPHA LATIFOLIA L.—Abundant. It easily pioneers exposed, wet places and shallow pools. In some instances it has taken over recently impounded flowages.

SPARGANIUM AMERICANUM Nutt.—Common, particularly in creeks.

SPARGANIUM CHLOROCARPUM Rydb.—Common, particularly in creeks.

POTAMOGETON CAPILLACEUS Poir.—Uncommon. A plant of the coastal plain (Fernald 1932) which exhibits a range in Wisconsin typical of this group of plants. One station is known in northern Wisconsin in Sawyer County and two stations occur in Juneau County in this region.

POTAMOGETON EPIHYDRUS Raf. var. NUTTALLII (C. & S.) Fernald.—The most abundant of the Potamogetons of this region. Many of the ditches and flowages support at least some individuals.

POTAMOGETON FOLIOSUS Raf.—Fairly common, particularly in some of the creeks of eastern Jackson County.

POTAMOGETON ILLINOENSIS Morong.—Generally uncommon, but abundant in one ditch in northern Juneau County.

POTAMOGETON NATANS L.—Uncommon. Restricted to older flowages and ditches.

POTAMOGETON OAKESIANUS Robbins.—Uncommon. Restricted to older flowages and ditches.

POTAMOGETON PULCHER Tuckerm.—Rare. A plant of the coastal plain with a range in Wisconsin similar to that of *Potamogeton capillaceus*. In this region it occurs only in Juneau County in a cranberry reservoir which is over 40 years old.

POTAMOGETON SPIRILLUS Tuckerm.—Rare. Found in the same reservoir in which *Potamogeton pulcher* was found.

SAGITTARIA CRISTATA Engelm.—Common on sandy shores of lakes in southern Adams County.

SAGITTARIA LATIFOLIA Willd.—Common in ditches and shallow pools. It frequently pioneers exposed, wet places.

SAGITTARIA LATIFOLIA Willd. var. OBTUSA (Muhl.) Wiegand.—Similar in habit to the above species and often occurring with it.

SAGITTARIA LATIFOLIA Willd. forma GRACILIS (Pursh) Robinson. —Fairly common. Many individuals occur which grade into the true form.

SAGITTARIA RIGIDA Pursh.—Rare. Only one station was located —a flowage in northeastern Monroe County.

ALISMA PLANTAGO-AQUATICA L.—Common. It requires a habitat similar to that of *Sagittaria latifolia* and often pioneers exposed, wet places.

ALISMA PLANTAGO-AQUATICA L. var. PARVIFLORUM (Pursh) Farwell.—Similar in habit to *Alisma Plantago-aquatica* and often found with it.

ANACHARIS OCCIDENTALIS (Pursh) Victorin.—Uncommon. Found in some of the older reservoirs.

VALLISNERIA AMERICANA Michx.—Uncommon, but locally abundant in northern Juneau County.

ZIZANIA AQUATICA L. var. ANGUSTIFOLIA Hitchc.—Uncommon. A few scattered colonies occur along some of the creeks.

ZIZANIA AQUATICA L. var. INTERIOR Fassett.—Uncommon. Fair stands occur along the Lemonweir River in Juneau County; in addition, many plantings have been made, some of which have been successful.

GLYCERIA CANADENSIS (Michx.) Trin.—Common along shallow creeks and ditches, and along the shores of flowages.

GLYCERIA GRANDIS Wats.—Less common than the above species; occurs in much the same habitat.

PHRAGMITES COMMUNIS Trin.—Fairly common. It pioneers areas similar to those of Typha, but to a lesser degree.

ECHINOCHLOA PUNGENS (Poir.) Rydb.—Fairly common. Mucky shores of flowages and ditches.

LEERSIA ORYZOIDES (L.) Schwartz.—Very common. Often occurs as a monotype along wet shores of flowages or ditches.

LEERSIA ORYZOIDES (L.) Schwartz forma GLABRA Eaton.—Less common than the above species. It is usually a submersed form.

CALAMAGROSTIS CANADENSIS (Michx.) Beauv.—This grass often dominates many acres of wet peat meadows. It easily invades burned-over peat areas which are subsequently flooded to the extent that a wet, mucky soil is exposed.

PHALARIS ARUNDINACEA L.—Uncommon. Occasionally along shores of older flowages.

DULICHIUM ARUNDINACEUM (L.) Britton.—Common, especially in old cranberry reservoirs in the western half of the region.

ELEOCHARIS OBTUSA (Willd.) Schultes.—Abundant on wet ground or in extremely shallow water.

SCIRPUS CYPERINUS (L.) Kunth var. PELIUS Fernald.—The most common member of the sedge family in this region.

SCIRPUS VALIDUS Vahl.—Uncommon. Occurs along the shores of flowages, often extending well into deeper water.

CAREX OLIGOSPERMA Michx.—Uncommon, locally common. This plant was at one time so abundant that it provided the raw material for an extensive weaving industry in this region.

CAREX VULPINOIDEA Michx.—Common in wet meadows.

CALLA PALUSTRIS L.—Uncommon, but abundant in several of the older cranberry reservoirs.

LEMNA MINOR L.—Common throughout the region.

LEMNA TRISULCA L.—Less common than the above species.

PONTEDERIA CORDATA L.—Uncommon. Mucky shores or shallow water.

JUNCUS BALTICUS Willd. var. LITTORALIS Engelm.—Rare. Sandy shores.

JUNCUS EFFUSUS L.—Common in wet meadows.

IRIS VIRGINICA L. var. SHREVEI (Small) Anderson.—Creeks and older reservoirs.

POLYGONUM CAREYI Olney.—Common on exposed, mucky peat.

POLYGONUM COCCINEUM Muhl. var. PRATINCOLA (Greene) Stanford.—Common on exposed, mucky peat.

POLYGONUM NATANS Eaton forma GENUINUM Stanford.—Common on exposed, mucky peat.

CERATOPHYLLUM DEMERSUM L.—Uncommon. Occurs abundantly in an old cranberry reservoir in northern Juneau County.

NYMPHAEA ODORATA Ait.—Fairly common in older ditches and reservoirs.

NUPHAR VARIEGATUM Engelm.—Fairly common in older ditches and reservoirs.

NASTURTIUM OFFICIONALE R. Br.—Common in cold creeks, especially in Jackson County.

POTENTILLA PALUSTRIS (L.) Scop.—Uncommon. Occurs in older cranberry reservoirs.

CALLITRICHE HETEROPHYLLA Pursh.—Rare. There are three authentic stations in Wisconsin: one in eastern Jackson County, and two in the Baraboo Hills in Sauk County.

HYPERICUM CANADENSE L.—Uncommon. Several stations were found: one in northern Juneau County, and several in eastern Jackson County (McLaughlin 1931).

HYPERICUM VIRGINICUM L. var. FRASERI (Spach) Fernald. Common on wet, mucky soil or in shallow water.

VIOLA LANCEOLATA L.—Uncommon. Wet, mucky soil.

DIDIPLIS DIANDRA (Nutt.) Wood forma AQUATICA (Koehne) Fassett.—Only one station was found, in an old cranberry reservoir in northern Juneau County.

LUDWIGIA PALUSTRIS (L.) Ell. var. AMERICANA (D. C.) Fern. & Grisc.—Common on wet, mucky soil.

LUDWIGIA PALUSTRIS (L.) Ell. var. AMERICANA (D. C.) Fern. & Grisc. forma ELONGATA Fassett. Uncommon. Grows in relatively deep water.

LUDWIGIA POLYCARPA Short and Peter.—Uncommon. Wet, mucky soil.

MYRIOPHYLLUM FARWELLII Morong.—Uncommon. One station occurs in eastern Jackson County, in an old cranberry reservoir.

UTRICULARIA INTERMEDIA Hayne.—Less common than the following species. Ditches and flowages.

UTRICULARIA VULGARIS L. var. AMERICANA Gray.—Common. Many of the ditches and flowages contain this species.

CEPHALANTHUS OCCIDENTALIS L.—Uncommon. Common in the bottom lands of Beaver Creek in northern Juneau County.

LOBELIA CARDINALIS L.—Fairly common in bottom lands of the Wisconsin and Yellow Rivers.

MEGALODONTA BECKII (Torr.) Greene.—Occasional in flowages and ditches.

EUPATORIUM PERFOLIATUM L.—Common in wet meadows.

ASTER PANICULATUS Lam.—Common in wet meadows.

HELIANTHUS GIGANTEUS L.—Common in wet meadows.

BIDENS FRONDOSA L.—Common in damp or wet meadows, and along ditch banks.

BIDENS COMOSA (Gray) Wiegand.—Common on wet shores and ditch banks.

BIDENS CONNATA Muhl.—Common on wet shores and ditch banks.

BIDENS CERNUA L.—Common in wet meadows and along ditch banks.

CIRSIUM MUTICUM Michx.—Common in wet meadows.

Literature Cited

Fernald, M. L.
1932. The linear-leaved North American species of Potamogeton. Memoirs of the American Academy of Arts and Sciences, 17: 108-112.

McLaughlin, W. T.
1931. Preliminary reports of the flora of Wisconsin: *Hypericaceae*. Trans. of the Wis. Acad. of Sci. 2: 285-287.

THE MOSSES OF WISCONSIN

L. S. CHENEY AND RICHARD EVANS

The following list of mosses was compiled in part from Mr. Cheney's manuscript which was partially complete at the time of his death on April 10th, 1938, and in part from his herbarium material. He had planned the list to cover not only his own collections, but likewise the Wisconsin collections of others. So far as possible, this plan has been followed in completing his list.

Some of the earlier collections here listed are those of T. J. Hale, I. A. Lapham, R. H. True, Barnes and True, Cheney and True, and J. M. Holzinger. Later collections which are included are those of D. F. Costello, J. T. Curtis, R. S. Nanz, and L. R. Wilson. The great majority of these collections, particularly the older ones, are to be found in the Herbarium of the University of Wisconsin; some of the later ones are represented only in the Cheney Herbarium, which has been deposited through the courtesy of his daughter, Miss Monona L. Cheney, in the University Herbarium.

In 1893 Cheney in conjunction with R. H. True published "On the Flora of Madison and Vicinity, a Preliminary Paper on the Flora of Dane County, Wisconsin" in the *Transactions of the Wisconsin Academy of Sciences, Arts and Letters* (9: 45-135). This list includes three species of Sphagnum and one hundred thirty-two Eubryales. In 1894 Cheney published in the same Transactions (10: 66-68) a list of Sphagna collected during the summer of 1893 along the Wisconsin River between Lac Vieux Desert and Wausau. The identifications were made by Dr. Carl Warnstorf. These earlier collections are included in the present list. No attempt at specific mention of collectors has been made in completing the list, since by far the greatest number of the collections were made by Cheney. The portion of his original manuscript which was completed, in which collectors and identifying collection numbers were given, is deposited with his herbarium.

Some few liberties were taken in editing this list. Nomenclature has been brought in line as completely as possible with Grout's "Moss Flora of North America North of Mexico" and with Grout's "List of Mosses of North America North of Mexico" (Bryologist 43: 117-131, 1940). Nomenclatorial changes in all cases have been indicated. In a very few cases in which Cheney left identifications in doubt, material has been reworked, but in the main identifications have been left as he made them.

It is certain that Mr. Cheney would have expressed his gratitude to various investigators—among them Miss Winona Welch who checked, seemingly, most of his *Fontinalis* identifications. It is unfortunate that others cannot be cited specifically because of lack of information with respect to their contributions. I should like to express my own gratitude to Prof. N. C. Fassett of the University of Wisconsin and to Prof. H. S. Conard of Grinnell College for aid in solving nomenclatorial puzzles; likewise to Mr. E. F. Bean, State Geologist, and to Mr. C. E. Brown of the State Historical Society for aid in identifying obscure or antedated place names—many of them carried over from old logging days in the north.

RICHARD EVANS
Department of Botany
The University of Wisconsin

ACAULON

A. RUFESCENS Jaeger. Barron Co.: Barron Twp. Grant Co.: Glen Haven; Potosi.

AMBLYODON

A. DEALBATUS (Hedw.) Beauv. Polk Co.: Osceola.

A. DEALBATUS var. AMERICANUS Ren. & Card. Polk Co.: Osceola.

AMBLYSTEGIELLA

A. CONFERVOIDES (Brid.) Loeske. Grant Co.: near Bridgeport; Glen Haven; Lancaster; Pososi; Werley. Jefferson Co.: Palmyra. Lafayette Co.: Fayette. Rock Co.: Beloit; Janesville; Bradford Twp. Waukesha Co.: Okauchee Lake; Pine Lake.

A. MINUTISSIMA (Sull. & Lesq.) Nichols. Grant Co.: Glen Haven; Potosi.

A. SPRUCEI (Bruch) Loeske. Ashland Co.: near Ashland on White River; Oak Island. Door Co.: Baileys Harbor. Grant Co.: Glen Haven.

A. SUBTILIS (Hedw.) Loeske. Vilas Co.: Lac Vieux Desert.

AMBLYSTEGIUM

A. COMPACTUM (C. Müll.) Aust. Dane Co.: Madison. Grant Co.: North Andover; Wyalusing. Jefferson Co.: Palmyra. Rock Co.: Bradford Twp. Trempealeau Co.: Trempeuleau Ridge. Waukesha Co.: Lake LaBelle; Waukesha.

A. JURATZKANUM Schimp. Bayfield Co.: Drummond; LaChapelle (Lashabel's homestead). Dane Co.: Madison; Blue Mounds. Grant Co.: Glen Haven. Jefferson Co.: Helenville. Lafayette Co.: Argyle. Lincoln Co.: Grandfather Falls; Grandmother Falls. Oneida Co.: Tomahawk Lake; Whirlpool Rapids. Rock Co.: Beloit; Bradford Twp.; Clinton. Vilas Co.: Conover; Lac Vieux Desert. Washington Co.: Newburg. Waukesha Co.: Big Bend; Lannon; Oconomowoc; Oconomowoc Lake; Pine Lake; Vernon Station; Waukesha.

A. SERPENS (Hedw.) Bry. Eur. Ashland Co.: Oak Island. Barron Co.: Barron. Bayfield Co.: Bayfield; Mason; Orienta; Port Wing. Dane Co.: Madison. Dodge Co.: Horicon. Douglas Co.: St. Louis River. Grant Co.: Bagley; Fennimore; Glen Haven; Montfort; Wyalusing. Jefferson Co.: Hebron; Helenville; Palmyra. Lincoln Co.: NE corner of Co.; Grandfather Falls; Grandmother Falls. Milwaukee Co.: N. Milwaukee. Oneida Co.: N. central part; McNaughton; Tomahawk Lake. Portage Co.: Stevens Point. Rock Co.: Beloit; Bradford Twp.; Clinton; Janesville; Newark Twp. Rusk Co.: Island Lake; Strickland. Sauk Co.: Devils Lake. Trempealeau Co.: Galesville. Vilas Co.: Lac Vieux Desert. Waukesha Co.: Beaver Lake; Eagle; Lannon; Menomonee Falls; Menomonee Twp.; Mouse Lake; Mukwonago; Nashota; Lower Nashota Lake; Upper Nemahbin Lake; Oconomowoc; Oconomowoc Lake; Okauchee Lake; Pine Lake; Wales; Waukesha.

A. VARIUM (Hedw.) Lindb. Ashland Co.: Manitou Island. Barron Co.: Barron. Bayfield Co.: Drummond; Orienta. Buffalo Co.: Marshland. Dane Co.: Madison; Verona. Douglas Co.: St. Louis River. Grant Co.: Bagley; Glen Haven; Patch Grove; Potosi. Iowa Co.: Union Mills. Jefferson Co.: Palmyra; Sullivan. Kewaunee Co.: Kewaunee. Lincoln Co.: Grandfather Falls. Marathon Co.: Granite Heights. Marinette Co.: Menominee River. Ozaukee Co.: Cedarburg. Polk Co.: T 37 N R 11 W, near Doran, Burnett Co.; St. Croix Falls.

Rock Co.: Beloit; Bradford Twp.; Clinton; Janesville; near Whitewater. Sheboygan Co.: Cedar Grove; Little Elkhart Lake. Trempealeau Co.: Trempealeau. Washington Co.: Newburg. Waukesha Co.: Eagle; Lannon; Upper Lake Nemahbin; North Lake; Oconomowoc; Oconomowoc Lake; Okauchee Lake; Pewaukee; Pine Lake; Vernon Station; Wales; Waukesha.

ANACAMPTODON

A. SPLACHNOIDES (Froehl.) Brid. Barron Co.: Maple Grove Twp. Grant Co.: Potosi.

ANOMODON

A. ATTENUATUS (Hedw.) Hüben. Ashland Co.: Penokee Iron Range. Columbia Co.: Wisconsin Dells. Dane Co.: Blue Mounds; Madison. Dodge Co.; Horicon. Grant Co.: Glen Haven; Potosi. Iron Co.: Montreal River. Lincoln Co.: Grandmother Falls; Merrill. Milwaukee Co.: S. Milwaukee. Oneida Co.: McNaughton; Rhinelander. Outagamie Co.: Appleton; Medina. Ozaukee Co.: Cedarburg. Rock Co.: Bradford Twp.; Clinton. Sauk Co.: Devils Lake. Sheboygan Co.: Cedar Grove; Plymouth. Vilas Co.: Lac Vieux Desert. Washington Co.: Newburg. Waukesha Co.: Mukwonago; Waukesha.

A. MINOR (Beauv.) Lindb. Ashland Co.: Ashland; White River. Barron Co.: Barron. Bayfield Co.: Drummond; Port Wing. Dane Co.: Madison. Dodge Co.: Horicon. Grant Co.: Glen Haven. Kewaunee Co.: Kewaunee. Lafayette Co.: Fayette. Lincoln Co.: Grandfather Falls; Grandmother Falls. Oconto Co.: Oconto. Outagamie Co.: Appleton. Ozaukee Co.: Cedarburg. Rusk Co.: Murry. Sauk Co.: near Wisconsin Dells. Sheboygan Co.: Cedar Grove. Waukesha Co.: Waukesha.

A. ROSTRATUS (Hedw.) Schimp. Barron Co.: Barron. Dane Co.: Madison. Dodge Co.: Horicon. Door Co.: Baileys Harbor. Grant Co.: Glen Haven; Platteville; Potosi. Jefferson Co.: Helenville; Palmyra. Lincoln Co.: Grandfather Falls. Outagamie Co.: Appleton. Rock Co.: Bradford Twp.; Clinton. Rusk Co.: Strickland. Sauk Co.: near Wisconsin Dells. Washington Co.: Newburg. Waukesha Co.: Eagle; Keesus Lake; Nagawicka Lake; Mouse Lake; Muskego; New Berlin; Okauchee Lake; Ottawa; Pine Lake; Waukesha.

A. TRISTIS (Cesati) Sull. Barron Co.: Barron. Columbia Co.: Wisconsin Dells. Grant Co.: Potosi. Lincoln Co.: Grandfather Falls; Grandmother Falls. Marathon Co.: Granite Heights.

A. VITICULOSIS (Hedw.) Hook. & Tayl. Rock Co.: Bradford Twp. Waukesha Co.: Waukesha.

APHANORHEGMA

A. SERRATUM (Hook. & Wils.) Sull. Barron Co.: Barron.

ASTOMUM

A. MUHLENBERGIANUM (Sw.) Grout. Barron Co.: Barron as *A. crispum* (Hedw.) Hampe; Barron Co.: Barron as *A. Sullivantii* Sch.; Dane Co.: Madison as *A. Sullivantii* Sch.; Grant Co.: Potosi as *A. Sullivantii* Sch.

ATRICHUM

A. ANGUSTATUM (Brid.) Bry. Eur. as *Catharinea angustata* Brid. Barron Co.: Barron. Bayfield Co.: Drummond. Dane Co.: Blue Mounds; Madison; McFarland. Grant Co.: Werley. Jefferson Co.: Palmyra. Sauk Co.: Delton. Washington Co.: Newburg.

A. CRISPUM var. MOLLE (Holz.) Frye as *Catharinea mollis* Holz. Buffalo Co.: Marshland.

A. UNDULATUM (Hedw.) Beauv. as *Catharinea undulata* Web. & Mohr. Adams Co.: Cold Water Canyon. Ashland Co.: Basswood Island; Mellen. Barron Co.: Barron; Barron Twp., secs. 20 & 32; Maple Grove Twp., sec. 3. Dane Co.: Madison. Douglas Co.: Amnicon River; Brule River. Grant Co.: Glen Haven. Jefferson Co.: Palmyra. Lincoln Co.: Grandfather Falls; Tomahawk. Marathon Co.: Granite Heights; Mosinee. Oconto Co.: Oconto. Sauk Co.: Baraboo; Devils Lake. Vilas Co.: Eagle River; Star Lake. Waukesha Co.: Eagle Lake; Oconomowoc; Pine Lake; Waukesha.

AULACOMNIUM

A. HETEROSTICHUM (Hedw.) Bry. Eur. Dane Co.: Blue Mounds. Grant Co.: Bagley; Potosi. Lafayette Co.: Fayette.

A. PALUSTRE (Web. & Mohr) Schwaegr. Ashland Co.: Odanah; Basswood Island. Bayfield Co.: Port Wing; Sand Bay. Dane Co.: Madison. Door Co.: Baileys Harbor. Douglas Co.:

Brule River. Iron Co.: Montreal River. Jefferson Co.: Lake Mills. Lincoln Co.: Tomahawk. Outagamie Co.: Appleton. Ozaukee Co.: Cedarburg. Rock Co.: Newark. Sauk Co.: near Wisconsin Dells. Vilas Co.: near State Line. Washington Co.: Newburg. Waukesha Co.: Summit Center; Sussex; near Wales; Waukesha. Wood Co.: Wisconsin Rapids.

BARBULA

B. ACUTA (Brid.) Brid. as *B. gracilis* Schwaegr. Rock Co.: Avon.

B. CONVOLUTA Hedw. Jefferson Co.: Palmyra. Outagamie Co.: Seymour. Waukesha Co.: Pine Lake.

B. FALLAX Hedw. Bayfield Co.: Mason. Dane Co.: Madison. Douglas Co.: Amnicon River. Grant Co.: Beetown; near Bridgeport; Glen Haven; Mt. Hope; Patch Grove; Potosi; Werley. Jefferson Co.: Jefferson. Lafayette Co.: Fayette. Rock Co.: Clinton; Newark. Waukesha Co.: Waukesha.

B. UNGUICULATA Hedw. Dane Co.: Blue Mounds; Madison. Door Co.: Baileys Harbor. Grant Co.: Glen Haven; Mt Hope; Potosi. Jefferson Co.: Palmyra. Ozaukee Co.: Cedarburg. Rock Co.: Beloit; Bradford Twp.; Newark. Trempealeau Co.: Trempealeau. Walworth Co.: Whitewater. Waukesha Co.: Eagle; Glen Cove Station (Pewaukee Lake); Menomonee Falls; Nashotah; Waukesha.

BARTRAMIA

B. POMIFORMIS Hedw. Adams Co.: near Wisconsin Dells. Ashland Co.: Basswood Island; Mellen; Oak Island; White River, near Ashland. Barron Co.: Barron; Barron Twp., secs. 5 & 20. Bayfield Co.: Drummond; Herbster; Sand Bay. Dane Co.: Blue Mounds; Madison. Douglas Co.: Amnicon Falls; Old Superior. Grant Co.: Millville; Patch Grove; Potosi. Iron Co.: Montreal River. Lincoln Co.: Grandfather Falls; Tomahawk. Manitowoc Co.: Manitowoc. Milwaukee Co.: Milwaukee. Oneida Co.: Newbold; Rhinelander. Sauk Co.: Devils Lake.

BLINDIA

B. ACUTA (Hedw.) Bry. Eur. Bayfield Co.: Herbster; Houghton Quarry; Port Wing.

BRACHYTHECIUM

B. ACUTUM (Mitt.) Sull. Barron Co.: Barron; Barron Twp., sec. 32; Clinton Twp. Dane Co.: Madison. Grant Co.: Glen Haven. Jefferson Co.: Palmyra. Outagamie Co.: Appleton. Ozaukee Co.: Cedarburg. Rock Co.: Clinton; Newark Twp. Waukesha Co.: Mukwonago; Waukesha.

B. CAMPESTRE Bry. Eur. Bayfield Co.: White River. Iron Co.: Montreal River, near Lake Superior. Price Co.: Ogema. Sheboygan Co.: near Cedar Grove.

B. DIGASTRUM C. Müll. & Kindb. Bayfield Co.: LaChapelle (Lashabel's homestead). Dodge Co.: Horicon. Grant Co.: Glen Haven. Rock Co.: Avon. Sheboygan Co.: Cedar Grove.

B. FLAGELLARE (Hedw.) Jennings. as *B. plumosum* (Sw.) Br. & Sch. Ashland Co.: Basswood Island; Oak Island. Barron Co.: Canton. Bayfield Co.: Herbster; Houghten Quarry; Port Wing; Sand Bay; Sand Island. Iron Co.: Montreal River. Juneau Co.: Germantown. Rock Co.: Clinton. Rusk Co.: Old Murry.

B. FLEXICAULE Ren. & Card. Jefferson Co.: near Palmyra.

B. OXYCLADON (Brid.) Jaeger & Sauerb. Barron Co.: near Barron; Barron Twp., secs. 20 & 32; Maple Grove Twp., sec. 3. Bayfield Co.: Drummond; Port Wing. Douglas Co.: near mouth of Brule River. Grant Co.: near Potosi. Iron Co.: NW corner, near Lake Superior. Lafayette Co.: Fayette. Lincoln Co.: Tomahawk. Milwaukee Co.: Lake Park. Oneida Co.: Tomahawk Lake. Rock Co.: Bradford Twp.; near Clinton; near Newark. Sheboygan Co.: near Cedar Grove. Washington Co.: near Newburg. Waukesha Co.: near Eagle; Okauchee Lake; near Wales; Waukesha.

B. PLUMOSUM (Sw.) Br. & Sch. (cf. *B. flagellare*)

B. POPULEUM (Hedw.) Bry. Eur. Bayfield Co.: Sand Bay. Dane Co.: Blue Mounds. Lincoln Co.: Grandfather Falls. Vilas Co.: Lac Vieux Desert.

B. REFLEXUM (Starke) Bry. Eur. Barron Co.: Barron. Lincoln Co.: Grandmother Falls. Oneida Co.: Newbold. Sheboygan Co.: Cedar Grove. Vilas Co.: Lac Vieux Desert.

B. RIVULARE Bry. Eur. Ashland Co.: Oak Island. Barron Co.: Barron; Barron Twp., sec. 20; Doyle Twp.; Maple Grove Twp., sec. 3. Clark Co.: Abbotsford. Door Co.: Sister Bay. Douglas Co.: Amnicon River. Grant Co.: Bagley; near Castle Rock; Potosi. Jefferson Co.: Palmyra. Juneau Co.: near "Old Dell House". Oneida Co.: Rhinelander; Tomahawk Lake. Ozaukee Co.: Cedarburg. Rock Co.: Bradford Twp. Rusk Co.: Old Murry. Sauk Co.: Devils Lake. Sheboygan Co.: near Cedar Grove. Waukesha Co.: North Lake; near Vernon Station; Waukesha.

B. RUTABULUM (Hedw.) Bry. Eur. Bayfield Co.: near Herbster. Dane Co.: near Madison. Door Co.: Europe Bay. Iron Co.: Montreal River. Oneida Co.: near Tomahawk Lake. Ozaukee Co.: near Cedarburg. Rusk Co.: near Old Murry. Vilas Co.: Star Lake.

B. SALEBROSUM (Web. & Mohr) Bry. Eur. Barron Co.: near Barron; Barron Twp., sec. 20; Maple Grove Twp., sec. 3. Bayfield Co.: Port Wing. Dane Co.: Hook Lake; Madison. Douglas Co.: Brule River. Jefferson Co.: near Cambridge. Lincoln Co.: Grandfather Falls; Grandmother Falls. Milwaukee Co.: Lake Park. Price Co.: near Ogema. Rock Co.: Clinton. Rusk Co.: Old Murry. Sauk Co.: Parfreys Glen. Vilas Co.: Eagle River; Lac Vieux Desert. Waukesha Co.: Eagle; Lannon; Oconomowoc; Okauchee Lake; Pine Lake; Waukesha.

B. STARKEI (Brid.) Bry. Eur. Barron Co.: Barron Twp.; Maple Grove Twp.; Stanley Twp. Outagamie Co.: Appleton; Medina. Rusk Co.: Old Murry. Vilas Co.: Conover; Lac Vieux Desert.

B. VELUTINUM (Hedw.) Bry. Eur. Barron Co.: Barron Twp., sec. 32; Maple Grove Twp., sec. 3. Calumet Co.: Highcliff. Iron Co.: Montreal River. Lincoln Co.: Grandfather Falls; Grandmother Falls; Tomahawk.

BROTHERA

B. LEANA (Sull.) C. Müll. Barron Co.: Barron; Barron Twp., secs. 20 & 32. Jefferson Co.: Helenville; Johnson Creek. Trempealeau Co.: Trempealeau.

BROTHERELLA

B. DELICATULA (James) Fleisch. Grant Co.: Glen Haven.

B. RECURVANS (Mx.) Fleisch. Adams Co.: Cold Water Canyon; Dells of Wisconsin River. Ashland Co.: Basswood Island; Hermit Island. Barron Co.: Barron. Bayfield Co.: Herbster; Houghton Quarry; near Bayfield. Door Co.: Baileys

Harbor. Douglas Co.: Lucius Lake; T 45 N R 15 W. Grant Co.: Bagley. Iron Co.: Montreal River. Lincoln Co.: Grandfather Falls; Grandmother Falls; Tomahawk. Marathon Co.: Granite Heights; Mosinee. Oneida Co.: Newbold; Rainbow Rapids; Rhinelander; Tomahawk Lake. Outagamie Co.: Appleton. Ozaukee Co.: Cedarburg. Rusk Co.: Murry. Sheboygan Co.: Crystal Lake; Oostburg. Vilas Co.: Conover; Lac Vieux Desert; State Line; Star Lake. Washington Co.: Newburg. Wood Co.: Wisconsin Rapids.

B. TENUIROSTRIS (Schimp.) Broth. Grant Co.: Werley. Rock Co.: Clinton.

BRUCHIA

B. FLEXUOSA (Sw.) C. Müll. Trempealeau Co.: Dodge.

B. SULLIVANTII Aust. Grant Co.: Bagley; Glen Haven. Waukesha Co.: Delafield; Mukwonago; Summit Center.

BRYHNIA

B. GRAMINICOLOR (Brid.) Grout. Adams Co.: Artists Glen, Dells of Wisconsin River. Door Co.: Bailey Harbor.

B. NOVAE-ANGLIAE (Sull. & Lesq.) Grout. Adams Co.: Cold Water Canyon, Dells of Wisconsin River. Barron Co.: Barron Twp., sec. 20; Clinton Twp., sec. 26; Maple Grove Twp., sec. 3. Bayfield Co.: Bark Bay; Houghton Quarry. Iron Co.: Montreal River. Lincoln Co.: Grandfather Falls. Oneida Co.: near Tomahawk Lake. Vilas Co.: Lac Vieux Desert. Waukesha Co.: Okauchee Lake.

BRYOXIPHIUM

B. NORVEGICUM (Brid.) Mitt. Adams Co.: Witches Gulch, Dells of Wisconsin River. Columbia Co.: Wisconsin Dells. Juneau Co.: Lemonweir River. Sauk Co.: Pewits Nest, near Baraboo.

BRYUM

B. ARGENTEUM (L.) Hedw. Bayfield Co.: Drummond; Orienta. Dane Co.: Madison. Douglas Co.: T 45 N R 15 W. Grant Co.: Cassville; Glen Haven; Potosi. Lincoln Co.: Grandfather Falls. Marathon Co.: Mosinee. Oneida Co.: Newbold. Portage Co.: Stevens Point. Rock Co.: Bradford Twp. Walworth Co.: Whitewater. Waukesha Co.: Saylesville; Waukesha; near Waukesha; Waukesha Twp., sec. 24.

B. BIMUM Schreb. cf. *B. pseudotriquetrum* (Hedw.) Schwaegr.

B. CAESPITICIUM (L.) Hedw. Ashland Co.: Basswood Island; Oak Island; Bayfield Co.: Drummond; Houghten Quarry; Sand Bay. Burnett Co.: Swiss. Dane Co.: Hook Lake; Madison. Grant Co.: Bagley; Glen Haven; Potosi; Williams. Lafayette Co.: Argyle. Lincoln Co.: Grandfather Falls; same station as *B. synoico-caespiticium* C.M. & Kindb.; Tomahawk; Wisconsin River Valley. Polk Co.: near Doran. Sheboygan Co.: Cedar Grove. Vilas Co.: Lac Vieux Desert. Washburn Co.: Spooner. Waukesha Co.: Lannon; Nagawicka Lake; Pewaukee; Waukesha.

B. CAPILLARE (L.) Hedw. Barron Co: Maple Grove Twp., sec. 1. Grant Co.: Mt. Ida. Lincoln Co.: Grandfather Falls as *B. obconicum* Hornsch. Oneida Co.: Rhinelander; Tomahawk Lake. Ozaukee Co.: Cedarburg. Polk Co.: near Doran. Waukesha Co.: Waukesha. Wood Co.: Wisconsin Rapids, as *B. obconicum* Hornsch.

B. CIRRATUM Hoppe & Hornsch. Grant Co.: Montfort. Lincoln Co.: Tomahawk. Waukesha Co.: Lisbon Twp.; Waukesha.

B. CUSPIDATUM (Bry. Eur.) Schimp. as *B. affine* Lindb. Bayfield Co.: Houghton Quarry; Sand Island. Grant Co.: Cornelia; Glen Haven; Potosi. Lincoln Co.: Grandfather Falls; near Grandfather Falls. Milwaukee Co.: S. Milwaukee. Waukesha Co.: Lannon; Lisbon Twp.; Waukesha.

B. INCLINATUM (Web. & Mohr) Sturm. Bayfield Co.: Drummond. Grant Co.: Dickeysville. Lincoln Co.: Grandfather Falls; Tomahawk.

B. INTERMEDIUM (Ludw.) Brid. (?) M.F.N.A. 2:229. Grant Co.: Glen Haven. Iron Co.: Montreal River. Washington Co.: Newburg. Waukesha Co.: Waukesha.

B. PALLENS (Web. & Mohr) Brid. Barron Co.: Barron; Doyle Twp., sec. 28. Grant Co.: Glen Haven; Jamestown; Potosi. Oneida Co.: Rainbow Rapids; near Tomahawk Lake. Ozaukee Co.: Cedarburg. Waukesha Co.: Mukwonago; Waukesha.

B. PENDULUM (Hornsch.) Schimp. Ashland Co.: Basswood Island. Barron Co.: Cameron; Maple Grove Twp. Bayfield Co.: Herbster; Port Wing; Siskowitt Bay. Dane Co.: Blue Mounds; Madison; Marshall; Windsor. Grant Co.: Bagley; Glen Haven; Montfort. Iron Co.: Montreal River, near Lake Superior. Juneau Co.: Dells of Wisconsin River. Lincoln

Co.: Grandfather Falls; near Grandfather Falls. Rock Co.: Beloit; Bradford Twp.; Janesville. Sauk Co.: Ironton. Sheboygan Co.: Cedar Grove. Waukesha Co.: Eagle.

B. PSEUDOTRIQUETRUM (Hedw.) Schwaegr. as *B. bimum* Schreb. excepting for those stations marked with an *. These collections were listed originally as *B. pseudotriquetrum.* Ashland Co.: Basswood Island; same station *; Oak Island; White River. Bayfield Co.: Drummond; same station *; Orienta; Port Wing; Sand Bay; Siskowitt Bay; Squaw Bay. Door Co.: Baileys Harbor. Douglas Co.: Amnicon Falls; Manitou Falls. Grant Co.: Glen Haven; Potosi. Lincoln Co.: Grandfather Falls; same station *; Merrill *; Tomahawk. Manitowoc Co.: Two Rivers. Oneida Co.: McNaughton; Newbold; Rhinelander *; Tomahawk Lake. Ozaukee Co.; Cedarburg. Polk Co.: near Doran. Portage Co.: Stevens Point. Rock Co.: Beloit; Clinton. Rusk Co.: NW corner of county. Washington Co.: Newburg. Waukesha Co.: Eagle; North Lake; Vernon Station; Waukesha; same station *.

B. TORTIFOLIUM Funck. as *B. cyclophyllum* Br. & Sch. Bayfield Co.: Siskowitt Bay. Door Co.: Baileys Harbor.

B. ULIGINOSUM (Brid.) Bry. Eur. Dane Co.: Hook Lake; Lake Kegonsa. Grant Co.: Patch Grove. Lafayette Co.: Fayette. Outagamie Co.: Appleton.

B. WEIGELII Spreng. as *B. Duvalii* Voit. Barron Co.: Barron Twp., secs. 5 & 20; Cameron. Oneida Co.: Tomahawk Lake. Ozaukee Co.: Cedarburg. Vilas Co.: Lac Vieux Desert.

BUXBAUMIA

B. APHYLLA Hedw. Vilas Co.: Conover.

CALLIERGON

C. CORDIFOLIUM (Hedw.) Kindb. Ashland Co.: Ashland; LaPointe, Madeline Island. Barron Co.: Barron; Barron Twp., sec. 20; Maple Grove Twp., sec. 3. Bayfield Co.: Bark Bay; Houghton Quarry; Orienta; Sand Bay. Door Co.: Baileys Harbor. Douglas Co.: Upper Lucius Lake. Lincoln Co.: Grandfather Falls; near Grandfather Falls; Merrill. Marathon Co.: Granite Heights. Oneida Co.: Rhinelander; Tomahawk Lake. Outagamie Co.: Cedarburg. Portage Co.: near Stevens Point. Rusk Co.: Strickland. Vilas Co.: near State Line. Waukesha Co.: Waukesha.

C. GIGANTEUM (Schimp.) Kindb. Ashland Co.: Mellen. Burnett Co.: Swiss. Door Co.: Baileys Harbor. Milwaukee Co.: Milwaukee. Outagamie Co.: Appleton. Ozaukee Co.: Cedarburg.

C. RICHARDSONII (Mitt.) Kindb. Vilas Co.: near Eagle River.

C. STRAMINEUM (Brid.) Kindb. Bayfield Co.: Port Wing. Oneida Co.: Newbold. Vilas Co.: Conover; Lac Vieux Desert; near State Line.

C. TRIFARIUM (Web. & Mohr) Kindb. Bayfield Co.: Port Wing.

CALLIERGONELLA

C. CUSPIDATA (Brid.) Loeske. Dane Co.: Madison. Ozaukee Co.: Cedarburg. Waukesha Co.: Mukwonago; Waukesha.

C. SCHREBERI (Bry. Eur.) Grout. Ashland Co.: LaPointe, Madeline Island. Barron Co.: Maple Grove Twp., sec. 1. Dane Co.: Blue Mounds; Madison; Pine Bluff. Grant Co.: Glen Haven; Mt. Hope. Iron Co.: NW corner of county. Jefferson Co.: Palmyra. Lafayette Co.: Fayette. Outagamie Co.: Appleton. Rock Co.: Bradford Twp.; Newark. Vilas Co.: near State Line; Conover.

CAMPTOTHECIUM

C. NITENS (Hedw.) Schimp. Ashland Co.: Ashland. Door Co.: Baileys Harbor. Jefferson Co.: Lake Mills; Palmyra. Ozaukee Co.: Cedarburg. Vilas Co.: Lac Viuex Desert. Waukesha Co.: Nagawicka Lake; Mukwonago.

CAMPYLIUM

C. CHRYSOPHYLLUM (Brid.) Bryhn. Ashland Co.: Oak Island; White River. Barron Co.: Barron; Maple Grove Twp. Bayfield Co.: Bayfield; Herbster; Mason; Port Wing; Squaw Bay. Dane Co.: Mendota. Dodge Co.: Iron Ridge. Douglas Co.: T 45 N R 15 W. Grant Co.: Bagley; Glen Haven; Jamestown Twp. Iron Co.: Montreal River. Lincoln Co.: Grandmother Falls; near Tomahawk. Oneida Co.: near Tomahawk Lake. Rock Co.: Clinton; Newark. Sauk Co.: near Baraboo. Sheboygan Co.: Cedar Grove. Vilas Co.: Lac Vieux Desert; near State Line. Washington Co.: Newburg. Waukesha Co.: Lannon; Oconomowoc Lake; Vernon Station.

C. HISPIDULUM (Brid.) Mitt. Adams Co.: Dells of Wisconsin River. Ashland Co.: Basswood Island; Manitou Island; Oak Island; White River. Barron Co.: Barron; Barron Twp., secs. 19 and 20; Maple Grove Twp., sec. 3. Bayfield Co.: Bayfield; Drummond; Houghton Quarry; Port Wing; Sand Bay. Dane Co.: Madison. Dodge Co.: Horicon. Door Co.: Ellison Bay. Douglas Co.: near Superior, T 45 N R 15 W. Grant Co.: Bagley; Glen Haven; Potosi. Iron Co.: Montreal River; Pence. Jefferson Co.: Palmyra. Lafayette Co.: Fayette. Lincoln Co.: Grandfather Falls; Merrill. Marathon Co.: Granite Heights. Oneida Co.: Newbold; Rhinelander; Tomahawk Lake; Whirlpool Rapids. Rock Co.: Clinton; Newark. Rusk Co.: Old Murry. Sauk Co.: Devils Lake. Sheboygan Co.: Cedar Grove. Vilas Co.: Conover; Eagle River; Lac Vieux Desert. Washington Co.: Newburg. Waukesha Co.: Mouse Lake; Nashotah Lake; Norris Farm for Boys; Oconomowoc Lake; Okauchee Lake; Pine Lake.

C. POLYGAMUM (Bry. Eur.) Bryhn. Barron Co.: Barron. Bayfield Co.: Herbster; Sand Bay. Lincoln Co.: Grandfather Falls; Tomahawk. Oneida Co.: Rhinelander. Outagamie Co.: Appleton. Sheboygan Co.: Cedar Grove. Waukesha Co.: Waukesha.

C. STELLATUM (Hedw.) Lange & C. Jens. Dane Co.: Windsor. Door Co.: Baileys Harbor. Iron Co.: Montreal River. Jefferson Co.: Palmyra. Ozaukee Co.: Cedarburg. Waukesha Co.: Mukwonago; Waukesha; near Waukesha.

CERATODON

C. PURPUREUS (Hedw.) Brid. Ashland Co.: Oak Island. Bayfield Co.: Houghton; Siskowitt Bay; Squaw Bay. Burnett Co.: Swiss. Dane Co.: Madison. Dodge Co.: Horicon. Door Co.: Baileys Harbor. Douglas Co.: Sand Lake; Winneboujou. Grant Co.: Potosi. Juneau Co.: Germantown. Milwaukee Co.: N. Milwaukee. Ozaukee Co.: Thiensville. Rock Co.: Beloit; Bradford Twp. Sheboygan Co.: Cedar Grove; Sheboygan. Vilas Co.: Lac Vieux Desert; Star Lake. Washburn Co.: Spooner. Washington Co.: Newburg. Waukesha Co.: Lannon; Menomonee Falls; Mukwonago; Oconomowoc; Okauchee Lake; Waukesha.

CHAMBERLAINIA

C. ACUMINATA (Hedw.) Grout. as *Brachythecium acuminatum* (Hedw.) Kindb. Barron Co.: Barron Twp., sec. 20. Dane Co.: Madison. Grant Co.: Glen Haven; Mt. Ida Twp.; Platteville; Potosi. Lafayette Co.: Fayette. Lincoln Co.: Grandfather Falls; Tomahawk. Outagamie Co.: Appleton. Price Co.: Ogema. Rusk Co.: Murry. Vilas Co.: Conover; Eagle River. Waukesha Co.: Mukwonago; Okauchee Lake.

C. CYRTOPHYLLA (Kindb.) Grout. as *Brachythecium cyrtophyllum* Kindb. Barron Co.: Barron Twp., sec. 20; Maple Grove Twp. Dane Co.: Blue Mounds; Madison. Grant Co.: Glen Haven; Patch Grove; Potosi. Oneida Co.: McNaughton. Outagamie Co.: Greenville. Rusk Co.: near Old Murry. Sheboygan Co.: near Cedar Grove; Sheboygan. Walworth Co.: Whitewater. Waukesha Co.: Lake LaBelle; Muskego; Nehmabin Lake; Oconomowoc; Okauchee Lake; Pewaukee; Pine Lake; near Wales; Waukesha.

CLIMACEUM

C. AMERICANUM Brid. Dane Co.: Blue Mounds; McFarland. Grant Co.: Beetown; Bloomington; Glen Haven; Platteville; Potosi. Lafayette Co.: Fayette. Oconto Co.: Oconto. Rock Co.: Clinton. Sauk Co.: Devils Lake. Washington Co.: Newburg. Waukesha Co.: Brookfield Twp.; Menomonee Twp., Pine Lake; near Vernon Station; Waukesha.

C. DENDROIDES (Hedw.) Web. & Mohr. Ashland Co.: Penokee Iron Range. Barron Co.: Barron; Clinton Twp., sec. 26; Doyle Twp., sec. 33; Maple Grove Twp., sec. 3. Bayfield Co.: Houghton Quarry; LaChapelle, (Lashabel's Homestead). Columbia Co.: Wisconsin Dells. Door Co.: Baileys Harbor. Douglas Co.: Brule River; Lucius Lake; SW corner of county. Oneida Co.: Tomahawk Lake. Ozaukee Co.: Cedarburg. Rusk Co.: Old Murry; Strickland. Sheboygan Co.: Cedar Grove; Sheboygan. Vilas Co.: Lac Vieux Desert. Wood Co.: Nekoosa.

CRATONEURON

C. FALCATUM (Brid.) Roth. Jefferson Co.: Palmyra. Waukesha Co.: Big Bend.

C. FILICINUM (Hedw.) Roth. Dane Co.: Madison. Douglas Co.: T 45 N R 15 W. Grant Co.: Glen Haven. Iron Co.: Montreal River. Jefferson Co.: Palmyra. Lincoln Co.: Tomahawk. Polk Co.: St. Croix Falls. Rock Co.: Newark. Sheboygan Co.: near Cedar Grove. Vilas Co.: Lac Vieux Desert. Waukesha Co.: Eagle; Eagle Lake; Mukwonago; Ottawa Twp.; Vernon Station; Waukesha.

DESMATODON

D. CERNUUS (Hueben.) Bry. Eur. Waukesha Co.: Waukesha.

D. OBTUSIFOLIUS (Schwaegr.) Jur. as *D. arenaceus* Sull. Ashland Co.: Basswood Island. Barron Co.: Barron. Bayfield Co.: Houghton Quarry; Port Wing. Dane Co.: Black Earth; Madison. Grant Co.: Bagley; Beetown; near Bridgeport; Glen Haven; Potosi. Jefferson Co.: Lake Koshkonong. Lafayette Co.: Fayette. Polk Co.: Osceola. Rock Co.: Avon; Beloit; Bradford Twp.; Carvers Rock, Bradford Twp.; Janesville. Waukesha Co.: Menomonee Falls.

DICHELYMA

D. CAPILLACEUM Bry. Eur. Marathon Co.: Granite Heights. Oneida Co.: Rhinelander. Portage Co.: Stevens Point.

D. FALCATUM (Hedw.) Myrin. Ashland Co.: Stockton Island (Presque Isle). Bayfield Co.: Houghton Quarry. Douglas Co.: shore of Lake Superior near Amnicon River. Lincoln Co.: Grandfather Falls; Merrill. Marathon Co.: Granite Heights. Outagamie Co.: Appleton. Rusk Co.: Horseman; Old Murry.

D. PALLESCENS Bry. Eur. Lincoln Co.: Grandfather Falls. Oneida Co.: Rhinelander.

DICHODONTIUM

D. PELLUCIDUM (Hedw.) Schimp. Ashland Co.: Basswood Island. Bayfield Co.: Orienta.

D. PELLUCIDUM var. FAGIMONTANUM (Brid.) Schimp. Iron Co.: Montreal River, near Lake Superior.

DICRANELLA

D. CERVICULATA (Hedw.) Schimp. Bayfield Co.: Houghton Quarry.

D. HETEROMALLA (Hedw.) Schimp. Adams Co.: near Wisconsin Dells. Dane Co.: Madison. Grant Co.: Castle Rock. Polk Co.: St. Croix Falls. Rock Co.: Newark Twp. Waukesha Co.: New Berlin Twp.

D. HUMILIS Ruthe. Buffalo Co.: Marshland.

D. RUFESCENS (Smith) Schimp. Grant Co.: near Potosi.

D. SUBULATA (Hedw.) Schimp. Bayfield Co.: Houghton Quarry.

D. VARIA (Hedw.) Schimp. Bayfield Co.: Houghton Quarry. Dane Co.: Madison. Grant Co.: Bagley; Glen Haven; Potosi.

Lafayette Co.: Fayette. Milwaukee Co.: Milwaukee. Outagamie Co.: Appleton. Trempealeau Co.: Trempealeau Mountain. Waukesha Co.: Waukesha.

DICRANUM

D. BERGERI Bland. Barron Co.: Barron. Bayfield Co.: Drummond; Herbster; Port Wing. Buffalo Co.: Marshland. Dane Co.: Windsor. Door Co.: Baileys Harbor. Green Lake Co.: Princeton. Jefferson Co.: Lake Mills. Marathon Co.: N. of Wausau. Oneida Co.: Newbold. Outagamie Co.: Appleton. Ozaukee Co.: Cedarburg.

D. BONJEANI De Not. Ashland Co.: Basswood Island; La Pointe, Madeline Island; Manitou Island; Hermit Island. Bayfield Co.: Bayfield; Houghton Quarry; Port Wing; Siskowitt Bay. Dane Co.: Blue Mounds; Hook Lake as *D. Bonjeani* var. *Schlotthaueri* Barnes; Madison; Windsor. Door Co.: Baileys Harbor. Jefferson Co.: Helenville; Jefferson; Lake Mills; same station as *D. Bonjeani* var. *juniperifolium* Braith. Lincoln Co.: Grandfather Falls; same station as *D. Bonjeani* var. *Schlotthaueri* Barnes; Merrill. Manitowoc Co.: Two Rivers. Marathon Co.: near Pine River. Oneida Co.: Newbold; Tomahawk Lake; near Tomahawk Lake. Ozaukee Co.: Cedarburg. Sauk Co.: Devils Lake. Vilas Co.: Lac Vieux Desert; near State Line. Waukesha Co.: Beaver Lake; Menomonee Falls; Mukwonago; Vernon.

D. CONDENSATUM Hedw. Dane Co.: Pine Bluff. Grant Co.: Castle Rock.

D. DRUMMONDII C. Müll. Ashland Co.: Manitou Island. Barron Co.: Barron; near Canton. Bayfield Co.: Bark Point; Sand Bay; Mason; Orienta; Squaw Bay. Dane Co.: Blue Mounds; Madison. Door Co.: Baileys Harbor. Douglas Co.: Allouez Bay; T 45 N R 15 W. Iron Co.: Montreal River. Jefferson Co.: Palmyra. Lincoln Co.: Grandfather Falls; Pine River; Tomahawk. Oconomowoc Co.: Oconomowoc. Oneida Co.: Newbold. Vilas Co.: Eagle River.

D. FLAGELLARE Hedw. Adams Co.: Cold Water Canyon; Dells of Wisconsin River. Barron Co.: Barron. Bayfield Co.: Bayfield; Mason; Port Wing; Sand Bay. Dane Co.: Blue Mounds; Madison; Windsor. Door Co.: Baileys Harbor. Douglas Co.: Brule River; Lucius Lake; T 45 N R 15 W. Grant Co.: Lancaster. Jefferson Co.: Helenville; Lake Mills. Lafayette Co.:

Fayette. Lincoln Co.: Grandmother Falls. Manitowoc Co.: Two Rivers. Oneida Co.: Rhinelander; Tomahaw Lake. Polk Co.: St. Croix Falls. Sauk Co.: near Wisconsin Dells. Sheboygan Co.: Cedar Grove; Sheboygan. Trempealeau Co.: Trempealeau Mountain. Vilas Co.: Conover; Lac Vieux Desert; Sayner. Washburn Co.: Spooner. Washington Co.: Newburg. Waukesha Co.: Calhoun; Pine Lake. Wood Co.: Wisconsin Rapids.

D. FULVUM Hook. Barron Co.: Barron. Dane Co.: Blue Mounds. Grant Co.: Castle Rock; Glen Haven; near Platteville; Potosi. Lincoln Co.: Grandfather Falls. Marathon Co.: Granite Heights. Oneida Co.: Hat Rapids (5 miles N of Whirlpool Rapids). Sheboygan Co.: Cedar Grove.

D. FUSCESCENS Turn. Ashland Co.: Basswood Island; LaPointe, Madeline Island; Hermit Island. Bayfield Co.: Port Wing; Siskowitt Bay. Dane Co.: Pine Bluff. Door Co.: Baileys Harbor. Douglas Co.: T 45 N R 15 W. Lincoln Co.: Grandfather Falls. Oneida Co.: Rhinelander. Vilas Co.: near State Line.

D. MONTANUM Hedw. Ashland Co.: Hermit Island; Oak Island. Barron Co.: Barron. Bayfield Co.: Drummond; Herbster; Houghton Quarry; Mason; Port Wing. Dane Co.: Madison. Iron Co.: N W corner, on shore of Lake Superior. Lincoln Co.: Grandmother Falls; Pine River. Ozaukee Co.: Cedarburg. Portage Co.: Stevens Point. Trempealeau Co.: Trempealeau Mountain. Vilas Co.: Lac Vieux Desert; Sayner. Waukesha Co.: Okauchee Lake; Pine Lake.

D. MUHLENBECKII Bry. Eur. Dane Co.: Blue Mounds. Lincoln Co.: Merrill. Sauk Co.: Devils Lake.

D. RUGOSUM (Hoffm.) Brid. Ashland Co.: Basswood Island; Kakagin River, at Lake Superior; Hermit Island; Long Island; Madeline Island; Odanah. Barron Co.: Barron. Bayfield Co.: Bark Point; Drummond; Houghton Quarry; Sand Bay; Sand Island; Siskowitt Bay. Dane Co.: Blue Mounds; Mendota. Door Co.: Baileys Harbor; Ellison Bay. Douglas Co.: T 45 N R 15 w; Lake Superior, near Brule River; Upper Lucius Lake, Brule River. Jefferson Co.: Lake Mills. Lincoln Co.: Merrill; Tomahawk. Manitowoc Co.: Two Rivers. Oneida Co.: Newbold; Tomahawk Lake. Outagamie Co.: Appleton. Ozaukee Co.: Cedarburg. Vilas Co.: Eagle River; State Line. Waukesha Co.: Vernon.

D. SCOPARIUM Hedw. Ashland Co.: LaPointe, Madeline Island; Oak Island; Hermit Island. Barron Co.: Prairie Lake Twp., sec. 7. Bayfield Co.: Bark Bay; Drummond; Herbster; Houghton Quarry; La Chapelle (Lashabel's homestead); Port Wing; Sand Island; Squaw Bay. Dane Co.: Belleville; Blue Mounds; Madison; near Windsor. Door Co.: near Baileys Harbor; Garrett Bay. Douglas Co.: T 45 N R 15 W; Brule River; Upper Lucius Lake. Grant Co.: Glen Haven; Montfort; Werley. Iron Co.: Montreal River. Jefferson Co.: Lake Mills. Lincoln Co.: Grandmother Falls; Tomahawk. Marathon Co.: Granite Heights; near Wausau. Oneida Co.: near Eagle Lake; Rhinelander; Tomahawk Lake; Whirlpool Rapids. Ozaukee Co.: Cedarburg. Rusk Co.: Murry; Strickland. Sauk Co.: Devils Lake. Sheboygan Co.: Cedar Grove; Sheboygan. Vilas Co.: Eagle River; Lac Vieux Desert. Waukesha Co.: Oconomowoc; Pewaukee; Pine Lake; Waukesha Twp.

D. VIRIDE (Sull. & Lesq.) Lindb. Barron Co.: Barron; near Barron. Bayfield Co.: Bayfield; Mason. Dane Co.: Madison. Douglas Co.: near mouth of the Brule River. Grant Co.: Glen Haven; Mt. Hope; Potosi. Jefferson Co.: Palmyra. Lafayette Co.: Fayette. Lincoln Co.: Grandmother Falls; Merrill; Tomahawk. Milwaukee Co.: South Milwaukee. Oneida Co.: Hat Rapids; McNaughton; Newbold; Rhinelander; Tomawak Lake. Outagamie Co.: Appleton. Ozaukee Co.: Cedarburg. Rusk Co.: Strickland. Sauk Co.: near Wisconsin Dells. Sheboygan Co.: Cedar Grove; Plymouth. Vilas Co.: Lac Vieux Desert; near State Line. Washington Co.: Newburg. Waukesha Co.: Lake Nagawicka; Nashotah Lake; Pine Lake.

DIDYMODON

D. RECURVIROSTRIS (Hedw.) Jennings as *D. rubellus* Bry. Eur. Ashland Co.: Basswood Island; Manitou Island; Oak Island; near White River. Bayfield Co.: Herbster; Houghton Quarry; LaChapelle (Lashabel's homestead); Mason; Port Wing. Dodge Co.: Horicon. Door Co.: Ellison Bay. Douglas Co.: T 45 N R 15 W. Grant Co.: Bagley; Bloomington; Glen Haven; Lancaster; Millville; Mt. Hope; North Andover; Patch Grove; Platteville; Potosi. Iron Co.: Montreal River. Lincoln Co.: Grandfather Falls; Grandmother Falls. Marathon Co.: Wausau. Milwaukee Co.: South Milwaukee. Rock Co.: Beloit; Carver's Rock, Bradford Twp.; Janesville. Sheboygan Co.: Cedar Grove.

DIPHYSCIUM

D. FOLIOSUM (Hedw.) Mohr. Columbia Co.: Dells of Wisconsin River.

DISTICHIUM

D. CAPILLACEUM (Hedw.) Bry. Eur. Bayfield Co.: between Port Wing and Herbster.

D. INCLINATUM (Hedw.) Bry. Eur. Bayfield Co.: Squaw Bay.

DITRICHUM

D. HETEROMALLUM (Hedw.) E. G. Britton. as *D. homomallum* Hampe. Jefferson Co.: Palmyra.

D. LINEARE (Sw.) Lindb. as *D. vaginans* (Sull.) Hpe. Barron Co.: Maple Grove Twp., sec. 8. Iron Co.: lower Montreal River.

D. PALLIDUM (Hedw.) Hampe. Adams Co.: Dells of Wisconsin River. Grant Co.: Bagley; Glen Haven. Milwaukee Co.: Milwaukee. Rock Co.: Clinton. Sauk Co.: Devils Lake.

D. PUSILLUM (Hedw.) E. G. Britton. as *D. tortile* Brockm. excepting for those stations marked with an *. These collections were listed originally as *D. pusillum*. Barron Co.: Barron Twp., sec. 26; Barron; Doyle Twp., sec. 33; Maple Grove Twp., sec. 8; Prairie Lake Twp., sec. 7. Bayfield Co.: Drummond. Buffalo Co.: Marshland. Dane Co.: Madison; same station *. Iron Co.: Pence. Lincoln Co.: Tomahawk. Marathon Co.: Granite Heights. Oneida Co.: Noisy Creek; Rhinelander; Tomahawk Lake. Polk Co.: Osceola. Price Co.: Ogema. Rock Co.: Newark. Trempealeau Co.: Trempealeau Mountain *.

DREPANOCLADUS

D. ADUNCUS (Hedw.) Warnst. Dane Co.: Madison. Grant Co.: Potosi. Waukesha Co.: Eagle; Ottawa Twp.

D. ADUNCUS f. AQUATICUS (Sanio) Mönkem. Door Co.: Baileys Harbor. Jefferson Co.: Palmyra. Sheboygan Co.: Cedar Grove.

D. ADUNCUS var. KNEIFFII (Bry. Eur.) Warnst. Jefferson Co.:

Ixonia. Manitowoc Co.: Two Rivers. Waukesha Co.: Mukwonago; Okauchee Lake.

D. ADUNCUS var. KNEIFFII f. INTERMEDIUS (B. & S.) Mönkem. Waukesha Co.: Waukesha.

D. ADUNCUS var. KNEIFFII f. PSEUDOFLUITANS (Sanio) Mönkem. Oneida Co.: Tomahawk Lake. Waukesha Co.: Waukesha.

D. ADUNCUS var. POLYCARPUS (Bland.) Warnst. Lincoln Co.: Tomahawk. Polk Co.: near Doran. Waukesha Co.: Oconomowoc; Vernon; Waukesha.

D. ADUNCUS var. POLYCARPUS f. GRACILESCENS (Br. & Sch.) Mönkem. Dane Co.: Blue Mounds. Rock Co.: Newark. Waukesha Co.: Mukwonago; Oconomowoc.

D. ADUNCUS var. POLYCARPUS f. UNCUS Grout. Waukesha Co.: near Vernon.

D. ADUNCUS var. PSEUDOFLUITANS f. PATERNUS (Sanio) Grout. Ashland Co.: Madeline Island. Douglas Co.: mouth of Brule River.

D. EXANNULATUS (Gümb.) Warnst. Barron Co.: Barron. Oneida Co.: Newbold.

D. EXANNULATUS var. BRACHYDICTYUS (Ren.) Grout. Oneida Co.: Tomahawk Lake.

D. EXANNULATUS var. ROTAE f. FALCIFOLIUS (Ren.) Grout. Bayfield Co.: Drummond. Oneida Co.: Tomahawk Lake. Outagamie Co.: Appleton. Portage Co.: Stevens Point. Vilas Co.: Weber Lake.

D. FLUITANS (Hedw.) Warnst. Oneida Co.: Tomahawk Lake. Vilas Co.: Conover.

D. FLUITANS f. JEANBERNATI (Ren.) Mönkem. Barron Co.: Barron; Barron Twp., sec. 29. Oneida Co.: Tomahawk Lake.

D. INTERMEDIUS (Lindb.) Warnst. Door Co.: Baileys Harbor. Jefferson Co.: Palmyra.

D. REVOLVENS (C. Müll.) Warnst. Door Co.: Baileys Harbor. Jefferson Co.: Palmyra.

D. SENDTNERI (Schimp.) Warnst. Waukesha Co.: Waukesha.

D. SENDTNERI f. ARISTINERVIS Mönkem. Rock Co.: Newark.

D. UNCINATUS (Hedw.) Warnst. Ashland Co.: Basswood Island; Hermit Island; Oak Island; near White River. Bayfield Co.: LaChapelle (Lashabel's homestead); Mason; Port Wing; near Port Wing; Sand Bay; Sand Island; Siskowitt Bay. Dane Co.: Madison. Door Co.: Baileys Harbor. Douglas Co.: Amnicon River. Iron Co.: Montreal River. N W corner of La Pointe Indian Reservation. Lincoln Co.: Grandfather Falls; near Grandfather Falls. Oneida Co.: Tomahawk Lake.

D. UNCINATUS var. PLUMULOSUS (Schimp.) Roth. Door Co.: Baileys Harbor. Vilas Co.: Lac Vieux Desert. Waukesha Co.: Big Bend.

D. VERNICOSUS (Lindb.) Warnst. Bayfield Co.: Herbster; Port Wing. Door Co.: Baileys Harbor. Douglas Co.: T 45 N R 15 W. Lincoln Co.: Tomahawk. Vilas Co.: Conover; Lac Vieux Desert; near State Line.

DRUMMONDIA

D. PROREPENS (Hedw.) Jennings as *D. clavellata* Hook. Barron Co.: Barron Twp., sec. 20; Doyle Twp., sec. 33; Maple Grove Twp. Burnett Co.: Webb Lake. Dane Co.: Madison. Rusk Co.: Strickland.

ENCALYPTA

E. CILIATA Hedw. Ashland Co.: Manitou Island. Bayfield Co.: Port Wing. Dane Co.: Blue Mounds. Douglas Co.: T 45 N R 15 W. Grant Co.: Bagley. Iron Co.: Montreal River. Lincoln Co.: Grandfather Falls. Marathon Co.: Wausau. Rusk Co.: Strickland. Sauk Co.: near Wisconsin Dells.

E. STREPTOCARPA Hedw. Door Co.: Cana Island. Outagamie Co.: Appleton.

ENTODON

E. BREVISETUS (Hook. & Wils.) Jaeger & Sauerb. Barron Co.: Barron. Lincoln Co.: Grandfather Falls; Merrill. Waukesha Co.: Menomonee Falls.

E. CLADORRHIZANS (Hedw.) C. Müll. Barron Co.: Barron. Dane Co.: Madison; near Madison. Grant Co.: Glen Haven. Jefferson Co.: Palmyra; Sullivan. Lafayette Co.: Fayette. Outagamie Co.: Appleton. Portage Co.: Stevens Point. Rock Co.: Clinton. Rusk Co.: Murry. Sauk Co.: near Wisconsin Dells. Waukesha Co.: Pine Lake; Saylesville.

E. SEDUCTRIX (Hedw.) C. Müll. Barron Co.: Poskin. Dane Co.: Madison; near Madison. Grant Co.: Glen Haven. Jefferson Co.: Johnson Creek; Palmyra. Portage Co.: Stevens Point. Rock Co.: Newark Twy. Sheboygan Co.: Franklin. Trempealeau Co.: Trempealeau Mountain. Waukesha Co.: Oconomowoc; Pine Lake; Waukesha.

EPHEMERUM

E. COHAERENS (Hedw.) Hampe. Dane Co.: Madison.

E. CRASSINERVIUM (Schwaegr.) C. Müll. Barron Co.: Barron. Grant Co.: Potosi.

E. SPINULOSUM Schimp. Barron Co.: Barron.

EURHYNCHIUM

E. HIANS (Hedw.) Jaeger & Sauerb. Dane Co.: Madison. Grant Co.: Glen Haven; Potosi. Jefferson Co.: Palmyra. Waukesha Co.: Waukesha.

E. RUSCIFORME (Neck.) Milde. Barron Co.: Campia. Rusk Co.: Old Murry; sec. 20 T 36 N R 7 W. Sauk Co.: Baraboo.

E. SERRULATUM (Hedw.) Kindb. Barron Co.: Barron. Dane Co.: Blue Mounds; Madison. Dodge Co.: Horicon. Grant Co.: Glen Haven; Lancaster; Werley. Iron Co.: Montreal River. Jefferson Co.: near Cambridge; Palmyra. Lafayette Co.: Fayette. Rock Co.: Bradford Twp.; Newark Twp. Rusk Co.: Murry. Vilas Co.: Lac Vieux Desert. Waukesha Co.: Oconomowoc; Pine Lake.

E. STOKESII (Turn.) Bry. Eur. Outagamie Co.: Appleton.

E. STRIGOSUM (Hoffm.) Bry. Eur. Ashland Co.: Hermit Island; Manitou Island; Penokee; White River. Barron Co.: Barron. Bayfield Co.: Drummond; Herbster; Houghton Quarry; La Chapelle (Lashabel's homestead); Mason; Orienta; Port Wing; Sand Bay. Door Co.: Baileys Harbor. Grant Co.: Glen Haven; Patch Grove. Iron Co.: Montreal River, near Lake Superior. Jefferson Co.: Palmyra. Lincoln Co.: Grandfather Falls; Grandmother Falls; Merrill; Tomahawk. Manitowoc Co.: Two Rivers. Oneida Co.: Hat Rapids; Tomahawk Lake. Outagamie Co.: Appleton. Price Co.: Ogema. Rusk Co.: Murry. Sauk Co.: near Wisconsin Dells. Sheboygan Co.: Cedar Grove. Vilas Co.: Eagle River; Lac Vieux Desert. Waukesha Co.: North Lake; Okauchee Lake; Pine Lake.

FABRONIA

F. CILIARIS (Brid.) Brid. as *F. octoblepharis* (Schleich.) Schwaegr. Barron Co.: Barron; near Barron. Grant Co.: Dutch Hollow; Glen Haven; Lancaster; Potosi. Polk Co.:

near Doran. Rusk Co.: Rusk Twp. Waukesha Co.: Oconomowoc.

FISSIDENS

F. ADIANTOIDES Hedw. Barron Co.: Barron. Bayfield Co.: Houghton Quarry. Dane Co.: Madison. Door Co.: Baileys Harbor. Iron Co.: Montreal River, near Lake Superior. Lincoln Co.: Grandfather Falls. Outagamie Co.: Appleton. Waukesha Co.: Vernon; Waukesha.

F. BRYOIDES Hedw. Bayfield Co.: Mason. Dane Co.: Madison; same station as *F. incurvus* (Web. & Mohr) Schwaegr. Douglas Co.: T 45 N R 15 W. Grant Co.: Lancaster; North Andover; Potosi. Lincoln Co.: Grandfather Falls; Grandmother Falls; Merrill. Oneida Co.: McNaughton; Tomahawk Lake. Portage Co.: Stevens Point. Washington Co.: Newburg. Waukesha Co.: Oconomowoc; Pine Lake, both as *F. incurvus* (Web. & Mohr) Schwaegr.

F. CRISTATUS Wils. Adams Co.: Witches Gulch. Ashland Co.: Basswood Island; White River. Barron Co.: Doyle Twp. Bayfield Co.: Houghton Quarry; Port Wing. Dane Co.: Blue Mounds. Door Co.: Baileys Harbor. Grant Co.: Glen Haven; Potosi; Werley. Lafayette Co.: Fayette. Lincoln Co.: Grandfather Falls. Milwaukee Co.: South Milwaukee. Oneida Co.: Hat Rapids; Whirlpool Rapids. Outagamie Co.: Greenville. Ozaukee Co.: Cedarburg. Rusk Co.: Murry; Strickland. Washington Co.: Newburg. Waukesha Co.: Menomonee Falls; Sussex; Vernon; Waukesha.

F. CRISTATUS var. WINONENSIS (Ren. & Card.) Grout. Sauk Co.: near Wisconsin Dells.

F. EXIGUUS Sull. as *F. incurvus* var. *exiguus* Barnes. Ashland Co.: Basswood Island. Grant Co.: Glen Haven. Milwaukee Co.: Milwaukee.

F. JULIANUS (Mont.) Schimp. Barron Co.: Barron. Jefferson Co.: Palmyra. Portage Co.: Stevens Point.

F. MINUTULUS Sull. The stations marked with an * indicate collections which were listed as *F. incurvus* (Web. & Mohr) Schwaegr. Adams Co.: Cold Water Canyon; same station *. Ashland Co.: Basswood Island; same station *. Barron Co.: Barron. Grant Co.: Bagley; Fennimore; Glen Haven; same station *; Jamestown Twp. *; Millville; Mt. Hope; Mt. Ida; North Andover; Patch Grove; same station *; Potosi; same station *; Werley. Lafayette Co.: Fayette; same station *. Lincoln Co.: Grandfather Falls *. Rock Co.: Beloit; Clinton; Janesville; same station *. Waukesha Co.: Oconomowoc.

F. OBTUSIFOLIUS Wils. Grant Co.: Bagley; near Bridgeport; Glen Haven; Werley.

F. OSMUNDIOIDES Hedw. Ashland Co.: Basswood Island; Oak Island. Barron Co.: Barron. Door Co.: Baileys Harbor. Grant Co.: Patch Grove. Lincoln Co.: Merrill. Oneida Co.: Hat Rapids; McNaughton; Tomahawk Lake.

F. RAVENELLII Sull. Lafayette Co.: Fayette.

F. SUBBASILARIS Hedw. Waukesha Co.: Waukesha.

F. TAXIFOLIUS Hedw. Grant Co.: Glen Haven. Lafayette Co.: Fayette. Rock Co.: Bradford Twp.; Clinton.

FONTINALIS

F. ANTIPYRETICA Hedw. Ashland Co.: Stockton Island. Barron Co.: Doyle Twp. Lincoln Co.: Tomahawk. Oneida Co.: Noisy Creek. Sauk Co.: Baraboo. Vilas Co.: Trout Lake. Washburn Co.: Minong.

F. ANTIPYRETICA var. GIGANTEA Sull. Ashland Co.: Stockton Island. Barron Co.: Barron; Campia; Doyle Twp. Douglas Co.: Amnicon Falls; Solon Springs. Lincoln Co.: Grandfather Falls. Manitowoc Co.: Manitowoc. Marathon Co.: Granite Heights. Oneida Co.: Newbold; Tomahawk Lake. Portage Co.: Stevens Point. Rusk Co.: Horseman. Sauk Co.: Devils Lake. Vilas Co.: Conover; Lac Vieux Desert.

F. DALECARLICA Bry. Eur. Marathon Co.: Mosinee.

F. DURIAEI Schimp. Barron Co.: Barron; Doyle Twp. Bayfield Co.: Drummond. Burnett Co.: Roosevelt Twp. Douglas Co.: Amnicon Falls; Lucius Lake; T 45 N R 15 W. Jefferson Co.: Palmyra. Lincoln Co.: Grandfather Falls; Merrill. Oneida Co.: Hat Rapids; Newbold; Tomahawk; Whirlpool Rapids. Polk Co.: near Doran. Portage Co.: Stevens Point. Vilas Co.: Conover; Eagle River; near State Line. Waukesha Co.: Eagle; North Lake.

F. FLACCIDA Ren. & Card. Vilas Co.: Trout Lake.

F. HYPNOIDES Hartm. Waukesha Co.: Waukesha.

F. MISSOURICA Card. Barron Co.: Doyle Twp., sec. 33. Lakeland Twp., Pipe Lake. Lincoln Co.: Merrill as *F. Umbachi* Card.

F. NOVAE-ANGLIAE Sull. Lincoln Co.: Grandfather Falls. Marathon Co.: Granite Heights.

FUNARIA

F. AMERICANA Lindb. Grant Co.: Glen Haven. Rock Co.: Bradford Twp.

F. HYGROMETRICA Hedw. Bayfield Co.: Herbster; Mason. Dane Co.: Ellenboro; Madison. Door Co.: Baileys Harbor. Douglas Co.: T 45 N R 15 W. Grant Co.: Bagley; Cornelia; Glen Haven; Potosi. Iron Co.: Hurley. Oneida Co.: Noisy Creek; Tomahawk Lake. Outagamie Co.: Appleton. Ozaukee Co.: Cedarburg. Polk Co.: near Doran. Rock Co.: Clinton. Sheboygan Co.: Sheboygan; Cedar Grove. Vilas Co.: Eagle River; Lac Vieux Desert; Star Lake. Washington Co.: Newburg. Waukesha Co.: Menomonee Falls; Menomonee Twp.; Mukwonago; Ottawa Twp.; Saylesville; Vernon Station; Waukesha. Wood Co.: Wisconsin Rapids.

GRIMMIA

G. ALPICOLA var. RIVULARIS (Brid.) Broth. as *G. apocarpa* var. *rivularis* Web. & Mohr. Barron Co.: Barron. Bayfield Co.: Herbster; Houghton Quarry. Lincoln Co.: Grandfather Falls; Grandmother Falls; Merrill. Marathon Co.: Mosinee. Oneida Co.: Hat Rapids; Rhinelander; Tomahawk Lake. Portage Co.: Stevens Point. Rusk Co.: Strickland.

G. APOCARPA Hedw. Barron Co.: Doyle Twp. Bayfield Co.: Port Wing. Dane Co.: Blue Mounds; Madison. Door Co.: Baileys Harbor. Grant Co.: Glen Haven; Potosi; Wyalusing. Iron Co.: Montreal River, near Lake Superior. Lincoln Co.: Grandfather Falls; Grandmother Falls. Oneida Co.: Noisy Creek; Rhinelander; Tomahawk Lake. Outagamie Co.: Appleton. Ozaukee Co.: Cedarburg. Rock Co.: Bradford Twp.; Clinton; Janesville. Washington Co.: Newburg. Waukesha Co.: North Lake.

G. APOCARPA var. AMBIGUA (Sull.) Jones. Jefferson Co.: Palmyra.

G. APOCARPA var. CONFERTA (Funck) Spreng. Dane Co.: Madison. Door Co.: Cana Island. Grant Co.: Glen Haven; Werley. Trempealeau Co.: Trempealeau Mountain.

G. APOCARPA var. GRACILIS (Schleich.) Web. & Mohr. Grant Co.: Glen Haven.

G. CALYPTRATA Hook. Douglas Co.: Manitou Falls.

G. COMMUTATA Hüben. Ashland Co.: Basswood Island.

G. DONIANA Smith. Dane Co.: near Madison. Grant Co.: near Potosi.

G. LAEVIGATA (Brid.) Brid. Dane Co.: Madison. Rock Co.: Bradford Twp.; Newark Twp.

G. OLNEYI Sull. Dane Co.: near Madison.

G. PILIFERA Beauv. Bayfield Co.: Houghton Quarry; Mason. Dane Co.: Blue Mounds. Grant Co.: Platteville; Potosi. Lincoln Co.: Grandfather Falls. Marathon Co.: Mosinee. Oneida Co.: Tomahawk Lake.

G. PLAGIOPODIA Hedw. Dane Co.: near Madison. Grant Co.: Glen Haven; Potosi.

G. PULVINATA (Hedw.) Smith. Dane Co.: near Madison.

G. TERETINERVIS Limpr. Trempealeau Co.: Trempealeau.

GYMNOSTOMUM

G. CALCAREUM Nees & Hornsch. Ashland Co.: Basswood Island. Bayfield Co.: Herbster; Houghton Quarry. Dane Co.: Madison. Douglas Co.: Falls of the Black River. Grant Co.: Bagley; Beetown; near Bridgeport; Cassville; Castle Rock; Glen Haven; Mt. Hope; North Andover; Potosi. Lafayette Co.: Fayette. Rock Co.: Beloit; Bradford Twp.; Janesville.

G. RECURVIROSTRUM Hedw. as *G. curvirostre* (Ehrh.) Hedw. Bayfield Co.: Port Wing; Squaw Bay. Columbia Co.: Wisconsin Dells. Dane Co.: Madison. Grant Co.: Burton; Glen Haven; Mt. Hope; Platteville; Wyalusing. Iron Co.: Montreal River, near Lake Superior. Rock Co.: Bradford Twp.

HAPLOHYMENIUM

H. TRISTE (Cesati) Kindb. cf. *Anomodon tristis* (Cesati) Sull.

HEDWIGIA

H. CILIATA (Ehrh.) Hedw. Adams Co.: Dells of the Wisconsin River. Bayfield Co.: Drummond; Houghton Quarry. Dane Co.: Madison. Douglas Co.: Superior. Grant Co.: Potosi. Jefferson Co.: Palmyra. Marathon Co.: Wausau. Milwaukee Co.: South Milwaukee. Outagamie Co.: Appleton. Rock Co.: Fairfield. Sheboygan Co.: Little Elkhart Lake. Vilas Co.: Lac Vieux Desert. Waukesha Co.: Brookfield Twp.; Oconomowoc; Waukesha.

H. CILIATA f. DETONSA (Howe) Grout. Ashland Co.: Basswood Island.

H. CILIATA f. VIRIDIS (Bry. Eur.) Grout. Dane Co.: near Madiison. Sheboygan Co.: Little Elkhart Lake.

HELODIUM

H. BLANDOWII (Web. & Mohr) Warnst. Jefferson Co.: near Palmyra. Ozaukee Co.: Cedarburg Swamp. Washington Co.: Newburg. Waukesha Co.: Mukwonago; sec. 33, T 5 N R 18 E.

HETEROPHYLLIUM

H. HALDANIANUM (Grev.) Kindb. as *Hypnum Haldanianum* Grev. Adams Co.: Cold Water Canyon. Ashland Co.: Oak Island. Barron Co.: Barron. Bayfield Co.: Drummond; Herbster; La Chapelle (Lashabel's homestead). Dane Co.: Madison; Pine Bluff. Door Co.: Sister Bay. Douglas Co.: Superior; Brule River; Upper Lucius Lake. Grant Co.: Glen Haven. Iron Co.: Montreal River, near Lake Superior. Jefferson Co.: Helenville; Lake Mills; Sullivan. Lafayette Co.: Fayette. Lincoln Co.: Grandfather Falls; Grandmother Falls; Pine Islands, near Tomahawk; Tomahawk. Oneida Co.: Newbold; Rhinelander; Wisconsin River, ten miles below Eagle River. Price Co.: Knox Mills. Sauk Co.: Baraboo. Sheboygan Co.: Cedar Grove; Oostburg; Sheboygan. Vilas Co.: Lac Vieux Desert; near State Line. Waukesha Co.: Eagle Lake; Pine Lake. Wood Co.: Wisconsin Rapids.

HOMALIA

H. JAMESII Schimp. Adams Co.: Cold Water Canyon. Bayfield Co.: Houghton Quarry. Lincoln Co.: Grandfather Falls. Marathon Co.: Goodrich Junction; Granite Heights. Oneida Co.: Hat Rapids. Sauk Co.: Parfreys Glen, near Baraboo.

HOMALOTHECIELLA

H. SUBCAPILLATA (Hedw.) Card. Barron Co.: Barron. Grant Co.: Glen Haven. Oneida Co.: Tomahawk Lake.

HOMOMALLIUM

H. ADNATUM (Hedw.) Broth. Barron Co.: Canton; Doyle Twp. Chippewa Co.: Long Lake. Dane Co.: Blue Mounds; Madison. Dodge Co.: Horicon. Grant Co.: Bagley; Glen Haven; Potosi. Jefferson Co.: Helenville; Johnson Creek; Palmyra;

Sullivan. Lafayette Co.: Fayette. Milwaukee Co.: Milwaukee. Outagamie Co.: Binghampton Bog, near Appleton. Polk Co.: St. Croix Falls. Rock Co.: Avon Twp.; Bradford Twp.; Carver's Rocks. Sauk Co.: Devils Lake. Sheboygan Co.: Cedar Grove. Waukesha Co.: Menomonee Falls; North Lake; Okauchee Lake; Pine Lake; Vernon; Wales; Waukesha.

HYGROAMBLYSTEGIUM

H. FLUVIATILE (Hedw.) Loeske. Ashland Co.: Stockton Island; White River. Barron Co.: sec. 12 T 35 N R 10 W; Canton; sec. 8, Maple Grove Twp. Bayfield Co.: Buffalo Bay; Drummond; Mason; Port Wing; Siskowitt Bay. Douglas Co.: Brule River. Grant Co.: Glen Haven; Potosi. Iowa Co.: Union Mills. Iron Co.: Montreal River. Lincoln Co.: N E corner; Grandfather Falls. Marathon Co.: Granite Heights. Oneida Co.: Rhinelander; ten miles S of Rhinelander; Tomahawk Lake. Portage Co.: Stevens Point. Rusk Co.: Murry; Strickland. Sauk Co.: Baraboo.

H. FLUVIATILE var. OVATUM Grout. Clark Co.: Abbotsford.

H. IRRIGUUM (Wils.) Loeske. Ashland Co.: White River. Barron Co.: Barron. Bayfield Co.: Drummond; La Chapelle (Lashabel's homestead); Port Wing. Dane Co.: Blue Mounds; Madison; Middleton. Douglas Co.: T 45 N R 15 W; Superior. Grant Co.: near Bridgeport; Glen Haven; Potosi; Wyalusing. Iron Co.: Montreal River, near Lake Superior. Jefferson Co.: Palmyra. Lincoln Co.: Grandfather Falls. Milwaukee Co.: Greenfield Twp.; Milwaukee. Oneida Co.: Rhinelander. Polk Co.: near Doran. Portage Co.: Stevens Point. Rock Co.: Beloit; Bradford Twp.; Clinton; Janesville. Sauk Co.: Devils Lake. Sheboygan Co.: Cedar Grove. Waukesha Co.: Beaver Lake; Big Bend; Eagle; Lake La-Belle; Lannon; Lisbon Twp.; Mukwonago; Upper Nemahbin Lake; Norris Farm for Boys; North Lake; Oconomowoc; Oconomowoc Lake; Okauchee Lake; Ottawa Twp.; Pewaukee; Pine Lake; Sawtelle; Vernon Station; Wales; Waukesha; Waukesha Twp.

H. IRRIGUUM var. SPINIFOLIUM (Schimp.) Grout. Ozaukee Co.: Thiensville. Rock Co.: Clinton.

H. NOTEROPHILUM (Sull.) Warnst. Dane Co.: Madison; Pheasant Branch; Lake Wingra. Grant Co.: Beetown; Castle Rock; Millville; Platteville; Potosi; Wyalusing. Green Lake

Co.: Green Lake. Rock Co.: Clinton; Fairfield. Waukesha Co.: Eagle; Ottawa Twp.

H. ORTHOCLADON (Beauv.) Grout. Mr. Cheney prefers referring this plant to a form of *H. irriguum*: "Dr. Grout makes this form a sub-species of *H. irriguum*, but says that it might better be ranked as a varietal form. My own observations of a large large number of specimens leads me to place it in the latter rank. My own series of specimens shows an unbroken gradation from typical *H. irriguum* to the extreme forms referred to *H. irriguum orthocladon*". Ashland Co.: White River; Ashland. Iron Co.: Montreal River near Lake Superior. Lafayette Co.: Fayette. Polk Co.: near Doran. Walworth Co.: Whitewater. Waukesha Co.: Okauchee Lake; Waukesha.

HYGROHYPNUM

H. EUGYRIUM (Bry. Eur.) Loeske. Oneida Co.: Tomahawk Lake.

H. OCHRACEUM (Turn.) Loeske. Ashland Co.: White River. Bayfield Co.: Houghton Quarry; Squaw Bay.

H. PALUSTRE (Hedw.) Loeske. Ashland Co.: Basswood Island; shore of Lake Superior; Oak Island; White River. Bayfield Co.: Herbster; Houghton Quarry; Port Wing; Sand Bay; Sand Island; Squaw Bay.

HYLOCOMIUM

H. SPLENDENS (Hedw.) Bry. Eur. as *H. proliferum* Lindb. Ashland Co.: Basswood Island; Mellen; White River. Barron Co.: Barron. Bayfield Co.: Bark Bay; Drummond; Herbster. Burnett Co.: Swiss; St. Croix River. Door Co.: Baileys Harbor. Douglas Co.: Brule River. Manitowoc Co.: Manitowoc. Oneida Co.: Tomahawk Lake. Outagamie Co.: Appleton. Ozaukee Co.: Cedarburg. Sheboygan Co.: Cedar Grove. Vilas Co.: Lac Vieux Desert; Star Lake.

HYPNUM

H. CRISTA-CASTRENSIS Hedw. Ashland Co.: Mellen; White River; Hermit Island. Barron Co.: Barron. Bayfield Co.: Port Wing; Sand Bay. Dane Co.: Madison. Douglas Co.: T 45 N R 15 W; Winneboujou. Grant Co.: Glen Haven. Iron Co.: Montreal River, near Lake Superior; La Pointe Indian Reservation. Jackson Co.: Black River Falls. Jefferson Co.: Lake Mills. Manitowoc Co.: Two Rivers. Oneida Co.: Rainbow Rapids. Rusk Co.: Murry. Sauk Co.: Baxters Hollow, Baraboo Hills. Vilas Co.: Lac Vieux Desert; Conover.

H. CUPRESSIFORME Hedw. Grant Co.: Glen Haven; Mt. Hope. Iron Co.: Montreal River, near Lake Superior.

H. CUPRESSIFORME var. ERICETORUM Bry. Eur. Bayfield Co.: Sand Island.

H. CUPRESSIFORME var. FILIFORME Brid. Bayfield Co.: Houghton Quarry. Lincoln Co.: Grandfather Falls.

H. CURVIFOLIUM Hedw. Barron Co.: Barron. Columbia Co.: Dells of the Wisconsin River. Lafayette Co.: Fayette. Outagamie Co.: Greenville. Sheboygan Co.: Cedar Grove.

H. FERTILE Sendt. Bayfield Co.: Herbster; Sand Bay. Douglas Co.: T 45 N R 15 W. Iron Co.: Montreal River, near Lake Superior. Lincoln Co.: Grandfather Falls. Oneida Co.: Rainbow Rapids; Rhinelander.

H. IMPONENS Hedw. Adams Co.: Dells of the Wisconsin River. Ashland Co.: Hermit Island; Oak Island. Barron Co.: Barron. Bayfield Co.: Drummond; Herbster; Mason; Squaw Bay. Dane Co.: Hook Lake. Door Co.: Baileys Harbor. Douglas Co.: Brule River; T 45 N R 15 W. Grant Co.: Glen Haven. Jefferson Co.: Lake Mills. Lincoln Co.: Grandmother Falls; near Grandmother Falls. Manitowoc Co.: Two Rivers. Oneida Co.: McNaughton; Newbold; 8 miles N of Rhinelander. Rusk Co.: Little Falls, Flambeau River. Sheboygan Co.: Cedar Grove; Sheboygan. Vilas Co.: Lac Vieux Desert.

H. PATIENTIAE Lindb. as *H. arcuatum* Lindb. Adams Co.: Cold Water Canyon, Dells of the Wisconsin River. Barron Co.: Barron. Bayfield Co.: Houghton Quarry; La Chapelle (Lashabel's homestead); Port Wing; Sand Bay. Dane Co.: Madison. Grant Co.: Bagley. Iron Co.: Montreal River, near Lake Superior. Jefferson Co.: Helenville; Palmyra. Lincoln Co.: Grandfather Falls; Pine River; Tomahawk. Marathon Co.: Granite Heights. Oneida Co.: McNaughton; Noisy Creek; Rhinelander; Whirlpool Rapids. Ozaukee Co.: Cedarburg. Polk Co.: near Doran. Racine Co.: Racine. Rock Co.: Newark Twp. Sheboygan Co.: Cedar Grove. Vilas Co.: Eagle River; Lac Vieux Desert. Washington Co.: Newburg. Waukesha Co.: Eagle; Lannon; Nashotah Lake; Oconomowoc

Lake; Okauchee Lake; Ottawa Twp.; Vernon Station; Waukesha.

H. PATIENTIAE var. ELATUM Schimp. as *H. arcuatum* var. *elatum* Schimp. Rock Co.: Clinton.

H. PRATENSE Koch. Ashland Co.: Basswood Island. Barron Co.: Barron. Bayfield Co.: Orienta; Port Wing; Sand Bay. Oneida Co.: Hat Rapids; Noisy Creek; Rhinelander; near Rhinelander; Whirlpool Rapids. Vilas Co.: Conover; Lac Vieux Desert; near State Line. Waukesha Co.: Pine Lake; Vernon Station; Waukesha. Waupaca Co.: Readfield.

H. REPTILE Mx. Ashland Co.: Basswood Island; Hermit Island; La Pointe, Madeline Island; White River. Barron Co.; Barron. Bayfield Co.: Drummond; Herbster; Houghton Quarry. Chippewa Co.: Long Lake. Dane Co.: Madison; Mendota; Pine Bluff. Douglas Co.: St. Louis River; Superior. Grant Co.: Castle Rock; Glen Haven. Iron Co.: Montreal River, near Lake Superior; Pence. Lafayette Co.: Fayette. Lincoln Co.: Grandmother Falls; near Grandmother Falls; Tomahawk. Oneida Co.: Rhinelander; Tomahawk Lake. Outogamie Co.: Medina. Rock Co.: Bradford Twp.; Clinton. Rusk Co.: Strickland. Sheboygan Co.: Cedar Grove. Vilas Co.: Lac Vieux Desert; Sayner. Waukesha Co.: Okauchee Lake; Pine Lake; Vernon; Wales.

LEPTOBRYUM

L. PYRIFORME (Hedw.) Schimp. Ashland Co.: Basswood Island. Bayfield Co.: Drummond; Mason; Port Wing. Dane Co.: Madison. Douglas Co.: near Burnett Co. line; T 45 N R 15 W. Grant Co.: Potosi. Lincoln Co.: Grandfather Falls. Oneida Co.: Newbold; Rainbow Rapids; Rhinelander. Outagamie Co.: West Center. Rock Co.: Beloit. Vilas Co.: Conover; near State Line. Waukesha Co.: Lannon; Menomonee Falls; Waukesha. Wood Co.: Wisconsin Rapids.

LEPTODICTYUM

L. RIPARIUM (Hedw.) Warnst. Ashland Co.: Ashland. Barron Co.: Maple Grove Twp. Bayfield Co.: Orienta; Drummond. Dane Co.: McFarland; Madison; Pine Bluff. Dodge Co.: Iron Ridge. Douglas Co.: St. Louis River; Superior. Grant Co.: Mt. Hope; Platteville; Potosi. Jefferson Co.: Palmyra. Kewaunee Co.: Kewaunee. Lincoln Co.: Grandfather Falls;

Merrill. Marathon Co.: Granite Heights. Milwaukee Co.: West Allis. Oneida Co.: Noisy Creek; Wisconsin River. Price Co.: Knox Mills. Portage Co.: Stevens Point. Rusk Co.: Wilkinson Twp. Sheboygan Co.: Sheboygan. Vilas Co.: Eagle River; Lac Vieux Desert. Waukesha Co.: Big Bend; Lake La Belle; Mukwonago Twp.; Oconomowoc Lake; Vernon Station; Wales; Waukesha.

L. RIPARIUM f. FLUITANS (L. & J.) Grout. Grant Co.: Bagley; Mt. Hope. Oneida Co.: Rainbow Rapids. Ozaukee Co.: Cedarburg.

L. RIPARIUM f. FLACCIDUM (L. & J.) Grout. Dane Co.: Madison. Portage Co.: Stevens Point.

L. RIPARIUM f. LONGIFOLIUM (Schultz) Grout. Portage Co.: Stevens Point.

L. TRICHOPODIUM (Schultz) Warnst. Door Co.: Ellison Bay. Grant Co.: Bagley; Glen Haven. Lincoln Co.: Grandfather Falls. Oneida Co.: Rhinelander. Sheboygan Co.: Cedar Grove.

L. VACILLANS (Sull.) Broth. Douglas Co.: West Superior. Jefferson Co.: Jefferson; Rome.

LEPTODON

L. OHIOENSIS Sull. as *Forsstroemia ohioensis* Lindb. Grant Co.: Potosi.

LESKEA

L. ARENICOLA Best. Grant Co.: Cassville; Glen Haven. Waukesha Co.: Pine Lake; Waukesha.

L. GRACILESCENS Hedw. Barron Co.: Barron. Grant Co.: Glen Haven. Jefferson Co.: Milford; Palmyra Rock Co.: Bradford Twp.; Carver's Rocks; Clinton; Janesville. Walworth Co.: Whitewater. Waukesha Co.: Nemahbin Lake; Oconomowoc; Oconomowoc Lake; Okauchee Lake; Pine Lake; Waukesha.

L. NERVOSA (Schwaegr.) Myrin. Ashland Co.: Hermit Island; Oak Island. Bayfield Co.: Port Wing. Door Co.: Ellison Bay. Iron Co.: Montreal River, near Lake Superior. Vilas Co.: Lac Vieux Desert. Waukesha Co.: Oconomowoc.

L. OBSCURA Hedw. Adams Co.: Dells of the Wisconsin River. Bayfield Co.: Mason. Dane Co.: Madison. Grant Co.: Glen Haven; Wyalusing. Iowa Co.: Arena. Jefferson Co.: Lake

Koshkonong; Palmyra. Lincoln Co.: Grandfather Falls; Grandmother Falls. Marathon Co.: Mosinee. Oneida Co.: Hat Rapids. Rock Co.: Afton; Beloit; Bradford Twp.; Janesville; Newark Twp. Walworth Co.: Whitewater. Waukesha Co.: Glen Cove Station; Lake La Belle; Waukesha.

L. POLYCARPA Hedw. Barron Co.: Barron. Bayfield Co.: near the White River. Dane Co.: Madison. Grant Co.: Glen Haven; Wyalusing. Iron Co.: Montreal River, near Lake Superior. Lafayette Co.: Fayette. Lincoln Co.: Grandmother Falls; Pine River. Marathon Co.: Granite Heights; Mosinee; Wausau. Oneida Co.: near Eagle River; McNaughton; Newbold; Rainbow Rapids. Price Co.: Knox Mills.

L. POLYCARPA var. PALUDOSA (Hedw.) Schimp. Barron Co.: Barron. Grant Co.: Glen Haven; Platteville. Lincoln Co.: Grandmother Falls. Oneida Co.: between Eagle River and Tomahawk Lake. Rock Co.: Beloit.

LEUCOBRYUM

L. GLAUCUM (Hedw.) Schimp. Adams Co.: Dells of the Wisconsin River. Ashland Co.: Basswood Island; Long Island; Mellen; Odanah. Barron Co.: Barron. Bayfield Co.: Bayfield; Drummond. Dane Co.: Blue Mounds; Madison. Douglas Co.: Winneboujou. Grant Co.: Glen Haven; Mt. Hope; Potosi. Jefferson Co.: Palmyra. Lafayette Co.: Fayette. Lincoln Co.: Merrill. Outagamie Co.: Medina. Ozaukee Co.: Cedarburg. Rock Co.: Newark Twp. Sheboygan Co.: Cedar Grove. Vilas Co.: Lac Vieux Desert; near State Line. Washington Co.: Newburg. Waukesha Co.: Brookfield Twp.; Pine Lake. Wood Co.: Wisconsin Rapids.

LEUCODON

L. BRACHYPUS Brid. Iron Co.: shore of Lake Superior, near Montreal River. Lincoln Co.: Grandfather Falls; Grandmother Falls; Merrill. Marathon Co.: Granite Heights; Wausau. Oneida Co.: Newbold; near Rainbow Rapids.

L. JULACEUS (Hedw.) Sull. Grant Co.: Cassville; Glen Haven; Potosi. Rock Co.: Bradford Twp.

L. SCIUROIDES (Hedw.) Schwaegr. Barron Co.: Barron; Barron Twp., sec. 20.; Canton; Sumner Twp. Bayfield Co.: Bark Bay; Drummond; Mason. Dane Co.: Blue Mounds. Douglas Co.: T 45 N R 15 W. Grant Co.: Glen Haven; Potosi. Jefferson Co.: Helenville; Jefferson. Oneida Co.: Whirlpool Rapids. Outagamie Co.: Greenville. Sauk Co.: Devils Lake. Vilas Co.: Lac Vieux Desert. Waukesha Co: Pine Lake.

LINDBERGIA

L. BRACHYPTERA var. AUSTINII (Sull.) Grout. Ashland Co.: Oak Island. Barron Co.: Barron; Barron Twp. Dane Co.: Madison. Grant Co.: Glen Haven; Platteville; Potosi. Jefferson Co.: Milford. Portage Co.: Stevens Point. Rock Co.: Bradford Twp.; Clinton. Rusk Co.: Horseman. Vilas Co.: Conover; Lac Vieux Desert. Walworth Co.: Whitewater. Waukesha Co.: Lake La Belle; Mouse Lake; Oconomowoc Lake; Pine Lake; Vernon Station; Waukesha.

MEESIA

M. TRIQUETRA (Hook. & Tayl.) Ångstr. Bayfield Co.: Drummond. Ozaukee Co.: Cedarburg. Vilas Co.: near State Line.

M. ULIGINOSA Hedw. Bayfield Co.: between Herbster and Port Wing.

MNIUM

M. AFFINE Bland. Adams Co.: Dells of the Wisconsin River. Barron Co.: Barron as *M. affine* var. *ciliare* (Grev.) C. M. Bayfield Co.: Drummond. Calumet Co.: near Menasha. Dane Co.: Madison. Door Co.: Baileys Harbor as *M. affine* var. *ciliare* (Grev.) C. M. Lincoln Co.: Grandmother Falls. Marathon Co.: Granite Heights. Oconto Co.: Oconto. Oneida Co.: Noisy Creek; Rainbow Rapids; Whirlpool Rapids. Outagamie Co.: Medina. Sheboygan Co.: Cedar Grove; same station as *M. affine* var. *ciliare* (Grev.) C. M.; Elkhart Lake as *M. affine* var. *rugicum* Bry. Eur. Vilas Co.: Conover.

M. CUSPIDATUM Hedw. Adams Co.: Cold Water Canyon. Ashland Co.: Oak Island. Barron Co.: Barron. Bayfield Co.: Drummond; Herbster; Houghton Quarry; La Chapelle (Lashabel's homestead); Port Wing; Sand Bay. Burnett Co.: Web Lake. Dane Co.: Hook Lake; Madison. Dodge Co.: Horicon. Door Co.: Baileys Harbor; Garrett Bay. Douglas Co.: Amnicon Falls; Brule River, near Lake Superior. Grant Co.: Glen Haven; Potosi. Kewaunee Co.: Kewaunee. Lafayette Co.: Fayette. Oneida Co.: McNaughton; Noisy Creek; Rainbow Rapids; Whirpool Rapids. Outagamie Co.: Appleton. Polk Co.: near Doran. Rock Co.: Beloit; Clinton. Sauk Co.: Devils Lake. Trempealeau Co.: near Marshland. Vilas Co.: Conover; Eagle River; Lac Vieux Desert. Washington Co.: Newburg. Waukesha Co.: Mukwonago; Ottawa Twp.; Pine Lake; Waukesha.

M. DRUMMONDII Bry. Eur. Barron Co.: Barron. Bayfield Co.: Bark Bay; Drummond; Sand Island; Squaw Bay. Burnett Co.: Web Lake. Lincoln Co.: Grandmother Falls; Tomahawk. Oneida Co.: Newbold; Rhinelander; Tomahawk Lake. Vilas Co.: Lac Vieux Desert.

M. LONGIROSTRUM Brid. as *M. rostratum* Schrad. Dane Co.: Madison. Jefferson Co.: Palmyra. Oneida Co.: Noisy Creek. Rock Co.: Bradford Twp.; Clinton. Sheboygan Co.: Cedar Grove. Waukesha Co.: Mukwonago.

M. LYCOPODIOIDES (Hook.) Schwaegr. Ashland Co.: Basswood Island; Stockton Island. Bayfield Co.: Herbster; Houghton Quarry; Port Wing. Douglas Co.: T 45 N R 15 W. Iron Co.: Montreal River, near Lake Superior. Lincoln Co.: Grandfather Falls. Oneida Co.: Noisy Creek.

M. MEDIUM Bry. Eur. Ashland Co.: Hermit Island. Barron Co.: near Barron. Bayfield Co.: Drummond; Port Wing. Burnett Co.: Web Lake. Douglas Co.: Brule River. Grant Co.: Glen Haven. Iron Co.: Montreal River, near Lake Superior. Lincoln Co.: Grandfather Falls; near Grandfather Falls. Oneida Co.: Rainbow Rapids; Whirlpool Rapids. Vilas Co.: Lac Vieux Desert. Washburn Co.: Spooner.

M. ORTHORHYNCHUM Brid. Ashland Co.: Basswood Island; Manitou Island. Bayfield Co.: Herbster; Houghton Quarry; Mason; Siskowitt Bay. Dodge Co.: Horicon. Door Co.: Ellison Bay; Sister Bay. Douglas Co.: Manitou Falls; St. Louis River. Iron Co.: Montreal River, near Lake Superior. Grant Co.: Bagley. Lincoln Co.: Grandfather Falls. Oneida Co.: Noisy Creek; Whirlpool Rapids.

M. PUNCTATUM Hedw. Adams Co.: Cold Water Canyon; Witches Gulch. Ashland Co.: Oak Island. Barron Co.: Barron. Bayfield Co.: Drummond; Houghton Quarry; Port Wing Dane Co.: Blue Mounds. Door Co.: Baileys Harbor as *M. subglobosum* Hpe. Douglas Co.: T 45 N R 15 W. Marathon Co.: Granite Heights. Oneida Co.: Noisy Creek. Price Co.: Knox Mills. Sauk Co.: Delton.

M. PUNCTATUM var. ELATUM Schimp. Barron Co.: Barron. Bayfield Co.: Herbster. Burnett Co.: Web Lake. Douglas Co.: Spruce Creek; Winneboujou. Iron Co.: La Pointe Indian Reservation; Montreal River, near Lake Superior. Lincoln Co.: Tomahawk. Oneida Co.: Noisy Creek; Tomahawk Lake; Whirlpool Rapids. Outagamie Co.: West Center. Ozaukee Co.: Cedarburg. Price Co.: Knox Mills. Vilas Co.: Lac Vieux Desert; near State Line Waukesha Co.: Nagawicka Lake. Wood Co.: Wisconsin Rapids.

M. SERRATUM Brid. Ashland Co.: Oak Island. Bayfield Co.: Herbster; Port Wing. Dane Co.: Madison; Mendota. Douglas Co.: Brule River, near Lake Superior. Grant Co.: Bagley; near Bridgeport; Cornelia; Glen Haven; Mt. Hope; Potosi. Iron Co.: Montreal River, near Lake Superior. Milwaukee Co.: Wauwatosa. Rock Co.: Beloit.

M. SPINULOSUM Bry. Eur. Adams Co.: Cold Water Canyon. Ashland Co.: Basswood Island. Bayfield Co.: Bark Bay; Drummond; La Chapelle (Lashabel's homestead); Mason; Sand Bay; Siskowitt Bay. Door Co.: Baileys Harbor. Douglas Co.: Amnicon River, near Lake Superior; T 45 N R 15 W. Iron Co.: Hurley; Montreal. Lincoln Co.: Grandfather Falls; near Grandfather Falls; Grandmother Falls; Merrill; Tomahawk. Marathon Co.: Granite Heights; Mosinee. Oneida Co.: Hat Rapids; Newbold; Rainbow Rapids; Tomahawk Lake. Rusk Co.: Ladysmith. Vilas Co.: Conover; Lac Vieux Desert; near State Line; Sayner. Washington Co.: Newburg.

M. STELLARE Hedw. Barron Co.: Barron. Bayfield Co.: Mason. Door Co.: Ellison Bay. Oneida Co.: Whirlpool Rapids. Outagamie Co.: Appleton. Polk Co.: near Doran.

MYURELLA

M. CAREYANA Sull. Ashland Co.: Oak Island. Bayfield Co.: Houghton Quarry. Door Co.: Baileys Harbor. Iron Co.: Montreal River, near Lake Superior.

M. JULACEA (Schwaegr.) Bry. Eur. Ashland Co.: Basswood Island; Oak Island. Bayfield Co.: Herbster; Port Wing.

NECKERA

N. PENNATA Hedw. Adams Co.: Cold Water Canyon. Ashland Co.: La Pointe, Madeline Island; Hermit Island. Barron Co.:

Barron. Bayfield Co.: Drummond; Houghton Quarry; Siskowitt Bay. Dane Co.: Madison. Door Co.: Baileys Harbor; Ellison Bay. Douglas Co.: T 45 N R 15 W; Winneboujou. Iron Co.: N E corner of the La Pointe Indian Reservation; Montreal River, near Lake Superior. Lincoln Co.: Grandfather Falls; Grandmother Falls. Marathon Co.: Granite Heights. Oneida Co.: between Eagle River and Tomahawk Lake; Rhinelander; Tomahawk Lake. Outagamie Co.: Greenville. Rusk Co.: Weyerhauser. Sheboygan Co.: Cedar Grove. Vilas Co.: Lac Vieux Desert; near State Line; Star Lake.

ONCOPHORUS

O. POLYCARPUS (Hedw.) Brid. Ashland Co.: Basswood Island. Grant Co.: Bagley. Jefferson Co.: Palmyra. Rock Co.: Newark Twp. Trempealeau Co.: Trempealeau.

O. TENELLUS (Bry. Eur.) Williams. Grant Co.: near Castle Rock.

O. VIRENS (Hedw.) Brid. Ashland Co.: Basswood Island. Bayfield Co.: Herbster.

O. VIRENS var. SERRATUS (Bry. Eur.) Limpr. Ashland Co.: Basswood Island; Oak Island. Bayfield Co.: Port Wing; Sand Bay; Sand Island; Squaw Bay.

O. WAHLENBERGII Brid. Bayfield Co.: Mason. Douglas Co.: St. Louis River. Iron Co.: Montreal River, near Lake Superior. Lincoln Co.: Merrill. Marathon Co.: Granite Heights. Oneida Co.: McNaughton; Rhinelander; Tomahawk Lake; Whirlpool Rapids. Rock Co.: Beloit. Vilas Co.: Eagle River; Lac Vieux Desert.

ORTHOTRICHUM

O. ANOMALUM Hedw. Ashland Co.: Basswood Island. Bayfield Co.: Bayfield. Houghton Quarry. Dane Co.: Madison. Door Co.: Baileys Harbor; Ellison Bay. Lincoln Co.: Grandfather Falls. Outagamie Co.: Appleton. Ozaukee Co.: Grafton. Rock Co.: Bradford Twp. Waukesha Co.: Pewaukee; Pine Lake.

O. ELEGANS Hook. & Grev. Ashland Co.: Madeline Island; Manitou Island; White River; Hermit Island. Barron Co.: Barron; Maple Grove Twp. Bayfield Co.: Herbster; Mason; Port Wing. Burnett Co.: Web Lake. Dane Co.: Madison. Douglas Co.: Amnicon River, near Lake Superior. Iron Co.: N W corner of La Pointe Indian Reservation; Montreal River, near Lake Superior. Lincoln Co.: Tomahawk. Oneida Co.: Newbold; Rhinelander. Rock Co.: Newark Twp. Rusk Co.: Sand Lake. Vilas Co.: Lac Vieux Desert.

O. LESCURII Aust. Dane Co.: near Madison. Dodge Co.: Horicon. Grant Co.: Andersons Mills; Bagley; Beetown; Cassville; Glen Haven; Potosi. Rock Co.: Avon Twp.; Bradford Twp.; Newark Twp. Waukesha Co.: Menomonee Falls.

O. OBTUSIFOLIUM Brid. Barron Co.: Barron; Barron Twp.; Maple Grove Twp.; Stanfold Twp. Bayfield Co.: Port Wing. Dane Co.: Hook Lake. Grant Co.: Glen Haven; North Andover; Platteville; Potosi. Lincoln Co.: Grandmother Falls; Tomahawk. Oneida Co.: Hat Rapids. Polk Co.: near Doran. Rock Co.: Bradford Twp.; Clinton; Newark Twp. Vilas Co.: Lac Vieux Desert.

O. OHIOENSE Sull. & Lesq. Barron Co.: Barron; Maple Grove Twp.; Sumner Twp. Rusk Co.: Rusk Twp.

O. PUMILUM Dicks. Barron Co.: Barron. Dane Co.: Madison. Grant Co.: Bagley; Dutch Hollow, near Potosi; Glen Haven; Platteville; Potosi. Jefferson Co.: Palmyra. Rock Co.: near Allens Grove; Beloit; Bradford Twp.; Clinton; near Clinton; Janesville. Walworth Co.: Whitewater. Waukesha Co.: Mouse Lake; Oconomowoc; Oconomowoc Lake; Pine Lake; Waukesha.

O. SORDIDUM Lesq. & James. Barron Co.: Barron; Doyle Twp. Bayfield Co.: Bark Bay; Bayfield; Drummond; Herbster; Mason; Siskowitt Bay. Burnett Co.: Web Lake. Dane Co.: Middleton. Douglas Co.: Falls of the Black River; Brule River, near Lake Superior; Lake Superior, near mouth of the Amnicon River. Grant Co.: Potosi. Iron Co.: Montreal River, near Lake Superior. Marathon Co.: Wausau. Sheboygan Co.: Cedar Grove. Vilas Co.: Lac Vieux Desert.

O. STELLATUM Brid. Ashland Co.: Madeline Island; Manitou Island. Barron Co.: Barron; Barron Twp. Burnett Co.: Web Lake. Dane Co.: Hook Lake; Madison. Grant Co.: Glen Haven; Platteville; Potosi; Woodman. Lafayette Co.: Fayette. Marathon Co.: Mosinee. Oneida Co.: Rhinelander. Portage Co.: Stevens Point.

PARALEUCOBRYUM

P. LONGIFOLIUM (Hedw.) Loeske. Marathon Co.: Granite Heights. Oneida Co.: near Rhinelander; Hat Rapids; between Lake Julia and Newbold. Vilas Co.: Lac Vieux Desert.

PHASCUM

P. CUSPIDATUM Hedw. Barron Co.: Barron Twp., sec. 28. Dane Co.: Madison. Grant Co.: Glen Haven; near Potosi. Waukesha Co.: near Menomonee Falls; near Mukwonago; near Waukesha.

P. CUSPIDATUM var. AMERICANUM Ren. & Card. The stations marked with an * indicate collections identified as *P. cuspidatum* var. *piliferum* (Schreb.) Hook. Barron Co.: Barron Twp., secs. 28 and 35 *. Grant Co.: Bagley; Glen Haven; Potosi; same station *.

PHILONOTIS

P. CALCAREA (Bry. Eur.) Schimp. Dane Co.: Madison.

P. FONTANA (Hedw.) Brid. Adams Co.: Dells of the Wisconsin River. Ashland Co.: Basswood Island. Barron Co.: Barron. Bayfield Co.: Roy's Point, the old landing near Redcliff; Drummond; Siskowitt Bay. Dane Co.: Windsor. Douglas Co.: Upper Lucius Lake. Grant Co.: Glen Haven; Potosi. Lincoln Co.: near Grandfather Falls. Marathon Co.: Mosinee. Oneida Co.: Noisy Creek. Vilas Co.: along Wisconsin River. Waukesha Co.: near Mukwanago.

PHYSCOMITRIUM

P. HOOKERI Hampe. Buffalo Co.: Marshland.

P. IMMERSUM Sull. Barron Co.: Barron. Waukesha Co.: Foster's Woods, Fox River.

P. KELLERMANI E. G. Britton. Rock Co.: Beloit.

P. TURBINATUM (Mx.) Brid. Barron Co.: Barron. Dane Co.: Madison. Grant Co.: near Glen Haven; Potosi. Lafayette Co.: Fayette. Milwaukee Co.: North Milwaukee. Rock Co.: Bradford Twp., Carver's Rocks. Waukesha Co.: Eagle; Foster's Woods, Fox River; Menomonee Falls; Oconomowoc Lake; Waukesha.

PLAGIOBRYUM

P. DEMISSUM (Hoppe & Hornsch.) Lindb. Grant Co.: Potosi;

near Potosi. Rock Co.: Janesville. Waukesha Co.: Eagle; Waukesha.

P. ZIERII (Hedw.) Lindb. Waukesha Co.: near Waukesha.

PLAGIOPUS

P. OEDERI (Brid.) Limpr. as *Bartramia Oederi* Schwaegr. Calumet Co.: Highcliff. Columbia Co.: Wisconsin Dells. Crawford Co.: near Bridgeport. Door Co.: Baileys Harbor; Ellison Bay. Douglas Co.: Falls of the Black River; Manitou Falls. Grant Co.: Andersons Mills; Bagley; near Bridgeport; Glen Haven; Mt. Hope; North Andover; Potosi. Lafayette Co.: Fayette. Outagamie Co.: Appleton. Sauk Co.: Devils Lake.

PLAGIOTHECIUM

P. DENTICULATUM (Hedw.) Bry. Eur. Ashland Co.: Hermit Island. Barron Co.: Barron. Bayfield Co.: Drummond; Herbster; Houghton Quarry; Mason; Sand Island. Dane Co.: McFarland. Douglas Co.: mouth of Brule River. Jefferson Co.: Lake Mills; Palmyra; Sullivan. Lincoln Co.: Grandfather Falls; between Merrill and Grandfather Falls; between Grandmother Falls and Gilbert; between Grandmother Falls and Tomahawk; near Rainbow Rapids. Milwaukee Co.: South Milwaukee. Oneida Co.: Noisy Creek; Rhinelander. Outagamie Co.: Medina Swamp. Ozaukee Co.: Cedarburg Swamp. Rock Co.: Clinton; near Fairfield. Sheboygan Co.: Cedar Grove. Vilas Co.: Lac Vieux Desert. Washington Co.: Barth's Swamp. Waukesha Co.: near Calhoun; Eagle Lake; Mukwonago; Vernon Station; near Waukesha. Wood Co.: Wisconsin Rapids.

P. DENTICULATUM f. PROPAGULIFERUM Ruthe. Barron Co.: Barron Twp., secs. 5, 20, 32. Jefferson Co.: near Helenville; Palmyra; Sullivan. Waukesha Co.: Waukesha.

P. DEPLANATUM (Sull.) Grout. Jefferson Co.: Sullivan. Waukesha Co.: Waukesha.

P. GEOPHILUM (Aust.) Grout. Grant Co.: Glen Haven; Lancaster; Potosi.

P. LAETUM Bry. Eur. Grant Co.: Potosi. Oneida Co.: Noisy Creek.

P. LATEBRICOLA (Wils.) Bry. Eur. Barron Co.: Clinton Twp.; Four Mile Swamp.

P. MICANS (Sw.) Paris. Washington Co.: Newburg.

P. PULCHELLUM (Hedw.) Bry. Eur. Bayfield Co.: Drummond; La Chapelle (Lashabel's homestead); Sand Bay. Douglas Co.: T 45 N R 15 W as *P. passaicense* Aust. (?). Iron Co.: Montreal River. Lincoln Co.: Whirpool Rapids. Outagamie Co.: Medina Swamp. Vilas Co.: along the Wisconsin River.

P. ROESEANUM (Hampe) Bry. Eur. Barron Co.: Four Mile Swamp. Grant Co.: Bagley; Mt. Hope; Patch Grove.

P. RUTHEI Limpr. Barron Co.: near Barron.

P. SELIGERI (Brid.) Lindb. Outagamie Co.: Greenville.

P. STRIATELLUM (Brid.) Lindb. Bayfield Co.: Herbster. Columbia Co.: Wisconsin Dells. Oneida Co.: Newbold.

P. SYLVATICUM (Brid.) Bry. Eur. Adams Co.: Cold Water Canyon. Barron Co.: Barron. Dane Co.: Blue Mounds; Windsor. Sheboygan Co.: Oostburg. Waukesha Co.: Pine Lake.

P. TURFACEUM (Lindb.) Lindb. Ashland Co.: Basswood Island; Manitou Island. Bayfield Co.: Drummond; Roy's Point, the old landing near Redcliff; Sand Island; Siskowitt Bay. Door Co.: Baileys Harbor. Douglas Co.: West Superior. Iron Co.: near Montreal. Lincoln Co.: Grandfather Falls; Grandmother Falls; between Grandmother Falls and Gilbert; Merrill; between Merrill and Grandfather Falls; near Tomahawk. Manitowoc Co.: Two Rivers. Marathon Co.: Granite Heights. Oneida Co.: Dorothy Lake; Newbold; Rhinelander. Outagamie Co.: Greenville; Medina Swamp; West Center Swamp. Sheboygan Co.: Cedar Grove; Little Elkhart Lake. Vilas Co.: between Conover and Eagle River; below Eagle River, near rapids in Wisconsin River; Lac Vieux Desert; Sayner. Waukesha Co.: Lower Nashotah Lake.

PLATYGYRIUM

P. REPENS (Brid.) Bry. Eur. Adams Co.: Cold Water Canyon; Dells of the Wisconsin River. Ashland Co.: Hermit Island. Barron Co.: Canton; Four Mile Creek. Bayfield Co.: Drummond; Herbster; Houghton Quarry; Orienta. Dane Co.: Blue Mounds; Middleton. Douglas Co.: Upper Lucius Lake; sec. 10 T 46 N R 10 W. Grant Co.: Bloomington; Glen Haven; Patch Grove. Jefferson Co.: Helenville; Palmyra. Lafayette Co.: Fayette. Lincoln Co.: Grandmother Falls; between Grandmother Falls and Gilbert. Milwaukee Co.: Donges Bay; West Allis. Outagamie Co.: near Readfield. Ozaukee

Co.: Cedarburg. Rusk Co.: sec. 20 T 36 N R 7 W. Sheboygan Co.: Cedar Grove. Vilas Co.: Lac Vieux Desert. Waukesha Co.: Bark River; Foster's Woods, Fox River; Mukwonago Marsh; Nemahbin Lake; Pine Lake; Saylesville; Waukesha.

PLEURIDIUM

P. SUBULATUM (Hedw.) Lindb. The stations marked with an * indicate collections identified as *P. alternifolium* (Dicks., Kaulf.) Rabenh. Barron Co.: Barron *; Barron Twp.; same station *. Dane Co.: Madison. Grant Co.: Bagley; Glen Haven; same station *; Potosi; same station *. Rock Co.: Beloit. Waukesha Co.: Delafield Twp.; Lower Nashotah Lake; Menomonee Falls; Mukwonago; same station *; New Berlin *; Oconomowoc; Prospect; Summit Twp.; Waukesha *; Waukesha Twp.

POGONATUM

P. ALPINUM (Hedw.) Röhl. Adams Co.: Dells of the Wisconsin River. Ashland Co.: Basswood Island; Oak Island. Bayfield Co.: Herbster; Houghton; Houghton Quarry; between Port Wing and Orienta; Sand Bay; between Sand Bay and Squaw Bay; Sand Island. Juneau Co.: near Quincy. Lincoln Co.: one mile above Pine River. Marathon Co.: Granite Heights; between Mosinee and Wausau.

P. ALPINUM var. SEPTENTRIONALE (Röhl.) Brid. Bayfield Co.: between Herbster and Port Wing.

P. URNIGERUM (Hedw.) Beauv. Chippewa Co.: Chippewa Falls.

POHLIA

P. ACUMINATA Hoppe & Hornsch. Adams Co.: Cold Water Canyon; Dells of the Wisconsin River; Witches Gulch. Barron Co.: Maple Grove Twp.; Prairie Lake Twp. Bayfield Co.: between Herbster and Port Wing; Sand Bay. Dane Co.: Blue Mounds. Grant Co.: Patch Grove. Iron Co.: Montreal River. Lafayette Co.: Argyle; Fayette.

P. ANNOTINA (Hedw.) Loeske. Barron Co.: Prairie Lake Twp.

P. CRUDA (Hedw.) Lindb. Bayfield Co.: Mason. Grant Co.: Glen Haven; Patch Grove. Iron Co.: Montreal River. Lincoln Co.: Grandfather Falls; near Grandfather Falls; between Grandfather Falls and Merrill; above Pine River. Marathon Co.: between Wausau and Mosinee.

P. CUCULLATA (Schwaegr.) Bruch. Grant Co.: Werley. Marathon Co.: between Mosinee and Wausau. Oneida Co.: between Lake Julia and Newbold; Whirlpool Rapids. Vilas Co.: Lac Vieux Desert. Waukesha Co.: Menomonee Twp.

P. DELICATULA (Hedw.) Grout. as *Webera carnea* Schimp. Marathon Co.: Goodrich Junction.

P. ELONGATA Hedw. Adams Co.: Dells of the Wisconsin River. Ashland Co.: Basswood Island; Oak Island. Barron Co.: Four Mile Creek. Bayfield Co.: Houghton Quarry. Lafayette Co.: Fayette.

P. FILIFORMIS (Dicks.) Andrews *as Anomobryum concinnatum* (Spruce) Lindb. These collections, some of which are fertile, seem to compare favorably with *Anomobryum filiforme* (Dicks.) Husn. *Die Laubmoose Europas* IV Band: 416, 417. Ashland Co.: Basswood Island. Barron Co.: Maple Grove Twp. Bayfield Co.: Herbster; Houghton Quarry. Grant Co.: Bagley.

P. NUTANS (Hedw.) Lindb. Ashland Co.: Basswood Island; Manitou Island; Oak Island. Barron Co.: near Cameron. Bayfield Co.: Drummond; Houghton Quarry; Orienta; between Sand Bay and Squaw Bay; Siskowitt Bay. Columbia Co.: Wisconsin Dells. Dane Co.: Hook Lake. Door Co.: Baileys Harbor. Douglas Co.: Brule River; Lucius Lake; St. Louis River. Grant Co.: Bagley; near Glen Haven. Juneau Co.: Germantown. Lincoln Co.: Grandfather Falls; Grandmother Falls; Tomahawk; near Pine River; between Tomahawk and Nigger Island. Marathon Co.: Granite Heights. Oneida Co.: Dorothy Lake; Newbold; between Newbold and McNaughton; between Lake Julia and Newbold; near Tomahawk Lake; Whirlpool Rapids. Outagamie Co.: Binghampton Bog. Sheboygan Co.: Crystal Lake; Plymouth; Terry Andrae Park. Vilas Co.: Conover; Lac Vieux Desert; Military Road, near Forest Co. line; between Plum and Razor Back Lakes; along the Wisconsin River. Waukesha Co.: near Calhoun; Menomonee Falls; Pine Lake; Sussex; Wales.

P. PROLIGERA Lindb. Barron Co.: Maple Grove Twp.; Prairie Lake Twp. Buffalo Co.: Bohri. Dane Co.: Lake Mendota. Grant Co.: Patch Grove. Iron Co.: Montreal River, near Lake Superior. Vilas Co.: near Eagle River.

P. PULCHELLA (Hedw.) Lindb. Grant Co.: Potosi; same station as *P. Lescuriana* Sull.

P. WAHLENBERGII (Web. & Mohr) Andrews. Dane Co.: Madison. Grant Co.: Bagley; Dickeysville; Platteville; Potosi. Milwaukee Co.: Milwaukee. Oconto Co.: Oconto. Rock Co.: Clinton; Janesville. Waukesha Co.: Vernon Station. As *Webera albicans* Schimp. Ashland Co.: Oak Island. Bayfield Co.: Houghton Quarry; Mason; between Port Wing and Herbster; between Port Wing and Orienta. Lincoln Co.: Grandfather Falls; Noisy Creek. As *P. albicans* Lindb. Grant Co.: Potosi. Sauk Co.: Ironton. Trempealeau Co.: Crow Branch.

POLYTRICHUM

P. COMMUNE Hedw. Adams Co.: Dells of the Wisconsin River. Ashland Co.: Basswood Island. Bayfield Co.: Drummond. Buffalo Co.: Marshland. Dane Co.: McFarland; Madison; Mazomanie. Douglas Co.: Amnicon Lake. Grant Co.: Glen Haven; Potosi. Iron Co.: Montreal. Juneau Co.: Necedah. Marathon Co.: Granite Heights. Ozaukee Co.: Cedarburg. Rock Co.: Bradford Twp., near Carver's Rocks; Newark Twp. Vilas Co.: between Conover and Eagle River; Lac Vieux Desert. Waukesha Co.: Eagle Twp.; Mukwonago; Wales.

P. FORMOSUM Hedw. Lincoln Co.: Tomahawk.

P. GRACILE Smith. Dane Co.: Madison. Douglas Co.: Brule River. Lincoln Co.: Tomahawk. Oneida Co.: between Lake Julia and Newbold. Rock Co.: Newark Twp. Waukesha Co.: Menomonee Twp.; Pine Lake; Waukesha.

P. JUNIPERINUM Hedw. Bayfield Co.: Drummond; Sand Island. Burnett Co.: near Swiss, St. Croix River. Columbia Co.: Wisconsin Dells. Dane Co.: Blue Mounds; Madison. Door Co.: Baileys Harbor. Douglas Co.: Amnicon Lake. Grant Co.: Glen Haven. Iron Co.: Montreal. Jefferson Co.: Lake Mills; Palmyra. Lafayette Co.: Fayette. Marathon Co.: Granite Heights. Oconto Co.: Oconto. Oneida Co.: Three Lakes. Ozaukee Co.: Port Washington. Rock Co.: Hanover. Sauk Co.: Delton. Sheboygan Co.: Crystal Lake; Sheboygan. Vilas Co.: Lac Vieux Desert; near Lac Vieux Desert. Washburn Co.: Spooner. Waukesha Co.: Eagle Lake; Oconomowoc; Waukesha.

P. JUNINERINUM var. ALPESTRE Bry. Eur. Dane Co.: Madison. Douglas Co.: Solon Springs. Rock Co.: Fairfield. Sawyer Co.: Seeley. Vilas Co.: Conover. Washington Co.: Newburg.

P. OHIOENSE Ren. & Card. Barron Co.: Barron; Four Mile Creek. Bayfield Co.: Sand Island. Dane Co.: Madison. Douglas Co.: Brule River. Grant Co.: Potosi. Jefferson Co.: Palmyra. Lincoln Co.: Gilbert; Grandfather Falls; between Grandfather Falls and Merrill. Marathon Co.: Granite Heights. Milwaukee Co.: Milwaukee. Oneida Co.: near Rhinelander; Tomahawk Lake. Rock Co.: Newark Twp. Vilas Co.: Conover; between Conover and Eagle River; Lac Vieux Desert; Sayner. Waukesha Co.: Pine Lake.

P. PILIFERUM Hedw. Adams Co.: Dells of the Wisconsin River. Ashland Co.: Kakagin River. Barron Co.: Yellow River, Stanfold Twp. Bayfield Co.: Houghton Quarry. Dane Co.: Pine Bluff. Grant Co.: Millville. Iron Co.: Montreal. Jefferson Co.: Palmyra. Juneau Co.: Point Bluff, near Mauston. Marathon Co.: Mosinee. Oneida Co.: Newbold; Stump Landing, near Newbold. Rock Co.: Newark Twp. Sheboygan Co.: Cedar Grove. Vilas Co.: Conover.

PYLAISIA

P. INTRICATA (Hedw.) Bry. Eur. Adams Co.: Dells of the Wisconsin River. Dane Co.: Madison. Iron Co.: Montreal. Jefferson Co.: Helenville. Lafayette Co.: Fayette. Lincoln Co.: Grandmother Falls; Rainbow Rapids. Oneida Co.: McNaughton; Tomahawk Lake; Wisconsin River. Vilas Co.: between Tomahawk Lake and Eagle River; Star Lake. Waukesha Co.: Oconomowoc Lake.

P. POLYANTHA Bry. Eur. Ashland Co.: Oak Island. Barron Co.: Barron Twp., sec. 8. Bayfield Co.: Buffalo Bay; Mason. Brown Co.: Green Bay. Douglas Co.: Brule River; St. Louis River. Jefferson Co.: near Sullivan. Lincoln Co.: Grandmother Falls; between Grandmother Falls and Gilbert; between Grandmother Falls and Tomahawk; Tomahawk. Oneida Co.: Dorothy Lake; Hat Rapids; along Wisconsin River. Rock Co.: Bradford Twp.; Clinton. Vilas Co.: Lac Vieux Desert; Pine Lake; along Wisconsin River.

P. SELWYNII Kindb. Ashland Co.: Hermit Island. Barron Co.: Barron. Bayfield Co.: Herbster; Houghton Quarry; Mason; Port Wing. Dane Co.: Madison as *P. Schimperi* Cardot.

Douglas Co.: St. Louis River. Grant Co.: Glen Haven; Platteville. Lincoln Co.: between Gilbert and Grandmother Falls; Grandmother Falls; Rainbow Rapids as *P. Schimperi* Cardot; Whirlpool Rapids. Oneida Co.: Newbold; Rhinelander; Tomahawk Lake; along Wisconsin River. Rock Co.: Clinton. Vilas Co.: Lac Vieux Desert; same station as *P. Schimperi* Cardot; near Lac Vieux Desert; near Eagle River. Waukesha Co.: Hartland; North Lake; Pine Lake; Waukesha.

P. SUBDENTICULATA Schimp. Barron Co.: Barron Twp. Bayfield Co.: Mason; Orienta. Douglas Co.: Brule River. Oneida Co.: Rhinelander; along Wisconsin River.

RHABDOWEISIA

R. DENTICULATA (Brid.) Bry. Eur. Adams Co.: Dells of the Wisconsin River. Bayfield Co.: Houghton Quarry.

R. DENTICULATA var. AMERICANA Culmann. as *R. fugax* (Hedw.) Bry. Eur. Adams Co.: Dells of the Wisconsin River.

RHODOBRYUM

R. ROSEUM (Bry. Eur.) Limpr. Ashland Co.: Penokee Iron Range. Bayfield Co.: Herbster. Dane Co.: Blue Mounds; Madison. Douglas Co.: T 44 N R 15 W; Upper Lucius Lake. Iron Co.: Montreal; Montreal River. Lafayette Co.: Fayette. Oconto Co.: Oconto. Price Co.: Ogema. Rusk Co.: Bruce. Sheboygan Co.: Cedar Grove; Evergreen Park. Washington Co.: Newburg. Waukesha Co.: Foster's Woods, Fox River.

RHYTIDIADELPHUS

R. TRIQUETRUS (Hedw.) Warnst. Dane Co.: Pine Bluff. Douglas Co.: Brule River. Grant Co.: Glen Haven; Montfort; Mt. Hope; Platteville. Iron Co.: near Montreal. Jefferson Co.: Palmyra. Lafayette Co.: Fayette. Lincoln Co.: Grandmother Falls; Whirlpool Rapids. Milwaukee Co.: South Milwaukee. Oneida Co.: Tomahawk Lake. Outagamie Co.: West Center Swamp. Ozaukee Co.: Cedarburg. Rock Co.: Bradford Twp. Rusk Co.: sec. 20 T 36 N R 7 W; near Bruce. Sheboygan Co.: Cedar Grove; Sheboygan. Waukesha Co.: Beaver Lake.

RHYTIDIUM

R. RUGOSUM (Hedw.) Kindb. Ashland Co.: Loon Lake, near

Mellen; Mellen. Bayfield Co.: Port Wing. Dane Co.: Black Earth. Grant Co.: Glen Haven. Iron Co.: Montreal River.

SAELANIA

S. GLAUCESCENS (Hedw.) Broth. Bayfield Co.: Sand Island. Dane Co.: Blue Mounds. Douglas Co.: St. Louis River. Grant Co.: Bagley; Montfort. Lafayette Co.: Fayette. Lincoln Co.: between Grandfather Falls and Merrill. Marathon Co.: near Pine River. Sauk Co.: Pine Hollow, Baraboo Hills.

SCHWETSCHKEOPSIS

S. DENTICULATA (Sull.) Broth. Grant Co.: Potosi.

SCORPIDIUM

S. SCORPIOIDES (Hedw.) Limpr. Bayfield Co.: Port Wing. Outagamie Co.: Medina Swamp.

SELIGERIA

S. PUSILLA (Hedw.) Bry. Eur. Grant Co.: Bagley; Beetown; Burton; Glen Haven; North Andover; Wyalusing.

S. RECURVATA (Hedw.) Bry. Eur. Grant Co.: Glen Haven.

SEMATOPHYLLUM

S. CAROLINIANUM (C. Müll.) E. G. Britton. as *Raphidostegium carolinianum* (C. Müll.) Jaeger & Sauerb. Grant Co.: Castle Rock.

SPLACHNUM

S. AMPULLACEUM Hedw. Barron Co.: near Cameron.

SPHAGNUM

S. CAPILLACEUM (Weiss) Schrank. Ashland Co.: Basswood Island; Madeline Island; Penokee Iron Range; Hermit Island. Barron Co.: Barron Twp. Bayfield Co.: Bark Bay. Dane Co.: Madison. Door Co.: Baileys Harbor. Douglas Co.: opposite Old Fond du Lac, Minn. Jefferson Co.: Palmyra. Oneida Co.: McNaughton; Newbold; Pelican Lake; Rhinelander. Outagamie Co.: Binghamton Bog, near Appleton. Ozaukee Co.: Cedarburg. Rock Co.: Newark Twp. Vilas Co.: Eagle River; Lac Vieux Desert. Washington Co.: Newburg. Waukkesha Co.: Wales.

S. CAPILLACEUM var. TENELLUM (Schimp.) Andrews. Barron Co.: Barron Twp. Chippewa Co.: Long Lake.

S. CENTRALE C. Jens. Barron Co.: Barron Twp., secs. 20 and 32. Waukesha Co.: Menomonee Twp.

S. COMPACTUM DC. Oneida Co.: McNaughton.

S. CUSPIDATUM Ehrh. Dane Co.: Madison. Outagamie Co.: near Appleton.

S. DUSENII C. Jens. Oneida Co.: McNaughton. Vilas Co.: State Line.

S. FIMBRIATUM Wils. Barron Co.: Barron; Barron Twp. Lafayette Co.: Fayette. Rusk Co.: Ten Mile Creek, Rusk Twp.

S. FUSCUM (Schimp.) H. Klinggr. Barron Co.: Barron. Bayfield Co.: Drummond; Port Wing. Burnett Co.: Web Lake. Chippewa Co.: Long Lake. Oneida Co.: McNaughton; Newbold. Outagamie Co.: Binghampton Bog, near Appleton. Ozaukee Co.: Cedarburg. Vilas Co.: near State Line. Waukesha Co.: Wales.

S. GIRGHENSOHNII Russow. Ashland Co.: Basswood Island; Mellen. Barron Co.: Stanley Twp. Bayfield Co.: Bark Bay; Drummond; Herbster; Houghton Quarry; La Chapelle (Lashabel's homestead); Port Wing. Chippewa Co.: Long Lake. Dane Co.: Madison, Lake Mendota; London. Douglas Co.: near the Amnicon River; opposite Old Fond du Lac, Minn. Lincoln Co.: Grandfather Falls; Grandmother Falls; Merrill; Pine River; Tomahawk. Oneida Co.: Rainbow Rapids; Tomahawk Lake. Vilas Co.: Lac Vieux Desert.

S. IMBRICATUM var. AFFINE (Ren. & Card.) Warnst. Juneau Co.: Witches Gulch.

S. MAGELLANICUM Brid. Ashland Co.: Basswood Island; Madeline Island; Mellen. Barron Co.: Barron. Bayfield Co.: Drummond; Port Wing. Burnett Co.: Web Lake. Dane Co.: Madison; London. Douglas Co.: Solon Springs. Jefferson Co.: Lake Mills. Lincoln Co.: Grandmother Falls; Merrill; Tomahawk. Marathon Co.: Granite Heights. Oneida Co.: McNaughton; Newbold; Rhinelander; Whirlpool Rapids; Wisconsin River, near Tomahawk Lake. Outagamie Co.: Binghampton Bog, near Appleton. Ozaukee Co.: Cedarburg. Portage Co.: near Stevens Point as *S. intermedium* Russow. Rock Co.: Newark Twp. Vilas Co.: Eagle River; near State Line. Washington Co.: Newburg. Waukesha Co.: Wales.

S. PALUSTRE L. Ashland Co.: Penokee Iron Range. Barron Co.: Barron. Douglas Co.: Brule Swamp; Upper Lucius Lake. Eau Claire Co.: Eau Claire. Jefferson Co.: Lake Mills. Juneau Co.: Hustler. Ozaukee Co.: Cedarburg. Portage Co.: Stevens Point. Washington Co.: Newburg. Waukesha Co.: Summit Twp.; Wales.

S. PAPILLOSUM Lindb. Barron Co.: Barron. Dane Co.: Madison; London. Vilas Co.: State Line.

S. PLUMULOSUM Röll. Ozaukee Co.: Cedarburg.

S. PULCHRUM (Lindb.) Warnst. Outagamie Co.: Binghampton Bog, near Appleton.

S. RECURVUM Beauv. Ashland Co.: Madeline Island. Barron Co.: Barron Twp. Bayfield Co.: Bark Bay; Drummond; Port Wing; Sand Bay. Burnett Co.: Web Lake. Douglas Co.: Amnicon River. Oneida Co.: Newbold; Tomahawk Lake. Ozaukee Co.: Cedarburg. Waukesha Co.: Lake Nagawicka.

S. RECURVUM var. TENUE H. Klinggr. Barron Co.: Barron Twp. Bayfield Co.: Port Wing. Dane Co.: London; Madison. Jefferson Co.: Lake Mills. Lincoln Co.: Merrill; Tomahawk. Oneida Co.: McNaughton; Newbold; Rainbow Rapids; Tomahawk Lake. Ozaukee Co.: Cedarburg. Sauk Co.: Delton. Vilas Co.: Eagle River; Lac Vieux Desert; State Line.

S. RIPARIUM Ångstr. Bayfield Co.: Drummond.

S. ROBUSTUM (Russow) Röll. Iron Co.: La Pointe Indian Reservation. Lincoln Co.: Tomahawk. Outagamie Co.: Appleton.

S. SQUARROSUM Crome. Ashland Co.: Basswood Island; Madeline Island; Penokee Iron Range; Hermit Island. Barron Co.: Barron. Bayfield Co.: Bark Bay; Drummond; Orienta; Port Wing. Lincoln Co.: Grandfather Falls; Grandmother Falls; Merrill; Pine River. Oneida Co.: Tomahawk Lake. Rock Co.: Newark Twp. Rusk Co.: Sand Lake, Big Bend Twp.; Wilkinson Twp., sec. 22. Vilas Co.: State Line. Waukesha Co.: Menomonee Twp.; Waukesha.

S. SUBSECUNDUM Nees. Barron Co.: Barron Twp.; Maple Grove Twp. Bayfield Co.: Drummond; Port Wing as *S. contortum* (Schultz) Limpr. Dane Co.: Madison. Juneau Co.: Dells of the Wisconsin River. Lincoln Co.: Pine River; Tomahawk. Oneida Co.: McNaughton; Clear Lake as *S. rufescens* Limpr.; Newbold; Tomahawk Lake; same station as *S. obesum Wils.* Outagamie Co.: Binghampton Bog, near Appleton.

Portage Co.: Stevens Point as *S. inundatum* Russow. Sauk Co.: Delton. Vilas Co.: Lac Vieux Desert; same station as *S. rufescens* Limpr.

S. TENELLUM Pers. Waukesha Co.: Wales.

S. TERES (Schimp.) Ångstr. Adams Co.: Witches Gulch. Barron Co.: Barron Twp. Bayfield Co.: Port Wing. Door Co.: Baileys Harbor. La Crosse Co.: West Salem. Vilas Co.: Lac Vieux Desert. Waukesha Co.: Oconomowoc; Waukesha.

S. WARNSTORFII Russow. Ashland Co.: La Pointe, Madeline Island. Barron Co.: Barron Twp. Bayfield Co.: Port Wing. Burnett Co.: Web Lake. Door Co.: Baileys Harbor. Douglas Co.: opposite Old Fond du Lac, Minn.; Upper Lucius Lake. Iron Co.: La Pointe Indian Reservation. Jefferson Co.: Palmyra. Lincoln Co.: Whirlpool Rapids. Outagamie Co.: Appleton. Ozaukee Co.: Cedarburg. Vilas Co.: Lac Vieux Desert. Waukesha Co.: Waukesha.

S. WULFIANUM Girg. Ashland Co.: Penokee Iron Range. Barron Co.: Barron. Burnett Co.: Web Lake. Door Co.: Baileys Harbor. Douglas Co.: mouth of Amnicon River; mouth of Brule River. Lincoln Co.: Grandmother Falls; Merrill. Oneida Co.: Newbold; Rainbow Rapids; Tomahawk Lake. Sheboygan Co.: Crystal Lake. Vilas Co.: Eagle River; State Line. Washington Co.: Newburg.

TETRAPHIS

T. PELLUCIDA Hedw. Ashland Co.: La Pointe, Madeline Island; Oak Island. Barron Co.: near Barron. Bayfield Co.: Herbster; Mason; Port Wing; Squaw Bay; Siskowitt Bay. Dane Co.: Windsor. Door Co.: Baileys Harbor. Douglas Co.: Brule Swamp. Grant Co.: Mt. Hope; Patch Grove. Iron Co.: Montreal River. Jefferson Co.: Lake Mills; Sullivan. Lafayette Co.: Fayette. Lincoln Co.: between Grandfather Falls and Merrill; Grandmother Falls. Marathon Co.: Granite Heights; between Mosinee and Wausau. Oneida Co.: Newbold. Outagamie Co.: West Center Swamp. Ozaukee Co.: Cedarburg Swamp. Sheboygan Co.: Cedar Grove. Vilas Co.: along the Wisconsin River. Washington Co.: Newburg. Waukesha Co.: near Menomonee Falls; Vernon Station. Wood Co.: Wisconsin Rapids.

THELIA

T. ASPRELLA Sull. Dane Co.: Blue Mounds; Madison. Grant Co.: Glen Haven; Lancaster; Potosi. Jefferson Co.: Lake Mills; Milford; Palmyra. Lafayette Co.: Fayette. Rock Co.: Bradford Twp.; Newark Twp. Sauk Co.: Baraboo. Waukesha Co.: Beaver Lake; Mukwonago Marsh; Nashotah; Lower Nashotah Lake; Upper Nemahbin Lake; Okauchee Lake; near Pine Lake; Saylesville; Waukesha.

T. HIRTELLA (Hedw.) Sull. Barron Co.: Four Mile Swamp. Dane Co.: Lake Wingra. Dodge Co.: Horicon.

T. LESCURII Sull. Adams Co.: Dells of the Wisconsin River. Dane Co.: Mazomanie; Pine Bluff. Grant Co.: near Woodman. Jefferson Co.: Palmyra. Rock Co.: Newark Twp.

THUIDIUM

T. ABIETINUM (Brid.) Bry. Eur. Ashland Co.: Mellen. Bayfield Co.: Mason; Orienta; Port Wing; between Port Wing and Herbster. Dodge Co.: Horicon. Door Co.: Ellison Bay. Grant Co.: Glen Haven. Iron Co.: Montreal River. Lincoln Co.: between Grandfather Falls and Merrill as *T. scitum.* Outagamie Co.: near Readfield. Waukesha Co.: Eagle Lake as *T. scitum.*

T. DELICATULUM (Hedw.) Mitt. Adams Co.: Dells of the Wisconsin River. Ashland Co.: Hermit Island. Bayfield Co.: Drummond. Dane Co.: Blue Mounds; Lake Wingra; Mendota; Windsor. Douglas Co.: Upper Lucius Lake. Grant Co.: Burton; Glen Haven; Platteville. Oneida Co.: Hat Rapids; Rhinelander; Tomahawk Lake. Outagamie Co.: West Center Swamp. Price Co.: sec. 35 T 35 N R 2 E. Rock Co.: Clinton. Rusk Co.: sec. 20 T 36 N R 7 W. Sheboygan Co.: Cedar Grove. Waukesha Co.: Mukwonago Marsh.

T. MICROPHYLLUM (Hedw.) Best. Barron Co.: sec. 20 T 34 N R 12 W. Bayfield Co.: Drummond. Grant Co.: Glen Haven. Marathon Co.: Granite Heights. Oneida Co.: Noisy Creek; Rhinelander. Portage Co.: near Knowlton. Vilas Co.: Lac Vieux Desert.

T. MINUTULUM (Hedw.) Bry. Eur. Barron Co.: Four Mile Swamp. Bayfield Co.: near Mason. Dane Co.: Madison. Grant Co.: Glen Haven. Lafayette Co.: Fayette. Vilas Co.: along Wisconsin River as *T. scitum.*

T. PHILIBERTI Limpr. Bayfield Co.: Herbster. Door Co.: Baileys Harbor. Grant Co.: Glen Haven. Lincoln Co.: Grandmother Falls; Whirlpool Rapids. Oneida Co.: near Newbold; along Wisconsin River. Vilas Co.: Lac Vieux Desert. Washington Co.: Newburg.

T. PYGMAEUM Bry. Eur. Grant Co.: Glen Haven; Potosi.

T. RECOGNITUM (Hedw.) Lindb. Adams Co.: Cold Water Canyon; Artists Glen, Dells of the Wisconsin River. Door Co.: Baileys Harbor. Douglas Co.: St. Louis River. Grant Co.: Mt. Hope; Platteville. Iron Co.: Montreal. Lincoln Co.: Grandmother Falls. Milwaukee Co.: South Milwaukee. Ozaukee Co.: Cedarburg Swamp. Rock Co.: Clinton. Sauk Co.: Devils Lake. Sheboygan Co.: Cedar Grove. Vilas Co.: Lac Vieux Desert. Washington Co.: Newburg. Waukesha Co.: North Lake; Mukwonago Marsh; Pine Lake. Wood Co.: Wisconsin Rapids.

T. SCITUM (Beauv.) Aust. Ashland Co.: Glidden. Bayfield Co.: Drummond; Mason. Dane Co.: Madison. Lincoln Co.: Grandmother Falls. Vilas Co.: Lac Vieux Desert.

T. SCITUM var. AESTIVALE Aust. Barron Co.: Four Mile Swamp as *T. scitum.* Dane Co.: Madison. Rusk Co.: Sec. 20 T 36 N R 7 W as *T. scitum.*

T. VIRGINIANUM (Brid.) Lindb. Barron Co.: Four Mile Swamp. Bayfield Co.: Mason. Dane Co.: Pine Bluff as *T. scitum.* Grant Co.: Bagley; Glen Haven. Jefferson Co.: Palmyra. Lincoln Co.: Tomahawk. Oneida Co.: McNaughton. Rock Co.: Newark Twp. Vilas Co.: between Eagle River and Tomahawk Lake. Waukesha Co.: Martin's Woods, Big Bend; Waukesha.

TIMMIA

T. MEGAPOLITANA Hedw. Barron Co.: sec. 20 T 34 N R 12 W. Bayfield Co.: Mason. Douglas Co.: St. Louis River. Grant Co.: Montfort. Outagamie Co.: Mosquito Hill.

T. MEGAPOLITANA f. CUCULLATA (Rich.) Sayre. Dane Co.: Madison as *T. cucullata* Mx. Dodge Co.: Horicon. Grant Co.: Potosi. Waukesha Co.: Waukesha.

TORTELLA

T. CAESPITOSA (Schwaegr.) Limpr. Grant Co.: Glen Haven. Jefferson Co.: Lake Mills; Palmyra. Milwaukee Co.: South

Milwaukee. Ozaukee Co.: Cedarburg. Waukesha Co.: Upper Nemahbin Lake; Pine Lake.

T. FRAGILIS (Hook. & Wils.) Limpr. Ashland Co.: Basswood Island. Bayfield Co.: Houghton; between Houghton Quarry and Bayfield. Door Co.: Baileys Harbor. Grant Co.: Glen Haven; Potosi. Outagamie Co.: near Readfield. Waukesha Co.: Okauchee Lake.

T. TORTUOSA (Turn.) Limpr. Ashland Co.: Basswood Island. Barron Co.: near Barron. Door Co.: Baileys Harbor; Garret Bay; Mud Bay.

TORTULA

T. MUCRONIFOLIA Schwaegr. Dane Co.: Madison. Iron Co.: Montreal River. Marathon Co.: Knowlton. Racine Co.: Racine.

T. RURALIS (Hedw.) Smith. Dane Co.: Madison. Door Co.: Europe Bay. Grant Co.: Glen Haven; Patch Grove; Potosi. Jefferson Co.: Palmyra. Sheboygan Co.: Cedar Grove.

TREMATODON

T. AMBIGUUS (Hedw.) Hornsch. Ashland Co.: Madeline Island. Bayfield Co.: Drummond; Port Wing; between Port Wing and Herbster. Lincoln Co.: Tomahawk. Oneida Co.: Noisy Creek. Portage Co.: Stevens Point. Vilas Co.: Lac Vieux Desert.

ULOTA

U. CRISPA (Hedw.) Brid. Ashland Co.: Basswood Island. Barron Co.: Barron Twp., sec. 35; Four Mile Swamp; Maple Grove Twp., sec. 33. Bayfield Co.: Drummond; Herbster; Mason; Roys Point, the old landing near Red Cliff. Dane Co.: Madison. Door Co.: near Ellison Bay. Iron Co.: Montreal; along Montreal River. Lincoln Co.: Grandmother Falls; near Grandmother Falls; between Nigger Island and Tomahawk. Marathon Co.: Granite Heights. Oneida Co.: near McNaughton; Rhinelander; along the Wisconsin River. Rock Co.: Beloit. Vilas Co.: Lac Vieux Desert; along the Wisconsin River.

WEISIA

W. VIRIDULA Hedw. Barron Co.: Barron Twp., sec. 35. Dane Co.: Madison. Grant Co.: Bagley; Beetown; Glen Haven;

Millville; Potosi. Jefferson Co.: Palmyra. Lafayette Co.: Fayette. Lincoln Co.: between Grandfather Falls and Merril. Milwaukee Co.: North Milwaukee. Rock Co.: Beloit; Clinton. Waukesha Co.: Foster's Woods, Fox River as *W. viridula* var. *stenocarpa* Bry. Eur.; Menonomee Falls; Nashotah; Upper Nemahbin Lake; Okauchee Lake; Waukesha; New Berlin Twp., sec. 19.

ZYGODON

Z. VIRIDISSIMUS (Dicks.) R. Br. Grant Co.: Glen Haven.

NOTES ON WISCONSIN PARASITIC FUNGI. V.

H. C. GREENE

In the course of routine checking of hosts in connection with the study of fungi parasitic on plants in Wisconsin, occasional herbarium specimens have been found to bear parasites which had not been reported for the state. During the last twenty years there have been thousands of accessions of phanerogamic specimens in the Wisconsin section of the University of Wisconsin Herbarium. It seemed that a systematic search would probably provide a considerable number of new records of parasitic fungi for the state. A survey was made, and this series of notes is in large part based upon the 75 additional hosts and 20 additional species which were discovered, and are here reported, together with other relevant material.

Between 1,200 and 1,300 species of fungi parasitic on plants have been recorded in the writings of the late J. J. Davis, and in these notes subsequently, as occurring in Wisconsin. More than 60% of these belong to the Fungi Imperfecti, about 20% to the Uredinales and Ustilaginales, about 10% to the Ascomycetes, and 5% to the Phycomycetes, together with a small number of other forms. These figures represent approximations only, but serve to emphasize the preponderance of imperfects in point of numbers of species. Davis' "Parasitic Fungi of Wisconsin," which is somewhat incomplete, lists about 1,100 host species, but of course this has no particular correlation with the number of fungus species, since some hosts harbor a variety of parasites, and certain parasites, such as some powdery mildews and rusts, may go to many hosts. About 125 new species and varieties of plant parasitic fungi have been described from Wisconsin material, nearly all of them by Davis, in notes from the University Herbarium.

Davis in his final publication, "Parasitic Fungi of Wisconsin," mentions *Gleditsia triacanthos* as a host of MICROSPHAERA ALNI. There is no report of this in any of his notes, and I find no specimens in either the University Herbarium or the Davis

Herbarium. However, Professor N. C. Fassett has recently collected a specimen of *G. triacanthos,* in the Sugar River bottoms at Avon, Rock Co., which is profusely mildewed with M. ALNI, and a portion of this is being entered as a mycological specimen.

Hydrophyllum appendiculatum from the vicinity of Viroqua, Vernon Co., is heavily infected with the oidial stage of a powdery mildew, presumably ERYSIPHE CICHORACEARUM DC.

Evonymus atropurpureus, which reaches the northern limit of its range in Wisconsin, is frequently infected with oidium, probably MICROSPHAERA ALNI, but mature perithecia are not formed.

Professor William Trelease in his "Preliminary List of Wisconsin Parasitic Fungi" records orchard grass (*Dactylis glomerata*) as a host of PHYLLACHORA GRAMINIS. Dr. C. R. Orton has examined this specimen, at present in the collection of the Missouri Botanical Garden, and states that as the result of very careful comparison, he has reached the conclusion that the host is undoubtedly *Hystrix patula* which is very commonly attacked by PH. GRAMINIS.

Dr. Orton finds that a specimen of PHYLLACHORA on *Panicum virgatum,* collected in October 1920 at Muscoda, Grant Co., has spores and asci that correspond to those of PHYLLACHORA GRAMINIS, although the specimen is somewhat ayptical in gross appearance. The fungus rarely matures on this host, and this is the only fully developed Wisconsin collection.

PHYLLACHORA PUNCTA (Schw.) Orton occurs on *Panicum* sp. belonging to the section Depauperata, collected at Brodhead, Green Co., in September 1926. The host is probably either *Panicum perlongum* or *Panicum depauperatum.* There are no previous reports of PHYLLACHORA on species belonging to this section.

On several occasions MYCOSPHAERELLA sp. has been observed on spring flowering specimens of *Clematis verticillaris,* on the more or less woody tendrils of the preceding season's growth. In the absence of proof to the contrary, however, it seems likely that the fungus developed saprophytically.

In the fall of 1942 MYCOSPHAERELLA sp. occurred on the leaves of *Panicum implicatum* in dead areas which contained abundant pycnidia of what I have previously reported as SEPTORIA GRAMINUM Desm. It seems possible that the two are connected.

Davis (Trans. Wis. Acad. Sci. 30: 14, 1937) noted the presence of MYCOSPHAERELLA sp. destructively parasitic on the leaves of *Iris lacustris* from Bailey's Harbor, Door Co., on the Lake Michigan shore. A fungus which is microscopically identical, and which affects the host in the same manner, has been found on the overwintered leaves of *Sisyrinchium graminoides*, collected on a bluff above Lake Michigan in the vicinity of Port Washington, Ozaukee Co. Since the latter collection was observed only on overwintered leaves, the parasitism of the fungus remains to be demonstrated.

A parasite found in small quantity on living foliage of *Potentilla recta* at Eagleville, Waukesha Co., July 2, 1941, appears to belong to the genus PHAEOSPHAERIA Miyake (Jour. Coll. Agr. Tokyo 2: 246, 1910). Saccardo includes this under his subgenus LEPTOSPHAERELLA of the genus LEPTOSPHAERIA Ces. & DeNot., which differs from EU-LEPTOSPHAERIA in that members of LEPTOSPHAERELLA are aparaphysate and folicole. The perithecia are epiphyllous on small white spots, the asci rather narrow, about $50 \times 10\mu$. The ascospores are olivaceous, fusiform, triseptate, about $20 \times 4\mu$. This is obviously not LEPTOSPHAERIA MINIMA (Duby) Sacc. occurring on *Potentilla argentea.* The latter has asci $50 \times 20\mu$ and biseptate spores, $20–25 \times 6–7\mu$.

The species of *Ribes* in Wisconsin bearing uredia and telia of CRONARTIUM RIBICOLA F. de Wal. do not appear to have been fully enumerated in earlier notes. There are specimens in the University Herbarium on *Ribes americanum, R. cynosbati, R. grossularia, R. hirtellum, R. nigrum, R. prostratum,* and *R. triste.* Specimens labelled as being on *Ribes oxyacanthoides* have been referred to *R. hirtellum.* Blister rust occurs in all the northern counties.

Although COLEOSPORIUM SOLIDAGINIS is frequently and consistently found on a number of species of *Solidago* and *Aster* in Wisconsin, certain other species are not attacked. C. SOLIDAGINIS has been observed on 14 species of *Solidago* and 18 species of *Aster* as follows: *Solidago altissima, S. canadensis, S. castrensis, S. glaberrima, S. hispida, S. latifolia, S. nemoralis, S. patula, S. riddellii, S. sciaphila**, *S. serotina, S. speciosa, S. uliginosa, S. ulmifolia; Aster azureus, A. cordifolius, A. ericoides, A. junciformis, A. laevis, A. lateriflorus, A. lindleyanus**, *A. lucidulus, A. macrophyllus, A. novae-angliae, A. novi-belgii, A. oblongi-*

folius, A. paniculatus var. *simplex* (*A. tradescanti*), *A. pilosus, A. prenanthoides, A. puniceus, A. sagittifolius*, and *A. umbellatus*. Where an asterisk follows the name it indicates that the fungus is not represented by a specimen in the Cryptogamic Herbarium, but has been observed on phanerogamic specimens in the University Herbarium.

Davis found RAVENELIA EPIPHYLLA (Schw.) Diet. II, III on *Tephrosia virginiana* at Muscoda, Grant Co., in 1934. In his "Parasitic Fungi of Wisconsin," p. 41, he states that this was likely introduced, since the focus of distribution was along the railroad right of way, and he offers the suggestion that successive hot summers may have been a factor in its introduction from farther south. That such is probably not the case is indicated by the fact that uredia of R. EPIPHYLLA have been noted on a phanerogamic specimen of *Tephrosia virginiana* which was collected in 1894 at Petenwell Rock near Necedah in Juneau Co., a locality which is 60 miles north of Muscoda. Since Petenwell Rock is at least 2 miles from a railroad it seems unlikely that the fungus was introduced there by that agency. Uredia also occur on another phanerogamic specimen collected in 1891 at Albany in Green Co., about 35 miles south of Muscoda. Thus, it would appear that RAVENELIA EPIPHYLLA has quite possibly been continuously in the state.

Pycnia which, in all likelihood, are those of UROMYCES HALSTEDII DeToni occur in circular amphigenous clusters on the leaves of a specimen of *Trillium cernuum* var. *macranthum* collected near Stanley in Clark Co., but in the absence of aecia a new record seems scarcely warranted. The fungus has been reported only on *Trillium grandiflorum* in Wisconsin, and is not listed on *T. cernuum* in Arthur's Manual.

Eriophorum viridi-carinatum which was recorded as a host for PUCCINIA ANGUSTATA Peck in Wisconsin should be dropped, for it has since been shown that the host plant, which was preserved along with the rust collection, is *Eriophorum virginicum*.

Uredia of PUCCINIA EXTENSICOLA Plowr. have been found on a specimen of *Carex aenea* Fernald (*C. foenea* var. *aenea*) collected at Port Wing, Bayfield Co., July 9, 1897 by L. S. Cheney (Host det. by K. Mackenzie). P. EXTENSICOLA is reported by Arthur (N. Amer. Flora 7(1) : 362) as occurring on this host in Wisconsin, but Davis, so far as I have been able to determine, does not mention it, nor do I find any specimens in the University Herbarium or in the Davis Herbarium.

In 1938 aecia of what is presumably UROMYCES SILPHII (Burr.) Arth. (U. JUNCI-TENUIS Syd.) were collected at Madison in profuse development on *Helianthus strumosus*. There is a single earlier collection on the same host. The small spores serve to distinguish this from PUCCINIA HELIANTHI, but not from UROMYCES JUNCI. Since the latter is not known to occur in Wisconsin, it seems probable that these are, as stated, the aecia of U. SILPHII.

UROMYCES SILPHII (Burr.) Arth. III occurs on a collection of *Juncus dudleyi* from Washburn Co., Minong, September 6, 1928, and also from Rock Co., Footville, October 25, 1936. A lone earlier collection is from Wausaukee in Marinette Co.

Davis in his "Third Supplementary List of Parasitic Fungi of Wisconsin" (Trans. Wis. Acad. Sci. 14(1): 101, 1903) records *Cypripedium pubescens*, from Somers, Kenosha Co., as a host of PUCCINIA CYPRIPEDII Arth. & Holw. In a later collection from Gays Mills, Crawford Co., the same host is entered as *Cypripedium parviflorum* var. *pubescens* in accordance with the then usage, but in his "Provisional List" and in his "Parasitic Fungi of Wisconsin" he lists *Cypripedium parviflorum* as the host. There are in the Cryptogamic Herbarium only these two collections from the state, both plainly on what certain authorities have called the var. *pubescens*. The most reliable present-day opinion is that *Cypripedium pubescens* and *C. parviflorum* are distinct and well-marked species. (See Fuller, A. M., Bull. Publ. Mus. Milwaukee 14(1): 64-70, 1933). *Cypripedium parviflorum*, therefore, should be deleted as a host of PUCCINIA CYPRIPEDII in Wisconsin. The fungus has also been found on a specimen of *C. pubescens* from the vicinity of Ashland, Ashland Co., collected by L. S. Cheney in July 1896, thus much extending the range over the two southern stations cited above.

PUCCINIA JUSSIAEAE Speg. I on *Ludvigia polycarpa* was collected once by Davis in the Wisconsin River bottoms, at Blue River in Grant Co. Another specimen has been discovered on the same host from the Mississippi River bottoms, opposite Dubuque, Ia., also in Grant Co.

PUCCINIA TUMIDIPES Peck II, III has been found in profuse development on a specimen of *Lycium halimifolium* collected at

Appleton, Outagamie Co., in September 1928. There is a single scanty earlier collection from Madison on this same host.

PUCCINIA HYSSOPI Schw. occurs on *Agastache scrophulariaefolia* from Fall Creek, Eau Claire Co. The one previous collection is from Viroqua, Vernon Co. On the upper leaf surface, above each telial sorus, there are definite spots bearing what appear to be perithecia of PHAEOSPHAERIA, mostly immature and very probably developed saprophytically following the rust.

PESTALOTIA sp. has been seen on spots on the leaves of *Hypericum kalmianum* from Sauk Co., but it seems improbable that the fungus developed parasitically.

CONIOTHYRIUM INSITIVUM Sacc. has been found on the stem of a specimen of *Berberis vulgaris* collected in the vicinity of Milwaukee in July 1837. (The specimen is from the herbarium of the noted Wisconsin naturalist, I. A. Lapham.) This may have been parasitic for it is deeply seated in the portion of the stem bearing the current year's foliage.

An examination of specimens of SEPTORIA COPTIDIS B. & C. on *Coptis trifolia* in the Cryptogamic Herbarium shows very narrow sporules (1μ or less) which run from 15 to 65μ long, the range being fairly small for any one specimen, e. g., 40–60μ, 30-50μ, 25-35μ, 15-25μ. The lesions are all very similar, and it seems reasonable to suppose that this is the organism described by Berkeley and Curtis, but the spore length is seen to be far more variable than the arbitrary 25μ indicated by them.

In August 1938 S. Fogelberg made a collection of SEPTORIA CEPHALANTHI Ell. & Kell. on *Cephalanthus occidentalis* at Blue River, Grant Co. This species must be very rare, for the Blue River locality was intensively worked by Davis, over a period of many years, without finding it. He made one collection in 1901 in Kenosha Co.

Ellis and Bartholomew described SEPTORIA GRINDELIAE on *Grindelia squarrosa* and issued specimens (with description on label) as No. 1874 of Ellis and Everhart's Fungi Columbiani. Their description is as follows: "Spots round, whitish at first, becoming brown, 1½–2½ mm. in diam., with a narrow, raised darker colored border. Perithecia epiphyllous, partially erumpent, mostly visible also on the under side of the leaf, few, often only one, in the center of the spot. Sporules slightly curved, continuous or obscurely septate(?), 40–60 × 2½ micr., a little thicker at one end. The leaves become brown and dead." SEPTORIA sp. has been found on a specimen of the same host collected near Plover in Portage Co. It is quite different from S. GRINDELIAE in that there are no definite spots, merely brown, dead areas, and in having sporules that are markedly curved, closely and distinctly septate, about 30–45 × 2μ, and not thicker at one end. Unfortunately the material is not sufficient to constitute a type specimen, but a slide has been preserved for future reference.

SEPTORIA collected on leaves of *Solidago serotina*, May 26, 1942 at Eagleville, Waukesha Co., is assigned to SEPTORIA FUMOSA Peck. As Davis pointed out (Trans. Wis. Acad. Sci. 19(2): 705, 1919) the classification of SEPTORIA on *Solidago* is in an unsatisfactory state, but the specimen in hand fits Peck's description quite closely. Davis indicated that in his opinion SEPTORIA DAVISII, also on Solidago, is probably not distinct from S. FUMOSA.

BOTRYTIS sp. occurs profusely on the leaves of *Ranunculus rhomboideus*, collected at Portage, Columbia Co. In an earlier publication (Trans. Wis. Acad. Sci. 32: 78, 1940) I reported BOTRYTIS sp. on *Ranunculus abortivus*. Davis, in describing the occurence of ASCOCHYTA INFUSCANS Ell. & Ev. on the latter host (Trans. Wis. Acad. Sci. 16(2): 757, 1910) states "The effects of this parasite upon the host are serious, causing speedy death of as much of the plant as is distal to the point of attack and in moist weather such dying portions are usually covered by a growth (BOTRYTIS as I have seen it) that seems to inhibit the development of the pycnidia, so that it is only in comparatively dry weather that I have been able to get satisfactory specimens." There is no trace of ASCOCHYTA in either of the specimens mentioned above, but it seems quite possible that the primary infection may have been due to ASCOCHYTA INFUSCANS, as suggested by Davis.

RAMULARIA MULTIPLEX Peck occurs on a specimen of *Vaccinium macrocarpon* from Fall Creek, Eau Claire Co. A single previous collection on this host was made at Gaslyn, Burnett Co. in 1911. This is likely more common than the lack of specimens would indicate, since the host is extensively cultivated in Wisconsin.

RAMULARIA DIERVILLAE Peck was found on *Diervilla lonicera* near Mt. Vernon, Dane Co., in June 1938. This is the first collection from southern Wisconsin. Earlier specimens are from the central counties of Marathon, Waushara, and Sheboygan.

CLADOSPORIUM sp. has been found in a seemingly parasitic development on the aecial cups of TRANZSCHELLA PRUNI-SPINOSAE (Pers.) Diet. on *Hepatica acutiloba,* collected at Madison in May, 1938. However, since the material is scanty, and there are apparently no previous reports of CLADOSPORIUM on uredinaceous hosts, no attempt is here made to determine the specific identity.

Well developed CLADOSPORIUM appears on a dried specimen of *Astragalus canadensis* from Lynxville, Crawford Co. It may be that the fungus developed while the bulky specimen was in press.

HETEROSPORIUM sp. occurs on a specimen of *Luzula salutensis* from Hogarty, Marathon Co. Coll. N. C. Fassett, May 21, 1932. This is perhaps closely allied to HETEROSPORIUM MAGNUSIANUM Jaap (occurring in Europe on *Narthecium/ossifragum* of the Liliaceae), but seems set apart by the darker, more pronouncedly geniculate conidiophores. The conidia are very similar. I do not find any reports of HETEROSPORIUM on Juncaceae. The material in hand is, however, insufficient for more extensive study.

Panicum boscii Poir. has been reported as a host for CERCOSPORA FUSIMACULANS Atk. (C. PANICI J. J. Davis) in Wisconsin, but it now appears that such reports should be referred to *Panicum latifolium,* since *P. boscii,* according to the best available information, does not occur in Wisconsin.

CERCOSPORA GEI Fckl. was found on a specimen of *Geum triflorum* from Searl's Prarie, Juneau Co., (T19N R4E S5). This is the second Wisconsin station for this uncommon fungus.

Lespedeza violacea from Potosi, Grant Co., bears CERCOSPORA LESPEDEZAE Ell. & Dearn. A single earlier collection on this rare host is from Glen Haven, Grant Co.

A scanty collection of CERCOSPORA sp. was made on *Oxypolis rigidior* in the vicinity of Troy Center, Walworth Co. A slide was prepared and submitted to Professor Chupp who believes that it may be a new species, since the conidiophores and conidia are appreciably more narrow than those of CERCOSPORA POLYTAENIAE Ell. & Kell., or others with acicular conidia on hosts closely related to *Oxypolis.* Description of the species must, however, of necessity await collection of more ample material.

It seems possible that SCLEROTIOMYCES COLCHICUS Woronochin is identical with SCLEROTIUM MENDAX Sacc. reported by me on *Solidago altissima.* Davis (Trans. Wis. Acad. Sci. 24: 301, 1929) states "While fungous growths on 'honey dew' on leaf surfaces are not parasites their effects are probably ill. An interesting form that occurs in Wisconsin on the leaves of various plants is apparently the one to which Woronochin gave the name SCLEROTIOMYCES COLCHICUS (Ann. Mycol. *24*: 234). The orbicular flattened sclerotia strongly resemble perithecia." This has also been found recently in heavy development on *Aster azureus* collected by N. C. Fassett at St. Croix Falls, Polk Co. Other specimens in the herbarium are on *Carya cordiformis* and *Elymus virginicus.* In their "Genera of Fungi" Clements and Shear do not recognize SCLEROTIOMYCES because of the lack of a generic diagnosis, and they conclude that it is "apparently a sclerotium."

ADDITIONAL HOSTS

ALBUGO CANDIDA (Pers.) O. Ktze. on *Lepidium apetalum.* Washburn Co., Chittamo, June 20, 1929. Coll. N. C. Fassett.

PERONOSPORA CORYDALIS DeBary on *Corydalis sempervirens.* Ashland Co., Marengo, May 14, 1931. Coll. Wesley Warvi.

PERONOSPORA CALOTHECA DeBary on *Galium tinctorium* (*G. claytoni* of Gray's Manual). Sauk Co., LaValle, September 5, 1927. Coll. J. J. Davis. A specimen of this same fungus on *Galium trifidum* from Blue River, Grant Co., June 15, 1935, collected by Davis and Greene has not hitherto been recorded.

BREMIA LACTUCAE Regel has been found on specimens of *Serinia oppositifolia* collected by Delzie Demaree at Monticello, Drew Co., Ark., May 2, 1941. Although not a Wisconsin collection, this is recorded since *Serinia* is, so far as I am aware, a new host genus for B. LACTUCAE.

Specimens distributed from the University of Wisconsin Herbarium as UNCINULA NECATOR (Schw.) Burr. on *Psedera quinquefolia,* Gibraltar Rock, Columbia Co., Wis., August 13, 1940, are probably on *Parthenocissus vitacea* (*Psedera vitacea*), since it seems that *P. quinquefolia* is found in Wisconsin only as an escape from cultivation.

MICROSPHAERA DIFFUSA Cke. & Peck on *Symphoricarpos occidentalis* Pierce Co., Prescott, August 30, 1927. Coll. N. C. Fassett. In this collection the appendages are quite short, but as is usual in this species, the ultimate tips of the branchlets are straight, and not recurved as in MICROSPHAERA ALNI.

ERYSIPHE POLYGONI DC. on *Polygonum atlanticum.* Milwaukee Co., Milwaukee, September 2, 1939. Coll. L. H. Shinners. Host det. by J. F. Brenckle. Perithecia not mature. On *Polygonum buxiforme.* Milwaukee Co., Milwaukee, August 4, 1939. Coll. L. H. Shinners. Host det. by J. F. Brenckle. It appears that most of the Wisconsin collections reported on *Polygonum aviculare* should probably be referred to *P. buxiforme.*

ERYSIPHE CICHORACEARUM DC. on *Coreopsis palmata.* Sauk Co., Devils Lake, August 23, 1900. Coll. L. M. Umbach.

ERYSIPHE CICHORACEARUM DC. on *Aster lucidulus.* Waukesha Co., Eagle, September 13, 1938. Coll. R. W. Pohl.

PHYLLACHORA PUNCTA (Schw.) Orton on *Panicum euchlamydeum* Shinners. Grant Co., Muscoda, October 5, 1920. Coll. J. J. Davis. Host det. by L. H. Shinners.

CRONARTIUM COMPTONIAE Arth. II on *Myrica gale.* Bayfield Co., Washburn, August 23, 1930. Coll. Newton Bobb. Not uncommon on *Myrica asplenifolia* in Wisconsin.

CRONARTIUM COMANDRAE Peck II on *Comandra richardsiana.* Ashland Co., Madeline Island, July 15, 1930. Coll. Newton Bobb. Arthur's Manual reports C.COMANDRAE on *Comandra livida* from Wisconsin. Presumably there is a specimen in the Arthur Herbarium. There is no specimen at the University of Wisconsin.

PUCCINIA CORONATA Cda. II, III on *Elymus canadensis.* Dane Co., Madison, August 24, 1942. Coll. & det. by C. G. Shaw. Arthur reports the rust on this host from Saskatchewan only.

PUCCINIA ANDROPOGONIS Schw. I on *Penstemon grandiflorus.* Polk Co., Osceola, June 13, 1927. Coll. Mrs. Henry Arndt, Jr.

PUCCINIA EXTENSICOLA Plowr. II, III on *Carex scoparia.* Polk Co., Dresser Junction, September 4, 1927. Coll. N. C. Fassett. Host det. by K. Mackenzie. Also on specimens of the same host from Dane and Bayfield Counties. On *Carex crawfordii.* Bayfield Co., Iron River, September 1, 1928. Coll. N. C. Fassett. Host det. by K. Mackenzie. Also on a specimen from Burnett Co. On *Carex convoluta.* Trempealeau Co., Trempealeau, August 23, 1927. Coll. N. C. Fassett. Host det. by K. Mackenzie. On *Carex rosea.* Polk Co., St. Croix Falls, September 3, 1927.

Coll. N. C. Fassett. Host det. by K. Mackenzie. On *Carex viridula.* Door Co., Bailey's Harbor, September 24, 1932. Coll. N. C. Fassett. On *Carex chordorrhiza.* Oneida Co., McNaughton, July 7, 1893. Coll. L. S. Cheney. Also on a specimen from Jefferson Co.

PUCCINIA BOLLEYANA Sacc. II, III on *Carex lupulina.* Portage Co., Meehan, August 28, 1938. Coll. J. W. Thomson.

PUCCINIA CANALICULATA (Schw.) Lagerh. III on *Cyperus inflexus* (*aristatus* of Gray's Manual). Dunn Co., Elk Mound, October 14, 1939. Coll. N. C. Fassett.

PUCCINIA ELEOCHARIDIS Arth. III on *Eleocharis smallii.* Washburn Co., Sarona, September 14, 1935. Coll. N. C. Fassett.

UROMYCES SILPHII (Burr.) Arth. II, III (U/JUNCI-TENUIS Syd.) on *Juncus balticus* var. *littoralis.* Adams Co., Big Springs, July 24, 1932. Coll. N. C. Fassett. Det. G. B. Cummins. Arthur's Manual cites an extensive list of localities in which UROMYCES JUNCI (Desm.) Tul. has been collected on *Juncus balticus,* but does not list it as a host for U. SILPHII.

UROMYCES SILPHII (Burr.) Arth. II, III on *Juncus interior.* Iowa Co., Arena, October 3, 1925. Coll. N. C. Fassett. Also on specimens from Trempealeau and Buffalo Counties. II on *Juncus brevicaudatus.* Vilas Co., Plum Lake, Land-o-Lakes, September 12, 1942. Coll. N. C. Fassett. Det. G. B. Cummins.

Specimens of UROMYCES HOLWAYI Lagerh. labelled as having been collected on *Lilium canadense* and *L. superbum* in Wisconsin should all be referred to *Lilium michiganense* since the two plants first mentioned apparently do not occur in this state.

PUCCINIA ANEMONES-VIRGINIANAE Schw. on *Anemone riparia.* Grant Co., McCartney, July 21, 1932. Coll. N. C. Fassett.

Davis in his "Parasitic Fungi of Wisconsin" does not list *Anemone virginiana* as an aecial host for PUCCINIA RUBIGO-VERA. Earlier collections of aecia on this host were in some doubt as to identity (see Trans. Wis. Acad. Sci. 21: 259, 1924), but Davis and this writer in July 1935 at Fish Creek, Door Co., made a collection of indubitable P. RUBIGO-VERA on *Anemone virginiana,* and the latter is therefore listed here as a Wisconsin host.

PUCCINIA MENTHAE Pers. II on *Mentha citrata* (cult.). Grant Co., Ellensboro, September 2, 1930. Coll. N. C. Fassett.

UROMYCES PECKIANUS Farl. I on *Plantago purshii.* Grant

Co., Muscoda, June 26, 1920. Coll. J. J. Davis. Closely associated with the aecia are pycnidia of SEPTORIA PLANTAGINEA var. PLANTAGINIS-MAJORIS Sacc.

GYMNOSPORANGIUM CLAVIPES Cke. & Peck I on fruit of *Amelanchier laevis* × *humilis*. Ashland Co., Madeline Island, July 15, 1930. Coll. Newton Bobb. Host det. by E. L. Nielsen.

GYMNOSPORANGIUM GLOBOSUM Farl. I on *Crataegus succulenta*. Dane Co., Madison, September 17, 1895. Coll. R. H. True. On *Crataegus punctata*. Milwaukee Co., Cudahy, September 19, 1940. Coll. L. H. Shinners. On *Crataegus holmesiana*. Milwaukee Co., Cudahy, September 19, 1940. Coll. L. H. Shinners. On *Crataegus calpodendron*. Milwaukee Co., Whitefish Bay, September 22, 1940. Coll. L. H. Shinners. Hosts det. by E. J. Palmer and L. H. Shinners.

ASTEROMELLA ANDREWSII Petr. on *Gentiana flavida*. Green Co., Browntown, September 24, 1926. Coll. J. J. Davis.

Fernald (Rhodora *19*: 147, 1917) differentiates *Gentiana clausa* from *G. andrewsii*. It appears that both are in Wisconsin, and probably ASTEROMELLA ANDREWSII and PUCCINIA GENTIANAE occur on both, although previously recorded only on *G. andrewsii*.

PHYLLOSTICTA DECIDUA Ell. & Kell. on *Nepeta cataria*. Vernon Co., Viroqua, July 20, 1929. This ubiquitous and rather dubious parasite has been collected in Wisconsin on the following diverse hosts which do not seem to have been listed in full elsewhere: *Agrimonia gryposepala, Agrimonia striata, Aralia racemosa, Armoracia rusticana, Bidens frondosa, Cynoglossum officinale, Eupatorium perfoliatum, Eupatorium sessilifolium, Galeopsis tetraheit, Geum canadense, Hieracium aurantiacum, Humulus lupulus Lactuca canadensis, Lappula virginiana, Leonurus cardiaca, Lycopus uniflorus, Mentha arvensis* var. *canadensis, Monarda punctata, Nepeta hederacea, Rudbeckia hirta, Scutellaria lateriflora, Stachys palustris, Stachys tenuifolia, Steironema ciliatum, Vernonia fasciculata* and *Veronica virginica*.

ASCOCHYTA GRAMINICOLA Sacc. on *Schizachne purpurascens* (*Melica striata* of Gray's Manual). Vilas Co., Trout Lake, July 2, 1935. Coll. J. T. Curtis.

STAGONOSPORA MELILOTI (Lasch) Petr. on *Medicago lupulina*. Dane Co., Madison, July 15, 1937. Coll. & det. by F. R. Jones;

Iowa Co., Blue Mounds, July 28, 1938. Coll. & det. H. C. Greene.

SEPTORIA GRAMINUM Desm. on *Panicum scribnerianum.* Dunn Co., Fall City, October 14, 1939. Coll. L. H. Shinners. On *Panicum tsugetorum.* Juneau Co., Necedah, June 18, 1936. Coll. F. Hamerstrom. On *Panicum euchlamydeum* Shinners. Pierce Co., Bay City, August 29, 1927. Coll. N. C. Fassett; Marquette Co., Montello, June 20, 1938. Coll. N. C. Fassett.

SEPTORIA CARICINELLA Sacc. & Roum. on *Carex cristata.* Brown Co., Green Bay, July 19, 1887. Coll. H. J. Schuette. On *Carex muhlenbergii.* Jackson Co., Millston, September 28, 1935. Coll. J. J. Davis.

SEPTORIA POLYGONORUM on *Polygonum lapathifolium* seems not to have been reported. There is a specimen in the herbarium from Port Wing, Bayfield Co. collected by Davis in September 1923. The fungus has also been found on other specimens of this host from Ashland, Buffalo, Burnett, Dane, Kenosha, Sawyer and Walworth counties.

SEPTORIA DIMERA Sacc. on *Silene latifolia.* Door Co., Bailey's Harbor, August 1, 1939. Coll. L. H. Shinners. This is a very distinctive species, hitherto reported, so far as I am aware, only on *Silene nutans* in Europe and on *S. antirrhina* in Wisconsin.

SEPTORIA HEPATICAE Desm. on *Hepatica americana.* (*H. triloba* of Gray's Manual). Walworth Co., Lauderdale Lakes, Town of Sugar Creek, April 20, 1938. Coll. Douglas Wade.

SEPTORIA RIBIS Desm. on *Ribes missouriense.* Dane Co., Madison, October 8, 1942. Previous reports of this fungus on *Ribes oxyacanthoides* should be referred to *R. hirtellum.*

SEPTORIA AGRIMONIAE-EUPATORIAE Bomm. & Rouss. on *Agrimonia pubescens* (*A. mollis* of Gray's Manual). Sauk Co., Devil's Lake, August 8, 1913. Coll. J. J. Davis. This was placed in the herbarium as *Agrimonia parviflora,* a species which it is now believed does not occur in Wisconsin. The specimen was later redetermined as *A. mollis.*

SEPTORIA ASTRAGALI Desm. on *Lathyrus japonicus* var. *glaber* (*L. martimus* of Gray's Manual). Ashland Co., Oak Island, July 27, 1936. Coll. Edith Seymour Jones. Trelease first reported this on *Vicia americana* in Wisconsin, and Davis many years later made a collection on the same host. Davis' remarks on his specimen (Trans. Wis. Acad. Sci. *24*: 298, 1929) apply without alteration to the present collection, and are as follows: "In this collection the pycnidia are very imperfect and the sporules grow out to a length of 120–200μ resembling Cylindrosporium."

SEPTORIA NOLITANGERE Thum. on *Impatiens pallida.* Grant Co., Wisconsin River bottoms opposite Bridgeport, September 15, 1930. Coll. N. C. Fassett; Grant Co., Wyalusing State Park, August 15, 1938. Coll. S. Fogelberg.

SEPTORIA CAMPANULAE (Lev.) Sacc. on *Campanula rapunculoides.* Winnebago Co., Waukau, July 4, 1941. Coll. L. H. Shinners. This appears to have been previously reported only on *Campanula americana* and on *C. aparinoides.* Oudemans does not list it as occurring on *C. rapunculoides* in Europe.

RAMULARIA URTICAE Ces. on *Urtica procera.* This fungus is abundant on *Urtica* in Wisconsin and has previously been reported on *Urtica gracilis.* I have found it on several phanerogamic specimens labelled *Urtica procera.* The distinction between *Urtica gracilis* and so-called *U. procera* seems tenuous indeed.

RAMULARIA OCCIDENTALIS Ell. & Kell. on *Rumex acetosella.* Sheboygan Co., Terry Andrae State Park, June 30, 1925. Coll. A. M. Fuller.

CLADOSPORIUM ASTERICOLA J. J. Davis on *Solidago casterensis.* Juneau Co., Mauston, September 1935. Coll. B. O. Dodge. Host det. by L. H. Shinners.

PASSALORA FASCICULATA (C. & E.) Earle on *Euphorbia glyptosperma.* Portage Co., Plover, August 23, 1917; Shawano Co., Shawano, September 1, 1921. Coll. J. J. Davis as on *Euphorbia* sp. indet. Host det. by N. C. Fassett.

CERCOSPORA SAGITTARIAE Ell. & Kell. on *Sagittaria arifolia.* Shawano Co., Shawano, September 1, 1921. Coll. J. J. Davis. Placed in the herbarium, but not reported. The host determination is confirmed from fruiting material present with the specimen.

CERCOSPORA CARICINA Ell. & Dearn. on *Carex crawfordii.* Dane Co., Sun Prairie, July 16, 1932. Coll. N. C. Fassett. In this specimen the multiseptate conidia are long and very slender, up to 100 × 2.5–3μ, the conidiophores short, mostly about 15μ. On *Carex convoluta.* Trempealeau Co., Trempealeau, August 23,

1927. Coll. N. C. Fassett. Host det. by K. Mackenzie. On *Carex projecta.* Oneida Co., Newbold, July 13, 1893. Coll. L. S. Cheney.

CERCOSPORA COMANDRAE Ell. & Dearn. on *Comandra richardsiana.* Ashland Co., Madeline Island, July 15, 1930. Coll. Newton Bobb. Davis has reported C. COMANDRAE on *Comandra umbellata.* Concerning the former host, Deam in his "Flora of Indiana" states in part "------ ------ he (M. L. Fernald) says that all of my specimens and all of those in the Gray Herbarium from west of the Allegheny Mountains belong to this species (*C. richardsiana*). It is undoubtedly separated from *Comandra umbellata* and in Britton and Brown, Illus. Flora, ed. 2, it was regarded as a synonym. Fernald gives the range of *Comandra umbellata* as restricted to the area east of the Allegheny Mountains." It is possible therefore that Wisconsin fungi reported on *Comandra umbellata* should all be referred to *C. richardsiana.*

CERCOSPORA NASTURTII Pass. on *Berteroa incana.* Waupaca Co., Weyauwega, July 9, 1933. Coll. J. J. Davis. The spots, while small, are fairly numerous and the fungus is mature.

CERCOSPORA ZEBRINA Pass. on *Trifolim agrarium.* Eau Claire Co., Fall Creek, July 18, 1928. Coll. Helen F. Kunz.

CERCOSPORA ALTHEINA Sacc. on *Hibiscus trionum.* Iowa Co., Avoca, September 10, 1923. Scanty. Coll. E. M. Gilbert and J. J. Davis.

CERCOSPORA SENECIONICOLA J. J. Davis on *Senecio balsamitae.* Forest Co., Laona, July 15, 1915. Coll. J. J. Davis. Davis (Trans. Wis. Acad. Sci. 30: 10, 1937) described CERCOSPORA SENECIONICOLA n. sp. on *Senecio aureus.* In the description it is stated that the spots are indeterminate. The specimen on *Senecio balsamitae* was originally placed in the herbarium as CERCOSPORA EMACULATA n. sp., but this was not published, perhaps because of the small size of the specimen. Davis redetermined it, presumably after description of the new species, but neglected to record it.

GRAPHIOTHECIUM VINOSUM J. J. Davis on *Ribes prostratum.* Wood Co., Dexterville, August 31, 1917. Coll. J. J. Davis. Davis described this fungus on *Ribes americanum* (Trans. Wis. Acad. Sci. 18(1): 90, 1915). It is admittedly highly variable, and perhaps doubtfully parasitic. The specimen on *Ribes prostratum* was set aside by Davis for study, but for some reason was overlooked. It appears to me to be but a somewhat slender version of G. VINOSUM.

ADDITIONAL SPECIES

In a study of soil fungi of Wisconsin, Mr. C. W. Hesseltine has found PIPTOCEPHALIS sp. and SYNCEPHALIS spp. parasitizing Mucors in culture.

PHYLLACHORA on *Paspalum stramineum*, collected by N. C. Fassett at Cassville, Grant Co., September 11, 1930, has been identified by Dr. C. R. Orton as PHYLLACHORA WILSONI sp. nov.

ELSINOE LEDI (Pk.) Zeller on *Ledum groenlandicum*. Douglas Co., Gordon, July 18, 1907. Coll. J. J. Davis. Peck's description of this interesting ascomycete is as follows: "Spots orbicular, grayish white, surrounded by a brown or purplish brown border; perithecia epiphyllous, few on a spot, elliptic or oblong, often substellately lobed by confluence, erumpent, black, context whitish; asci obovate or subglobose; spores ovate or oblong, continuous, at length uniseptate, 12–15μ long, 6–8μ thick."

BELONDIDIUM JUNCISEDUM (Karst.) J. Lind. occurs on a specimen of *Juncus balticus* var. *littoralis* from Oakland, Burnett Co. Coll. W. T. McLaughlin, August 19, 1929. Whether this is actively parasitic is doubtful. Although it occurs on the current season's growth, it is in an area that is entirely dead, and whether death was due to this organism or to some other cause is not known.

UROMYCES GLYCYRRHIZAE (Rab.) Magn. I, III on *Glycyrrhiza lepidota*. Pierce Co., stony shore of Lake St. Croix, August 3, 1934. Coll. N. C. Fassett. This is of interest in that both host and parasite are essentially western forms. Arthur's Manual gives the range of U/GLYCYRRHIZAE as North Dakota to Alberta, southward to New Mexico and southern California.

PUCCINIA CAULICOLA T. & G. II, III on *Salvia lanceolata*. Kenosha Co., 1 mi. S. of Racine Co. line, October 6, 1940. Coll. N. C. Fassett, L. H. Shinners and S. C. Wadmond. In Arthur's Manual the range of this rust is given as South Dakota to Texas and New Mexico; also in Mexico.

A fungus appearing parasitic on twigs of *Morus rubra* from Bridgeport, Crawford Co., is referred to PHOMA MORICOLA Sacc. The spore characters correspond well, the conidia being about 7–10 $\times$ 2–2.5μ hyaline, straight, and more or less biguttulate.

In the report of the New York State Botanist for 1915, p. 37, PHOMA LONGIPES B. & C. is listed as occurring on *Morus alba.* It is stated that this was cited earlier as PHOMA MORICOLA Sacc. by Burnham and Latham (Torreya 14: 210, 1914). It has not been possible to obtain material for comparison with the Wisconsin collection. Dr. House informs me that the specimen in question is not in the New York State Herbarium.

SEPTORIA ACICULOSA Ell. & Ev. on *Fragaria virginiana.* Waushara Co., Hancock, May 21, 1940. Coll. Max Partch. This was found on overwintered leaves still attached to the plant. There seems little doubt that the fungus developed during the previous growing season.

SEPTORIA CANADENSIS Peck on *Cornus canadensis.* Oconto Co., Keshena, June 22, 1934. Coll. E. E. Honey. The very slender sporules do not exceed 25μ in length. Apparently distinct from SEPTORIA CORNICOLA Desm.

SEPTORIA PENTSTEMONIS Ell. & Ev. on *Pentstemon digitalis.* Dane Co., Belleville, June 21, 1931. Coll. N. C. Fassett. Also on specimens from Jackson and Outagamie counties. This species differs from SEPTORIA PENSTEMONICOLA Ell. & Ev. (occurring in Wisconsin on *Pentstemon gracilis*) in that the pycnidia are borne on much more sharply delimited spots, and the sporules are very short, mostly about 20μ, as opposed to 30–50μ in S. PENTSTEMONICOLA.

SEPTORIA LANARIA Fairm. on *Antennaria parlinii.* Vernon Co., Ontario, May 9, 1931. Coll. N. C. Fassett. Also on *Antennaria fallax.* Juneau Co., Necedah, May 22, 1932. A minute form which Fairman (Ann. Mycol. 9: 151, 1911) described as having sporules 23–33 $\times$ 1–1.5μ. In the Wisconsin specimens many sporules are shorter than this. Fairman suggests that S. LANARIA may be a stage in the development of MOLLISIA LANARIA, described by him on *Antennaria plantaginifolia.*

SEPTORIA MOLLISIA Dearn. & House on *Antennaria plantaginifolia.* Iowa Co., Mineral Point, May 28, 1931. Coll. N. C. Fassett. A well-marked species with the mature pycnidia widely open, suggesting MOLLISIA. Dearness and House (New York State Museum Bull. 188: 39, 1916) state "It may be questioned whether the waxy appearing rim is a part of a true pycnidial wall and whether the plant should not be called a CYLINDROSPORIUM."

MELASMIA HYPOPHYLLA (B. & Rav.) Sacc. on *Gleditsia triacanthos*. Grant Co., Potosi, August 16, 1934. Coll. N. C. Fassett.

GLOEOSPORIUM CELTIDIS Ell. & Ev. on *Celtis occidentalis*. Grant Co., Millville, September 22, 1913. Coll. J. J. Davis. Davis determined but did not report this. It appears possible that it is but a weak parasite, since the leaves, as is usually the case with *Celtis* late in the season, bear numerous insect galls. The spores are decidedly fusoid, borne on rather long conidiophores, mostly about 10–12 × 5μ.

GLOEOSPORIUM PSORALEAE Peck on *Psoralea esculenta*. Pierce Co., Hager, August 25, 1935. Coll. N. C. Fassett. A very interesting fungus on a host that is extremely rare in Wisconsin. The minute pustules are borne on blackish brown orbicular spots, which are here amphigenous.

CERCOSPORA COPALLINA Cke. on *Rhus copallina*. Brown Co., Suamico, September 15, 1937. Coll. N. C. Fassett. In the past this species has been distributed as CERCOSPORA RHOINA Cke. & Ell. and as C. RHOINA var. NIGROMACULANS Peck. The fruiting is definitely on the upper leaf surface, and the dense fascicles are on a large black stroma which is from 50–125μ diam. The variation from C. RHOINA seems sufficiently great to warrant specific differentiation.

CERCOSPORA LUDWIGIAE Atk. on *Ludvigia polycarpa*. Grant Co., Mississippi River bottoms opposite Dubuque, Ia., August 31, 1930. Coll. N. C. Fassett. This corresponds very closely with Atkinson's description, so there seems no doubt that it is the same thing he found on *Ludvigia alternifolia* in Alabama.

CERCOSPORA ISANTHI Ell. & Kell. on *Isanthus brachiatus*. Lafayette Co., Belmont, July 28, 1922. Coll. Huron H. Smith. The round spots are very small, sordid whitish with a raised margin. The conidiophores are rather poorly developed, but the conidia are normal and are from 75–100 × 3–4μ as indicated in the description.

CERCOSPORA PLANTAGINIS Sacc. on *Plantago* sp. Dane Co., Madison, October 1, 1920. Coll. J. J. Davis and class. Referred to this species with doubt at the time of collection and not reported. The determination is confirmed by Professor Chupp, who regards CERCOSPORA PLANTAGINELLA Tehon as a synonym of C. PLANTAGINIS.

CERCOSPORA ASTERATA Atk. on *Aster lucidulus* (*A. puniceus* var. *lucidulus* of Gray's Manual). Waukesha Co., Eagleville, September 14, 1941. In general, this conforms rather closely to the fungus described by Atkinson, although the conidia are slightly longer. Professor Chupp informs me that the type does not have enough fruiting for satisfactory study.

NOTES ON WISCONSIN PARASITIC FUNGI. VI.

H. C. GREENE

The fungi mentioned in this series of notes, unless otherwise specified, were collected in the vicinity of Madison in 1943. Like 1942, 1943 was very favorable for the development of parasites and a considerable number of new and rare species were found.

The rare PHYSODERMA MENYANTHIS DeBary occurred on *Menyanthes trifoliata* near Eagleville in southwestern Waukesha Co. Coll. July 5, 1941. A single earlier collection of this was made by Davis in 1902 in Vilas Co.

PERONOSPORA PARASITICA (Pers.) Fr. was found on *Draba caroliniana* at Madison, May 1. Cheney found this on *D. caroliniana* at Madison in 1895, and Davis and I collected it in Columbia Co., near Prairie du Sac, in 1935. The scarcity of specimens is probably due to the fact that the host flourishes very early and is largely overgrown by other foliage by the time most collectors get into the field.

PERONOSPORA TRIFOLIORUM DeBary was collected in some abundance on *Lupinus perennis* at Hancock, Waushara Co., June 2, by Dr. B. M. Duggar. A single very scanty earlier specimen on this host is from Millston, Jackson Co., taken in 1915 by Davis.

PERONOSPORA HEDEOMAE Kell. & Sw. occurred on *Hedeoma hispida* at Madison, June 15. The only previous station for this on *H. hispida* is Blue River, Grant Co., where Davis and I collected it in 1935.

Tanacetum vulgare was heavily infected with the oidial stage of a powdery mildew. Species of Erysiphe and Sphaerotheca have been reported on this host in Europe. *Aster linariifolius* was similarly infected, presumably by ERYSIPHE CICHORACEARUM DC.

CAPNODIUM sp. has been seen in abundant development on *Pinus strobus* from Stanley, Chippewa Co. Although this is perhaps not a parasite it is probably damaging to the pine, and is said to produce serious effects on the trees bearing it. Whether this is identical with CAPNODIUM PINI B. & C., described on "pine" from Maine is questionable.

As previously noted, PHYLLACHORA BOUTELOUAE Rehm, so far as observed, comes to maturity on *Bouteloua curtipendula* in Wisconsin only after overwintering, and then but sparsely. Leaves of this grass bearing the Phyllachora, from the previous season, were collected and examined April 8. No asci with mature spores were observed. Portions of a number of the leaves were immersed in shallow water in a Petri dish and left at room temperature for 48 hours. Fifteen ascomata from as many leaf segments were then examined and all except one had matured. Ascomata from dry leaves showed no further development. In October leaves of the current season were treated in the same fashion, but none of the uniformly immature ascomata showed any change.

In the fall of 1942 several clumps of *Panicum virgatum* in the University Arboretum were very heavily infected with supposed immature PHYLLACHORA GRAMINIS. The clumps were marked and collections made in the spring of 1943, but no further development had taken place, and material placed in a moist chamber failed to mature.

CRYPTOSPORELLA ANOMALA (Pk.) Sacc. on living shoots of *Corylus americana*, May 21. Reported by Trelease, but there are no interim Wisconsin collections in the herbarium. Concerning this species Ellis and Everhart in "North American Pyrenomycetes", p. 531, state "The pustules appear first on the smaller branches and are seriately arranged along one side of the branch; afterwards they appear also on the larger branches and on the trunk itself, and in the course of two or three years the part of the tree above ground is entirely killed. The roots, however, still retain their vitality and continue to send up each year a luxuriant growth of new shoots destined to be destroyed the succeeding year by the inexorable pest."

ENTYLOMA COMPOSITARUM Farl. occurred on *Senecio aureus*, June 30. It has been found once or twice before in Wisconsin on this host, and on the basis of one of these collections Ciferri (Ann. Mycol. 26: 40, 1928) set up the new species ENTYLOMA WISCONSINENSE which Davis does not consider to be distinct from E. COMPOSITARUM.

Professor R. I. Evans has recently found among the manuscripts of the late L. S. Cheney a packet bearing rusted leaves of *Betula pumila*, collected in July 1906 at Bloomer, Chippewa Co. This is the uredial stage of MELAMPSORIDIUM BETULINUM (Pers.) Kleb., rarely collected in Wisconsin and hitherto represented in the herbarium by but a single specimen from the state.

Although the aecial stage of COLEOSPORIUM SOLIDAGINIS (Schw.) Thüm. is probably not uncommon on *Pinus banksiana* in Wisconsin it has seldom been collected. There are but three satisfactory specimens, all recent, from Dane, Grant, and Adams Cos. The lone collection on *Pinus resinosa* is from Grant Co.

If one may judge by the scarcity of material in the herbarium, the aecial stage of UROMYCES LESPEDEZAE-PROCUMBENTIS (Schw.) Curt. is rarely developed in Wisconsin. This was abundant on *Lespedeza capitata* in the University Arboretum in June. Despite considerable previous collecting experience, over a period of years, in regions where the host is fairly common, I have never before encountered aecia of this rust, although uredia and telia are of course regularly produced.

LIATRIS PYCNOSTACHYA was heavily infected by PUCCINIA LIATRIDIS (Webber) Bethel in the University Arboretum in July. The sole previous station for the rust on this host is near Eagle in Waukesha Co. The source of the infection is a puzzle, for there are no stands of rusted *Koeleria cristata*, the alternate host, anywhere in the vicinity so far as I know.

PUCCINIA HELIANTHI Schw. I has been found on *Helianthus strumosus*, June 14. Trelease in 1885 reported aecia of this rust on *H. strumosus*, but early reports are questionable.

PUCCINIA HIERACII (Schum.) Mart. II, III occurred in profusion on *Agoseris cuspidata*, June 9. Professor N. C. Fassett made a single small earlier collection on this rare host at Pine Bluff, Dane Co.

Davis in 1893 reported UROMYCES SILPHII (Burr.) Arth. I (as AECIDIUM COMPOSITARUM) on *Silphium integrifolium* from Racine. There is, however, no specimen at the University of Wisconsin. This was in great abundance on close plantings of *S. integrifolium* in the University Arboretum in June; also found on the Scuppernong Prairie near Eagle, Waukesha Co. in June.

Ellis and Everhart (Bull. Torr. Bot. Club *24*: 285, 1897) described PHYLLOSTICTA GALLICOLA occurring on insect-produced galls which have been known as "RHYTISMA SOLIDAGINIS". A somewhat similar form has been found at Madison on poorly developed galls on the leaves of *Solidago latifolia* (cult.). The conidia of PH. GALLICOLA were described as being 6–15 × 6–8μ, but those of the fungus on *Solidago latifolia* are 14–21 × 5–7μ. It seems improbable that this is a parasite.

DARLUCA FILUM (Biv.) Cast. occurs on telia of PUCCINIA ELEOCHARIDIS on *Eleocharis acicularis*. In the great majority of cases this parasite occurs on uredia only.

A fungus which is perhaps referable to Ascochyta was found on leaves of *Leonurus cardiaca,* July 13. It is definitely not ASCOCHYTA LEONURI Ell. & Dearn. In this specimen the spots are rather large, angled, blackish brown, one or two to a leaf. The thin-walled pycnidia are about 100–130μ, or somewhat more in diam. The conidia are quite variable with many of the larger ones running 10–12 × 3.5–4μ, with a single median septation. The shorter conidia are mostly about 5–6μ long, and continuous. It may be that they are immature. At any rate the material does not seem sufficiently well-defined to warrant description of a new species without additional confirmatory specimens.

So-called "Davisiella" has been found in PHYLLACHORA BOUTELOUAE Rehm on overwintered leaves of *Bouteloua curtipendula.* The conidia are obscurely 3-septate, almost cylindrical, tapering slightly at each end, mostly about 17–22 × 3μ. For previous discussions of conidial forms associated with Phyllachora see the following, all appearing in the Trans. Wis. Acad. Sci.: Vols. 19(2): 701, 1919; 22: 166 (1926); 30: 7 (1937); 34: 86 (1942); 35: 116 (1943). In addition to PH. BOUTELOUAE, PH. GRAMINIS, PH. LUTEOMACULATA, PH. PUNCTA and PH. VULGATA have been found bearing "Davisiella" in one or another form.

STAGONOSPORA CARICINELLA Brun. collected on *Carex pennsylvanica,* May 6, has spores some of which have as many 6 septations and are 27 × 5μ, while what is supposedly the same species, found on a broad-leaved Carex on May 8, has spores 10–13 × 3–3.5μ, some of which are uniseptate, others continuous. Davis gives a rather extensive discussion of this form in Trans. Acad. Sci. 18(1): 264 (1915).

A fungus which is assigned to STAGONOSPORA LUZULAE (West.) Sacc. was found on dead tips of leaves of *Luzula saltu-*

ensis from Sauk Co. The hyaline conidia are mostly 2-septate, guttulate, straight, 12–15 × 3μ. It is doubtful that this is parasitic.

SEPTORIA BETULAE (Lib.) West. and SEPTORIA BETULICOLA Peck show a tendency to integrade and may not be specifically distinct. A recent collection on *Betula alba* var. *papyrifera* has rather small, angled spots with a ragged, incomplete dark brown border and a light brown center on which the pycnidia are borne. The spots are distinct and sharply defined, with the pycnidia easily visible by transmitted light. The sporules are about 30–40 × 2–2.5μ. This has been filed under S. BETULAE. Davis discussed these forms at some length. (See Trans. Wis. Acad. Sci. 18(1): 102, 1915).

Aconitum novaboracense var. *quasiliatum* Fassett, collected at Parfrey's Glen, Sauk Co., July 30, 1929, bears a Septoria which may be allied to SEPTORIA LYCOCTONI Speg. Unfortunately the areas with the Septoria are overrun with Colletotrichum so that the character of the original spots cannot be determined. The pycnidia are about 100μ diam., or slightly more, and the slender continuous sporules 15–25 × 1μ. There are no previous reports of fungi on this rare host.

SEPTORIA LYTHRINA Peck was found in profuse development on *Lythrum alatum*, July 15. In 1910 Davis reported this from Union Grove, Racine Co., but there is no specimen at the University of Wisconsin.

A clean-cut and well-defined species of Septoria occurred in small quantity on leaves of *Gentiana procera*, Lake Wingra marsh, Madison, September. This is quite unlike S. GENTIANAE Thüm., S. GENTIANOIDES Dearn. & House, or S. MICROSORA Speg. The spots are gray with a distinct light tan border, rounded, 5 mm. diam.; the large black pycnidia are gregarious, strongly erumpent, their position being evident whichever side of the leaf is inspected; pycnidia 250–300μ diam.; sporules hyaline, pluriseptate, slender, about 40–50 × 1.5μ. This has filed temporarily under SEPTORIA sp., for the small size of the specimen precludes its use as a type.

Previous collections of SEPTORIA LINARIAE Greene on *Linaria canadensis* (see Trans. Wis. Acad. Sci. 35: 130, 1943) have been notable for heavy infections of stems as well as leaves, but a gathering made in early June 1943 shows pycnidia only on the tips of the lower leaves. Later specimens, however, show stems infected, so it would appear that the leaves are first attacked. The host is an annual and the presumption is that the infection is seed borne.

SEPTORIA CAMPANULAE (Lev.) Sacc. developed in some quantity on *Campanula aparinoides* in August. A single earlier collection on this host is from Spooner, Washburn Co., made by Davis in 1911.

The report of SEPTORIA DAVISII Sacc. (S. FUMOSA Peck) on *Solidago canadensis* in Davis' "Parasitic Fungi of Wisconsin" is in error as to host which should be *Solidago altissima.* (see Davis, Trans. Wis. Acad. Sci. 24: 281, 1929).

Until recently SEPTORIA COREOPSIDIS J. J. Davis has been represented in the herbarium only by the type specimen collected at Hixton, Jackson Co., in September 1917. This was found at Madison on the same host, August 1943. Here the sporules, which seem well-developed, are from 20–35μ long, instead of 30–50μ as in the type.

Davis reported SEPTORIA KRIGIAE Dearn. & House on the scapes and involucral bracts of *Krigia virginica.* This is one of the earliest of the spring flowering composites of the region and Davis' material taken on June 20, represents but the dried remains of the plant and does not include the basal rosette which had died away. A collection of the same parasite was made May 13 on the green basal leaves at Mazomanie, Dane Co.

A Septoria which appears to belong to the S. LACTUCAE-LACTUCICOLA group has been found in small quantity on leaves of *Agoseris cuspidata.* The pycnidia are small, slightly less than 100μ, the conidia slender, straight, continuous, about 22–25 $\times$ 1.5μ. The identification can be only tentative in the lack of ample material and seeming absence of previous reports of Septoria on Agoseris.

Trelease in his preliminary list of Wisconsin parasitic fungi reported SEPTORIA sp. on leaves of *Silphium integrifolium.* This was later reported by Davis as SEPTORIA SILPHII Ell. & Ev., so I suppose he checked the Trelease specimen, at present in the herbarium of the Missouri Botanical Garden. Davis did not find the fungus on this host, but it occurred in profusion on *S. integrifolium* in June in the University Arboretum. It seems to be without question the same thing Trelease had, judging from his short descriptive notes.

LEPTOSTROMA PINASTRI Desm. (the conidial stage of LOPHODERMIUM PINASTRI (Schrad.) Chev.) appears to be rarely developed on *Pinus resinosa* in Wisconsin. Out of many hundreds of leaves examined, most of them with the perfect stage, I have found but a single one bearing the Leptostroma. There are two specimens on *Pinus banksiana* in the herbarium.

In Notes II (Trans. Wis. Acad. Sci. 34: 98, 1942) in connection with SPORONEMA TRIFOLII n. sp. it was stated "Apparently it usually occurs in association with ASCOCHYTA TRIFOLII or GLOEOSPORIUM TRIFOLII. . . ." As should have been specified, these names are synonyms of STAGONOSPORA RECEDENS (C. Massal.) Jones & Weimer. (see Jour. Agr. Res. 57: 791-812, 1938).

A perplexing form intermediate between Gloeosporium and Colletotrichum, appearing parasitic, has been found on large, deep brown, orbicular spots on leaves of *Pyrola elliptica*. The acervuli are deeply seated in the host tissue, inconspicuous, small, about 60–75μ diam., with pale brown setae which are scarcely longer than the diameter of the acervulus. The conidia are fusoid or short-cylindrical, mostly about $10 \times 4\mu$, and are of a type more commonly associated with Gloeosporium than with Colletotrichum. Some of the acervuli lack setae, but since the conidia are the same it appears that only a single fungus is involved.

Bulblets of *Allium tricoccum* from Ridgeway, Iowa Co., bear acervuli of Colletotrichum on the scales. This does not seem to be COLLETOTRICHUM CIRCINANS, and it is difficult to say whether it is parasitic. There is no admixture of any other of the common saprophytes.

A fungus which is perhaps referable to CYLINDROCEPHALUM Bon. occurs on languishing foliage of *Caulophyllum thalictroides*, collected at Blue Mounds, Iowa Co., August 13, 1938. Microscopically this is not unlike CYLINDROCEPHALUM HYALINUM (Cke. & Harkn.) Sacc. as described, although the conidia are somewhat shorter. Occasional conidiophores are branched. It is likely that this is parasitic, since it causes more or less definite spotting in leaf areas which are still green.

RAMULARIA ARVENSIS Sacc. developed abundantly on *Potentilla canadensis* in June. This fungus is of course extremely common on *Potentilla norvegica* var. *hirsuta*, but is usually not found on *P. canadensis*.

A species of Cladosporium has been collected on living leaves of *Lysimachia terrestris*. There seem to be no reports of Cladosporium on Primulaceae. This fungus is not morphologically distinct from various other species of Cladosporium as described, and it is felt that host relationship alone is insufficient to warrant erection of a new species in this case.

CLADOSPORIUM ASTERICOLA J. J. Davis has been collected on *Solidago speciosa* on one previous occasion. The earlier specimen is on leaf blades only, as is the case with specimens on other hosts. In the recent collection, however, the fungus is principally on the upper stem, forming small, rounded, well-defined patches.

In a previous publication (Trans. Wis. Acad. Sci. 32: 81, 1940) I reported CLADOSPORIUM NERVALE Ell. & Dearn. on EUPHORBIA COROLLATA. It now appears that this was the dubious FUSICLADIUM FASCICULATUM C. & E. (PASSALORA FASCICULATA (C. & E.) Earle). I was misled by the exceptionally long and lax conidiophores in the specimen in question and by definite evidence of catenulation of the conidia. I believe that this organism would be much better placed under Cladosporium, but refrain from any action, since the proper position of the fungus has long been in dispute. Davis reported PASSALORA FASCICULATA on *E. corollata* from Racine in 1903, but there is no specimen collected by him on this host at the University of Wisconsin. I have specimens from Madison and from the vicinity of Lodi, Columbia Co.

The report of CERCOSPORELLA FILIFORMIS J. J. Davis on *Thalictrum dasycarpum* (Trans. Wis. Acad. Sci. 32: 80, 1940) is plainly in error. This is CYLINDROSPORIUM THALICTRI Ell. & Ev. which is probably not a good Cylindrosporium, but perhaps might be referred to CERCOSEPTORIA Petrak.

CERCOSPORA SEQUOIAE var. JUNIPERI Ell. & Ev., so-called, was destructive to plantings of *Juniperus communis* var. *depressa* in the University of Wisconsin Arboretum. Professor Chupp doubts that this is a good Cercospora, and states that in any case it bears so little resemblance to C. SEQUOIAE it can hardly be considered a variety thereof.

So far as I am aware the only hitherto known station for CERCOSPORA FUSIMACULANS Atk. on *Leptoloma cognatum* is Madison where I collected it in 1942. It has been found recently on a specimen of the same host from Muscoda, Grant Co., collected in 1935, but filed away at the time and later overlooked.

The rare CERCOSPORA SANGUINARIAE Peck was found in abundance on *Sanguinaria canadensis* in Baxter's Hollow, Town of Sumpter, Sauk Co., July 10, and also at Ridgeway, Iowa Co., July 24. As Peck states "Owing to the scattered mode of growth of the flocci the fungus is scarcely visible, but the large smoky-brown spots are very conspicuous." One scanty earlier collection of this was made at Phlox, Langlade Co., in 1914.

CERCOSPORA LYTHRI (West.) Niessl developed quite generally on *Lythrum alatum* at Madison. This is an exceedingly inconspicuous fungus, but its presence is detectable by the pronounced reddening of the host leaves. This species is perhaps more common than would be indicated by the two collections in the herbarium. (Davis took a specimen at Racine in August 1900).

ADDITIONAL HOSTS

The fungi mentioned in the following list have been previously reported as occurring in Wisconsin, but not on the particular hosts cited here.

ALBUGO CANDIDA (Pers.) O. Ktze. on *Lepidium campestre.* June 7. The weedy host has become widespread in southern Wisconsin.

BREMIA LACTUCAE Regel on *Lactuca ludoviciana.* August 29.

MICROSPHAERA ALNI (Wallr.) Wint. on *Betula sandbergii.* September 10.

ERYSIPHE POLYGONI DC. on *Delphinium cultorum.* October 12. University Horticultural Gardens.

ERYSIPHE CICHORACEARUM DC. on *Galium aparine.* July 7. In this material the perithecia are very large, approaching the upper size limits for the species. Davis (Trans. Wis. Acad. Sci. 18(1): 252, 1915) mentions that at one time at Racine there occurred a destructive outbreak of Erysiphe on this host. He states "On examination from time to time no spores were found in the asci and no specimens were preserved for that reason as I did not know at that time that they were not formed during the season. . . ." However that may be, in the present material the characteristic spores and asci are well developed. A massive growth of the host was completely covered by the mildew, perithecia being developed even on the fruits.

The fungus known as SPHAERIA SOLIDAGINIS Schw. (of questionable status) listed by Davis as occurring on *Solidago altissima* in Wisconsin is also found on *Solidago serotina.* October 12, 1942.

HYPOMYCES LACTIFLUORUM (Schw.) Tul. on *Cantharellus* sp. July 18. This seems not to have been reported before on Cantharellus in these lists, although it is not rare. Specific identification of the host cannot be made because of the distortion caused by the systemic infection.

EOCRONARTIUM MUSCICOLA (Pers. ex Fr.) Fitzp. on *Homomallium adnatum* (*Amblystegiella adnata*). Sauk Co., Parfrey's Glen, July 10. Coll. Prof. G. S. Bryan. Host det. by Prof. R. I. Evans.

COLEOSPORIUM TEREBINTHINACEAE (Schw.) Arth. II, III on *Silphium terebinthinaceum.* On seedling leaves. October 6. Davis collected this on *Silphium perfoliatum* at Lancaster, Grant Co., suggesting that the fungus was probably not a permanent member of the Wisconsin flora. The present collection, however, seems to offer evidence for the affirmative.

UROPYXIS AMORPHAE (Curt.) Schroet. I on *Amorpha fruticosa.* Sauk Co., Town of Prairie du Sac. Two collections made by Davis in 1931 and 1932 bear the uredinoid aecia, clustered and in close association with the pycnia. Uredia and telia only have hitherto been reported for Wisconsin. Davis undoubtedly saw the pycnia, but holding to the older usage, regarded the associated structures as uredia rather than aecia. The change is made to conform with Arthur's manual of the rusts, the accepted standard of present-day workers in this region. Determination confirmed by Dr. Cummins.

PUCCINIA GRAMINIS Pers. III on *Koeleria cristata.* Bayfield Co., Iron River, September 16, 1937. Coll. N. C. Fassett (No. 19119) This appears to be an eastward extension of the range insofar as this host is concerned. Determination confirmed by Dr. Cummins.

PUCCINIA EXTENSICOLA Plowr. I on *Aster paniculatus* var. *simplex* (*Aster tradescanti*), June 14.

PUCCINIA HELIANTHI Schw. I on *Helianthus grosseserratus.* June 18.; on *Helianthus giganteus,* June 19.

GYMNOSPORANGIUM GLOBOSUM Farl. I on *Crataegus mollis.*

September 6; on *Crataegus monogyna* (*C. oxyacantha*). September 15. Seemingly rarely developed on the latter host.

PHYLLOSTICTA TRILLII Ell. & Ev. on *Trillium declinatum.* Dane Co., Mt. Vernon, July 5, 1938. This is referred here with doubt. Davis reported this on *Trillium cernuum* and I have listed it on *T. grandiflorum.* Careful microscopic comparison of all three collections indicates that this fungus might perhaps better be assigned to Gloeosporium, although it is surely not GL. TRILLI Ell. & Ev. On the other hand, the leaves of Trillium are very thin, which might account for the imperfect development of the pycnidia.

PHYLLOSTICTA MINUTISSIMA Ell. & Ev. on *Acer/rubrum.* September 14. Probably merely the precursor of a perfect stage with the tiny "conidia" non-germinable.

PHYLLOSTICTA DESMODII Ell. & Ev. on *Desmodium canadense.* August 19.

PHYLLOSTICTA LIATRIDIS J. J. Davis on *Liatris spheroidea* f. *benkei.* Waukesha Co., Eagleville, August 8. The lesions here are very similar to those of the type specimen on *Liatris spicata,* but the spores are somewhat smaller and verging on the ellipsoidal.

PHYLLOSTICTA LABRUSCAE Thüm. on *Parthenocissus tricuspidata* (cult.). July 25.

PHYLLOSTICTA NEBULOSA Sacc. on *Silene latifolia.* July 8; on *Silene dichotoma.* July 13.

ASCOCHYTA PISI Lib. on leaves of *Lupinus perennis.* June 7. The spores here are of about the size specified by Sprague (Phytopath. 19: 927, 1929) for this fungus as it appears on *Pisum sativum* and varieties, i. e., usually rather narrow and with the mean spore length less than 13.5μ.

STAGONOSPORA ATRIPLICIS (West.) Lind. on *Atriplex patula* var. *littoralis.* Dane Co., Black Earth, August 11, 1941. Coll. M. P. Backus.

STAGONOSPORA APOCYNI (Peck) Davis on *Apocynum cannabinum.* August 5. This was excellent material and developed in quantity. Judging by his remarks, Davis seems at one time to have had an unsatisfactory specimen on *A. cannabinum,* but there is no collection of his in the herbarium.

SEPTORIA POPULI Desm. occurred as a disfiguring and defoliating leaf blight on a large array of poplar hybrids in a nursery in the University Arboretum. The infection was so severe as bring into serious question the desirability of these trees as subjects for ornatmental plantings. Some of the hybrids affected were as follows (the names are those employed by the nurserymen and are certainly in some cases botanically incorrect.): *Populus berolinensis* × *angulata*, *P. charkowiensis* × *caudina*, *P. charkowiensis* × *trichocarpa*, *P. maximowiczii* × *berolinensis*, *P. maximowiczii* × *plantierensis*, *P. maximowiczii* × *trichocarpa*, *P. nigra* × *laurifolia*, *P. nigra* × *trichocarpa*, *P. nigra betulifolia* × *trichocarpa*, *P. petrowskyana* × *caudina*, *P. rasumoskyana* × *caudina*, *P. sargentii* × *berolinensis rossica*, and *P. tacamahacca candicans* × *berolinensis*.

SEPTORIA VIOLAE West. on *Viola sagittata*. July 4. The sporules are small, 16–20 × 1μ, the dimensions given by Diedicke in the Kryptogamenflora der Mark Brandenburg.

SEPTORIA POLYGONORUM Desm. on *Polygonum persicaria*. July 29. Also found on a phanerogamic specimen of this host collected by Prof. N. C. Fassett at St. Croix Falls, Polk Co., September 3, 1927.

SEPTORIA MELANDRII Pass. on *Lychnis flos-cuculi*. Sheboygan Co., Sheboygan, June 1903. On a phanerogamic specimen collected by the late Chas. Goessl; on *Silene dichotoma*, Madison, July 13. Although this species seems not to have been reported on Silene, it corresponds well with S. MELANDRII as it appears on *Lychnis alba*. The sporules are up to 65μ long.

SEPTORIA SCUTELLARIAE Thüm. on *Scutellaria parvula* var. *ambigua*. June 17. This seems not to have been reported before on this host from Wisconsin or elsewhere.

SEPTORIA LYSIMACHIAE West. on *Lysimachia terrestris*. August 24. Apparently the first report of Septoria on this host.

SEPTORIA SONCHIFOLIA Cke. on *Sonchus arvensis*. July 13. Also found on a phanerogamic specimen of the same host collected at Appleton, Outagamie Co., in 1928.

LEPTOTHYRIUM PUNCTIFORME B. & C. on *Erigeron ramosus*. June 9.

MARSONIA FRAXINI Ell. & Davis on *Fraxinus americana*. August 5. The large uniseptate conidia are here borne in definite acervuli. Typical conidia measure 35–40 × 5–6μ.

COLLETOTRICHUM SOLITARIUM Ell. & Barth. on *Solidago juncea.* August 16.

CYLINDROSPORIUM BETULAE J. J. Davis on *Betula sandbergii.* July 30. Most of the specimens in the herbarium appear to be on the hybrid rather than on *B. pumila* as labelled.

CYLINDROSPORIUM ARTEMISIAE Dearn & Barth. on *Artemisia ludoviciana.* June 12.

RAMULARIA VIRGAUREAE Thüm. on *Aster ptarmicoides.* September 1. Many of the conidia in this specimen are of the Cercosporella type, up to 100μ long. It is possible that a scanty earlier collection on *A. ptarmicoides* from Eagleville, Waukesha Co., which was referred to RAMULARIA ASTERIS (Phil. & Plowr.) Bubak, should have been placed under R. VIRGAUREAE.

RAMULARIA TARAXACI Karst. on *Taraxacum erythrospermum.* May 26.

SCOLECOTRICHUM GRAMINIS Fckl. on *Muhlenbergia racemosa.* August 24.

HELMINTHOSPORIUM SATIVUM Pamm., King & Bakke on *Agropyron repens.* May 24. Professor J. L. Allison of the Department of Plant Pathology at the University of Wisconsin informs me that he has collected H. SATIVUM on quack grass on several occasions.

CERCOSPORELLA CANA Sacc. on *Erigeron philadelphicus.* July 4.

CERCOSPORA MUHLENBERGIAE Atk. on *Muhlenbergia racemosa.* August 14.

CERCOSPORA POLYGONACEA Ell. & Ev. on *Polygonum convolvulus.* July 1. Determination confirmed by Prof. Chupp.

CERCOSPORA VIOLAE Sacc. on *Viola sagittata.* July 4. Determined by Prof. Chupp.

CERCOSPORA PARVIMACULANS J. J. Davis on *Solidago altissima.* August 24.

CERCOSPORA BIDENTIS Tharp on *Bidens coronata.* September 10. The first report of Cercospora on this host. Determination confirmed by Prof. Chupp.

ADDITIONAL SPECIES

The species listed below have not previously been reported to occur in Wisconsin.

SYNCHYTRIUM HOLWAYI Farl. on *Monarda fistulosa.* A small collection made on June 29, but found in abundance in the same vicinity July 27. This species has resting sporangia much smaller than those of SYNCHYTRIUM AUREUM.

According to Professor Mix (Mycologia *30*: 570-5, 1938) the report of TAPHRINA FILICINA Rostr. on *Cystopteris fragilis* in Wisconsin is erroneous and the fungus should be referred to TAPHRINA CYSTOPTERIDIS Mix n. sp.

SCLEROTINA LAXA Aderh. & Ruhl. (Monilia stage) has been found on sour cherry (*Prunus cerasus*) in Door Co. Coll. J. D. Moore, June 1, 1942. Det. G. W. Keitt.

NAEMACYCLUS NIVEUS (Pers. ex Fr.) Sacc. on *Pinus sylvestris* (cult.). May 1. On fallen needles. Det. Dr. G. D. Darker. Clements and Shear place this interesting fungus in the family Stictidaceae of the Phacidiales. It is differentiated from similar forms in the Hysteriaceae by color and consistency and by the disk being widely exposed at maturity. This organism causes a typical needle casting of pines, and Darker in his "Hypodermataceae of Conifers" states that the disease is of sufficient importance to warrant careful investigation.

DOASSANSIA OCCULTA (Hoffm.) Cornu on *Potamogeton gramineus* var. *graminifolius.* Douglas Co., Town of Lake Nebagamon, Sect. 1, T46N, R11W, August 22. Coll. N. C. Fassett. Host det. by Prof. Fassett.

PUCCINIA VIRGATA Ell. & Ev. II, III on *Sorghastrum nutans.* October 2. Profuse development of uredia was observed as early as the last week in August.

PHYLLOSTICTA HISPIDA Ell. & Dearn. on *Smilax hispida.* Dane Co., near Sauk City, October 15, 1935. Coll. Davis & Greene. The conidia are very small, of the bacillary type, 5–6 $\times$ 1μ. The material was overwintered but failed to develop further. This is plainly the same thing which was issued under this name as No. 3541 in North American Fungi.

PHYLLOSTICTA VIOLAE Desm. on *Viola* sp. (probably *V. pubescens*). July 19. In this specimen the conidia are about 10–13 $\times$ 3.5–4.5μ. Davis in his "Parasitic Fungi of Wisconsin", p. 67, states "PHYLLOSTICTA VIOLAE Desm. was included in the Provisional List, but I find no Wisconsin specimen." The species is therefore entered here as new to the state.

PHYLLOSTICTA ROSAE Desm. on *Rosa* sp. September 2. Probably not uncommon, but apparently hitherto unreported.

PHYLLOSTICTA MONARDAE Ell. & Barth. on *Monarda fistulosa.* August 19. Referred here with some doubt. The spots are conspicuous, with a small rounded light gray center, about 1 mm. diam., and a wide much darker border, the whole producing a suborbicular spot 3–5 mm. diam. The spores are of the dimensions specified in the original description. A Phyllostica found on *Blephilia ciliata,* June 25, is likewise assigned to PH. MONARDAE. The conidia are small 4–6 × 1.5μ, and the pycnidia, which are about 100μ diam., are borne on very small, arid, purple-bordered spots. The spots are of the type so frequently seen on *Monarda fistulosa* which have been, in my experience, consistently sterile.

PHYLLOSTICTA SICCATA n. sp.

Spots white, arid, suborbicular, sunken, with raised border, 1–2 mm. diam.; pycnidia epiphyllous, gregarious, subglobose, olivaceous, thin-walled, ostiolate, 75–125μ diam.; conidia hyaline, ellipsoid, 4–5 × 3–3.5μ.

On leaves of *Solidago serotina.* Madison, Wis., U. S. A., July 14, 1943.

PHYLLOSTICTA SICCATA sp. nov.

Maculis albidis, aridis, suborbicularibus, depressis, cum marginibus elevatis, 1–2 mm. diam.; pycnidiis epiphyllis, gregariis, subglobosis, olivaceis, muris tenuibus, ostiolatis, 75–125μ diam.; conidiis hyalinis, ellipticis, 4–5 × 3–3.5μ.

In foliis *Solidaginis serotinae.* Madison, Wis., U. S. A.

SCLEROPHOMA PITHYOPHILA (Cda.) v. Hoehn. occurs commonly on fallen needles of various pines (e. g., *Pinus banksiana, P. resinosa, P. strobus* and *P. sylvestris* in Wisconsin). While this fungus is probably normally a saprophyte it appears that it may occasionally function as a weak parasite. Many small trees of *Pinus strobus* in a plantation in the University Arboretum show foliage with the individual needles brown and dead to about halfway back from the tip, but still green at the base. The brown portions are thickly beset with the erumpent pycnidia of S. PITHYOPHILA. It is possible that insects are primarily responsible for the discoloration, but not impossible that the fungus may also be involved. In addition to the above-mentioned pines, a scanty collection was made on languishing foliage of

P. ponderosa (cult.), and it is of interest that a fungus which is morphologically identical with S. PITHYOPHILA occurred on dead twigs of *Larix laricina.*

SELENOPHOMA DONACIS (Pass.) Sprague & Johnson on *Panicum virgatum.* Columbia Co., Lodi, June 30, 1938; Dane Co., Madison, August 1942 and 1943. This is what was formerly called SEPTORIA DONACIS Pass. f. PANICI Ell. & Barth. In a personal communication Dr. Sprague states "These things have no business being in Septoria. They have falcate spores, are nonseptate, have characteristically smallish globular pycnidia with coarse polygonal cell structure, stout cuspidate pycnophores, and produce a characteristic scurfy growth on media." According to Dr. Sprague this species is common in the prairie country, but there seem to be no previous reports for Wisconsin.

SEPTORIA MITELLAE Ell. & Ev. on *Mitella diphylla.* On green, overwintered leaves (basal). Vernon Co., Westby, May 9.

SEPTORIA WISCONSINA n. sp.

Spots none; tips of leaflets pale brown; pycnidia almost concolorous, gregarious, deeply imbedded, amphigenous, globose, small 50–75μ diam.; ostioles wide, thickened rings of tissue, prominent, 20–30μ diam.; conidia acicular, slightly curved, continuous or more or less distinctly septate, 12–25 $\times$ 1.5μ.

On leaves of *Astragalus canadensis.* Madison, Dane Co., Wis., U. S. A., July 28, 1943.

SEPTORIA WISCONSINA sp. nov.

Maculis nullis, foliis pallidis brunneis apici, pycnidiis prope concoloribus, gregariis, immersis, amphigenis, globosis, parvis, 50–75μ diam.; ostiolis latis, crassis annulis, prominentibus, 20–30μ diam.; conidiis acicularibus, leviter curvatis, continuis vel plusve minusve distincte septatis, 12–25 $\times$ 1.5μ.

In foliis *Astragali canadensis.* Madison, Wis., U. S. A.

This is different from other species described on Astragalus, none of which have conidia as short and slender as those of S. WISCONSINA.

SEPTORIA EUPATORII Rob. & Desm. on *Eupatorium perfoliatum.* July 20. There seems to be no previous record of this fungus on *E. perfoliatum.*

Dr. Berch Henry of the Department of Plant Pathology at the University of Wisconsin has given to the herbarium a specimen of needles of *Pinus nigra* var. *austriaca* bearing a parasite that he identifies as LECANOSTICTA ACICOLA (Thüm.) Syd. (SEPTORIA ACICOLA (Thum.) Sacc.). This was the cause of so-called brown spot disease of Austrian pine in a nursery at Waterloo, Jefferson Co., June 1943. Wolf and Barbour (Phytopath. 31: 61-74, 1941) have published on this disease.

PROTOCORONOSPORA NIGRICANS Atk. & Edg. on *Vicia villosa.* September 4.

GLOEOSPORIUM LEPTOTHYROIDES Kab. & Bub. on *Betula sandbergii.* July 30. This corresponds well with the description and with No. 429 of the Fungi imperfecti exsiccati issued by Kabat and Bubak.

HELMINTHOSPORIUM LEUCOSTYLUM Drechsler on *Eleusine indica.* August 14. Dr. C. L. Lefebvre suggests that this is very similar to HELMINTHOSPORIUM HADROTRICHOIDES Ell. & Ev. on *Eragrostis cilianensis.*

HELMINTHOSPORIUM INCONSPICUUM C. & E. var. BUCHLOES Ell. & Ev. was found in July on *Buchloe dactyloides* (cult.), *Bouteloua hirsuta,* and *Bouteloua curtipendula.* The specimen on Buchloe was collected by Prof. J. L. Allison. Dr. Sprague informs me that this is common on buffalo grass on the great plains, and also occurs on grama grass.

HELMINTHOSPORIUM LEUCOSTYLUM Drechsler on *Eleusine inlianensis.* September 16. Determined by Dr. Lefebvre.

A rather perplexing fungus has been found on leaves of *Cerastium vulgatum.* This is a very delicate form, being scarcely discernible with a good hand lens. It is close to Cercospora, so material was submitted to Professor Chupp. He considers that because of the extremely slender non-tapering conidia it is not a good Cercospora. The conidiophores are rudimentary and very short. Petrak (Ann. Myc. *23*: 68-70, 1925) sets out the new genus Cercoseptoria from the Cercospora-Cercosporella complex, and the fungus in question seems to fall under that genus as defined. No similar form appears to have been described on Cerastium or related genera, so the fungus is described as CERCOSEPTORIA CERASTII n. sp.

CERCOSEPTORIA CERASTII n. sp.

Spots none; fruiting amphigenous, mostly hypophyllous; tubercles intrastomatal, brown, 35–40μ diam.; conidiophores narraw, very short, almost obsolete, 5–10μ long; conidia hyaline, slender, filiform, continuous, slightly curved, 35–70 $\times$ 1μ.

On leaves of *Cerastium vulgatum*. Madison, Wis., U. S. A., July 1, 1943.

CERCOSEPTORIA CERASTII sp. nov.

Maculis nullis; fructificationibus amphigenis, plerumque hypophyllis; tuberculis in stomatis, brunneis, 35–40μ diam.; conidiophoris angustis, brevissimis, prope obsoletis, 5–10μ longis; conidiis hyalinis, angustis, filiformibus, continuis, leviter curvatis, 35–70 $\times$ 1μ.

In foliis *Cerastii vulgati*. Madison, Wis., U. S. A.

CERCOSPORELLA ONTARIENSIS Sacc. on *Euthamia graminifolia*. June 25. This has been compared with Fungi Columbiani No. 4710, issued as C. ONTARIENSIS, and seems to be the same thing. For convenience' sake I have thus listed the Wisconsin specimen, although to me it seems doubtful that it is a species distinct from the inter-grading assemblage of Ovularia-Ramularia-Cercosporella-like fungi that occur on various solidaginicolous hosts. Davis would perhaps have referred this to RAMULARIA VIRGAUREAE Thüm.

CERCOSPORA SEMINALIS Ell. & Ev. on *Buchloe dactyloides* (cult.). Coll. & det. by Prof. J. L. Allison. It seems probable that the parasite was imported with the host.

Cercospora cannabis (Hara) Chupp n. comb. (Syn. *Cercosporina cannabis* Hara). On Cannabis sativa Professor Chupp states that the only other specimen of this species reported from the United States was sent to him from Missouri. Madison, August 13.

CERCOSPORA ACETOSELLAE Ell. on *Rumex acetosella*. August 20. Determination confirmed by Professor Chupp.

CERCOSPORA THLASPIAE Chupp & Greene n. sp.

On silicles, spots minute to large, dark olivaceous to almost black, covered with minute black pustules; stromata small, dark olivaceous brown; fascicles 2–12 spreading stalks; conidiophores pale to medium in color and width, tips narrow and paler, indistinctly multiseptate, straight to mildly curved, not branched, rarely geniculate, subtruncate tip, 4–5.5 $\times$ 50–400μ; conidia hyaline, acicular, straight to curved, indistinctly multiseptate, base truncate, tipe acute to subacute, 2–4 $\times$ 40–300μ.

On silicles of *Thlaspi arvense*. Dane Co., near Sauk City, Wis., U. S. A., July 10, 1943.

CERCOSPORA THLASPIAE sp. nov.

In fructibus, maculis minutis vel magnis, fuscis-olivaceis vel prope nigris, cum nigris pustlis minutis; stromatis parvis, fuscis olivaceo- brunneis; fasciis 2–12 cauliculis divergentibus; conidiophoris pallidis vel mediis brunneis, latitudinibus mediis, apicibus pallidis, angustioribus, indistincte multiseptatis, rectis vel leviter curvatis, non ramosis, raro geniculatis, apicibus subtruncatis, 4–5.5 × 50–400μ; conidiis hyalinis, acicularibus, rectis vel curvatis, indistincte multiseptatis, basibus truncatis, apicibus acutis vel subacutis, 2–4 × 40–300μ.

In fructibus *Thlaspi arvensis.* Dane Co., Wis., U. S. A.

CERCOSPORA URAMENSIS Chupp & Müller on *Cleome spinosa* (cult.). University of Wisconsin campus, August 30. Professor Chupp states that he had previously seen this only on *Cleome* sp. from the type locality in Venezuela. Some of the conidia in the Madison specimen are considerably longer than the upper limit of 125μ set forth in the description. (Bol. Soc. Venez. Cien. Nat. 8 (52) : 58, 1942).

CERCOSPORA POTENTILLAE Chupp & Greene n. sp.

Spots subcircular, 0.5–3 mm. diam., brown center, wide dark red border; fruiting chiefly epiphyllous; stromata mostly a few large brown cells; fascicles 2–10 diverging stalks; conidiophores pale olivaceous brown, fairly uniform in color, somewhat irregular in width, multiseptate, not branched, not or only once geniculate, slightly curved or bent, subtruncate tip, 4–5.5 × 40–170μ; conidia hyaline, acicular, straight to curved, indistinctly multiseptate, base truncate, tip acute, 2–4 × 40–160μ.

On leaves of *Potentilla recta.* Madison, Wis., U. S. A., July 7, 1943.

CERCOSPORA POTENTILLAE sp. nov.

Maculis subrotundatis, 0.5–3 mm. diam., centris brunneis, marginibus latis, fuscis rubris; fructificationibus plerumque epiphyllis; stromatibus paucis magnis cellis brunneis; fasciis 2–10 cauliculis divergentibus; conidiophoris pallidis olivaceis brunneis, coloribus plerumque uniformibus, latitudinibus nonnihil irregularibus; multiseptatis, non ramosis, non vel 1-geniculatis, leviter curvatis vel sinuosis, apicibus subtruncatis, 4–5.5 × 40–170μ; conidiis hyalinis, acicularibus, rectis vel curvatis, indistincte multiseptatis, basibus truncatis, apicibus acutis, 2–4 × 40–160μ.

In foliis *Potentillae rectae*. Madison, Wis., U.S.A.

CERCOSPORA POTENTILLAE has also been found on *Potentilla norvegica* var. *hirsuta* at Madison, August 1943.

CERCOSPORA ASTRAGALI Woronichin on *Astragalus canadensis*. July 20. Determined by Professor Chupp who states that he believes this is the first report of this species other than the type.

CERCOSPORA DESMODIICOLA Atk. on *Desmodium canadense*. September 8. Determined by Professor Chupp.

In my third series of notes there was mention of a species of Cercospora on *Oxalis stricta* which Professor Chupp identified as C. OXALIDIPHILA Speg. ined. A description of this by Chupp & Müller has appeared (Bol. Soc. Venez. Cien. Nat. 8 (52) : 52, 1942) so the species is here included among fungi new to the state.

CERCOSPORA GRISEA Cke. & Ell. on *Polygala sanguinea*. September 7.

CERCOSPORA VULPINAE Ell. & Kell. on *Vitis vulpina*. August 16. Determined by Professor Chupp who finds the specimen to be not quite mature.

CERCOSPORA LECHEAE Chupp & Greene n. sp.

Spots minute, reddish, turning yellowish to pale or brownish; fruiting chiefly hypophyllous, stromata a few brown cells filling the stomatal opening; fascicles 2–12 spreading stalks; conidiophores pale to medium brown, fairly uniform in color and width, indistinctly 0–3 septate, rarely branched, slightly curved, undulate or tortuous, not geniculate, conic tip, $3–5.5 \times 15–80\mu$; conidia very pale olivaceous, obclavate, shortest ones cylindric, straight to mildly curved, indistinctly 1–5 septate, base obconically truncate, tip subobtuse, $2.5–5 \times 15–70\mu$.

On leaves of *Lechea intermedia*. Madison, Wis., U. S. A., September 8, 1943.

CERCOSPORA LECHEAE sp. nov.

Maculis minutis, rufulis, mutantibus ochraceis vel brunneolis; fructificationibus plerumque hypophyllis; stromatibus paucis brunneis cellis, replentibus stomatis; fasciis 2–12 cauliculis divergentibus; conidiophoris pallidis mediisve brunneis, coloribus et latitudinibus prope uniformibus, indistincte 0–3 septatis, raro ramosis, leviter curvatis, undulatis vel tortis, non geniculatis, apicibus conicis, 3–5.5 × 15–80μ; conidiis pallidissimis olivaceis, obclavatis vel cylindraceis si brevissimis; rectis vel leviter curvatis, indistincte 1–5 septatis, basibus obconicis truncatis, subobtusatis, 2.5–5 × 15–70μ.

In foliis *Lecheae intermediae*. Madison, Wis., U. S. A.

The two other species on the Cistaceae, C. HELIANTHEMI and C. CISTINEARUM, have hyaline conidia.

CERCOSPORA APII Fres. on *Apium graveolens* (cult.) August 26, 1941. Coll. R. E. Vaughn. This species seems not to have been reported before in these notes, nor is there any other specimen from Wisconsin in the herbarium.

There is in the Davis Herbarium at the University of Wisconsin a specimen on *Zizia cordata* from which, presumably, Ellis and Everhart described CYLINDROSPORIUM ZIZIAE. I had occasion to examine this and failed to find any Cylindrosporium, but did find a well-marked Cercospora. This was submitted to Professor Chupp in the belief that it might be CERCOSPORA PLATYSPORA Ell. & Holw. However, he finds it to be a new species, and it is therefore described as CERCOSPORA CORDATAE Chupp & Greene. (It would seem that the name CYLINDROSPORIUM ZIZIAE is highly dubious at best and should in all probability be dropped. No. 429 of the Fungi Dakotenses, issued as CYLINDROSPORIUM ZIZIAE, appears (so far as the specimen at Wisconsin is concerned at any rate) to be good CERCOSPORA ZIZIAE Ell. & Ev. which is even farther removed from Cylindrosporium.)

CERCOSPORA CORDATAE n. sp.

Spots angular to elongate, 1–2 × 2–5 mm., brown; fruiting chiefly hypophyllous; stromata a few hyaline to brown cells below stomatal openings; fascicles dense, compact, filling stomatal opening; conidiophores subhyaline to pale brown, tip frequently hyaline, irregular in width, not or rarely septate, not branched, rarely geniculate, bluntly rounded tip with large spore scar, sometimes several spore scars near tip, 4–7 × 10–35μ; conidia hyaline, cylindric, 0–3 septate, base subtruncate, tip obtuse, 4–6 × 15–65μ, straight to mildly curved.

On leaves of *Zizia cordata*. Coll. J. J. Davis, Racine, Wis. U. S. A., June 22, 1890.

CERCOSPORA CORDATAE sp. nov.

Maculis angulosis vel elongatis, 1–2 × 2–5 mm., brunneis; fructificationibus maxime hypophyllis; stromatibus paucis cellis hyalinis vel brunneis infra stomatis; fasciis densis, solidis, replentibus stomatis; conidiophoris subhyalinis vel brunneis pallidis, apicibus frequenter hyalinis, latitudinibus irregularibus, plerumque non-septatis, non ramosis, raro geniculatis, apicibus obtusatis, rotundatis, cum sporis cicatricibus magnis, interdum paucis cicatricibus ad apices, 4–7 × 10–35μ; conidiis hyalinis, cylindraceis, 0–3 septatis, basibus subtruncatis, apicibus obtusatis, 4–6 × 15–65μ, rectis vel leviter curvatis.

In foliis *Ziziae cordatae*. Racine, Wis., U. S. A.

CERCOSPORA ELAEOCHROMA Sacc. on *Asclepias amplexicaulis*. July 18. Determined by Professor Chupp.

CERCOSPORA VERBENICOLA Ell. & Ev. on *Verbena stricta*. August 16. Professor Chupp informs me that CERCOSPORA VERBENAE-STRICTAE Peck is a synonym for C. VERBENICOLA. There are several earlier specimens in the herbarium, listed as C. VERBENAE-STRICTAE.

CERCOSPORA BLEPHILIAE Chupp & Greene n. sp.

Spots subcircular, 2–6 mm. diam., brown or rarely with almost gray center; fruiting chiefly epiphyllous; stromata none or a few brown cells; fascicles 2–15 spreading stalks; conidiophores pale to medium olivaceous brown, almost hyaline apex, uniform in width, multiseptate, not branched, 0–2 geniculate, tip subtruncate, 4–5 × 30–150μ; conidia hyaline, acicular, occasionally cylindric when short, indistinctly multiseptate, straight to mildly curved, base truncate, tip subacute, 2–4.5 × 30–200μ.

On leaves of *Blephilia ciliata*. Scuppernong Prairie, 2 miles northwest of Eagle, Waukesha Co., Wis., U. S. A., August 8, 1943.

CERCOSPORA BLEPHILIAE sp. nov.

Maculis subrotundatis, 2-6 mm. diam., brunneis vel raro cum centris prope griseis; fructificationibus plerumque epiphyllis; stromatibus nullis vel paucis brunneis cellis; fasciis 2–15 cauliculis divergentibus; conidiophoris palladis vel mediis olivaceo-brunneis, apicibus prope hyalinis, latitudinibus uniformibus, multiseptatis, non ramosis, 0–2 geniculatis, apicibus subtruncatis, 4–5 × 30–150μ; conidiis hyalinis, acicularibus, nonnumquam cylindraceis si brevis, indistincte multiseptatis, rectis vel leviter curvatis basibus truncatis, apicibus subacutis, 2–4.5 × 30–200μ.

In foliis *Blephiliae ciliatae*. Eagle, Waukesha Co., Wis., U. S. A.

CERCOSPORA LOBELIAE Ell. & Ev. on *Lobelia spicata.* August 16.

CERCOSPORA SOLIDAGINIS Chupp & Greene n. sp.

Spots none, fruiting effuse, olivaceous, in numerous minute patches 0.5–2 mm. diam., stromata lacking; nonfasciculate to dense compact fascicles; conidiophores medium to dark brown, uniform in color, somewhat irregular in width, 0–7 septate, when nonfasciculate arising as branches from procumbent threads, rarely geniculate, variously curved or bent, tip conic to blunt, 3–5.5 × 10–50μ; conidia pale or very pale olivaceous, longest ones obclavate-cylindric, shorter ones distinctly cylindric, straight or mildly curved, ends rounded bluntly or base short obconically truncate, 1–7 septate, 2.5–5 × 15–50μ.

On leaves of *Solidago juncea.* Madison, Wis., U. S. A., August 18, 1943.

CERCOSPORA SOLIDAGINIS sp. nov.

Maculis nullis; fructificationibus effusis, olivaceis, amphigenis, in numerosis minutis acervis, 0.5–2 mm. diam.; stromatibus nullis; nonfasciculatis vel fasciculatis, fasciis nonnumquam densis; conidiophoris mediis vel fuscis brunneis, coloribus uniformibus, latitudinibus nonnihil irregularibus, 0–7 septatis, si nonfasciculatis ramis ab hyphis procumbentibus, raro geniculatis, varie curvatis vel sinuosis, apicibus conicis vel obtusatis, 3–5.5 × 10–50μ; conidiis pallidis vel pallidissimis olivaceis, si longioribus obclavatis-cylndraceis, si brevioribus distincte cylindraceis, rectis vel leviter curvatis, basibus obtusatis vel brevis obconicis truncatis, 1–7 septatis, 2.5–5 × 15–50μ.

In foliis *Solidaginis junceae.* Madison, Wis., U. S. A.

CERCOSPORA WISCONSINENSIS Chupp & Greene n. sp.

Spots pale brown or whitish with narrow dark purple border, rounded or angled, 1.5–5 mm. diam.; fruiting amphigenous, fascicles mostly not dense; conidiophores pale, tips paler and narrower, not branched, undulate to geniculate above, medium spore scar, tip subtruncate, 0–6 septate, variable, 3.5–5 × 15–180μ, longest when hypophyllous; conidia hyaline, acicular, 2–4 × 40–125μ; longer conidia continuous or indistinctly septate; shortest conidia narrow-obclavate, distinctly 4–5 septate.

On leaves of *Prenanthes alba.* Madison, Wis., U. S. A., September 9, 1943.

CERCOSPORA WISCONSINENSIS sp. nov.

Maculis pallidis brunneis vel albentibus, marginibus angustis fuscis purpureis, rotundatis vel angulosis, 1.5–5 mm. diam.; fructificationibus amphigenis; fasciis plerumque non densis; conidiophoris pallidis, apicibus pallidioribus et angustioribus, non ramosis, supra undulatis vel geniculatis, sporis cicatricibus mediis, apicibus subtruncatis, 0–6 septatis, variis, $3.5–5 \times 15–180\mu$, si hypophyllis longissimis; conidiis hyalinis, acicularibus, $2–4 \times 40–125\mu$; conidiis longioribus continuis vel indistincte septatis; conidiis brevissimis angustis-obclavatis, distincte 4–5 septatis.

In foliis *Prenanthis albae*. Madison, Wis., U. S. A.

An earlier collection of this species was made at Eagleville, Waukesha Co., August 31, 1941, but was held pending collection of further confirmatory specimens. C. WISCONSINENSIS has also been found in small quantity on *Prenanthes racemosa* at Madison, September 4, 1943.

Specimens of all new species described have been placed in the University of Wisconsin Cryptogamic Herbarium. Those of new species of Cercospora, described jointly with Professor Chupp are also deposited in the herbarium of the Department of Plant Pathology of Cornell University at Ithaca, New York.

SECOND GROWTH MAY SUPPLY TIMBER OF EXCEPTIONAL QUALITY

BENSON H. PAUL

*U. S. Forest Products Laboratory**

Investigations of wood reveal wide variations in quality due to environmental conditions. Among hardwoods, second-growth trees are likely to be more thrifty, the wood heavier, harder, and stronger than in old-growth trees. Among softwoods, second-growth trees, although more thrifty, usually supply wood that is lighter, softer, and weaker than that of old-growth trees due to the production of a higher proportion of springwood than summerwood in the annual growth ring.

Although in the past much emphasis has been placed upon locality of growth as influencing the quality of timber of a given species, investigations of wood properties do not confirm important differences on that account except where a species may be growing under extreme conditions of site. For example, jack pine grown in the Nebraska sand hills under semi-arid conditions was inferior in strength because it was lacking in summerwood, the heavy dense portion of the annual growth ring. The lack of summerwood may be attributed to a deficiency in soil moisture during the growing season. Conversely, trees grown under conditions of excessive moisture may produce wood of unusual character for a species. A good illustration of this type of behavior is ash grown in the Mississippi Delta where, because of periodic flooding, the trees develop buttresses containing light, weak wood. The wood from this source is far different from upland ash and is unsuitable for customary uses of the species.

So much for the extremes. A more common cause of variation in the quality of wood is due to differences in environmental conditions occurring among different stands in a locality, among trees in a stand, or even at different periods in the life of a single tree.

* Maintained at Madison, Wisconsin, in cooperation with the University of Wisconsin.

The individual tree responds to growth opportunities much as a stalk of corn (although corn belongs to an entirely different group of plants). In planting corn it is common practice to check-row carefully in order to give each stalk sufficient space to develop. In the natural forest all trees do not have equal growing space. Through the many decades of the natural development of a forest stand, there exists a constant struggle first for survival, later a continued competition among individual trees for moisture, food, light, and air. In the virgin forest, therefore, growth, even of dominant trees, is likely to be somewhat restricted, especially during their later years.

In considering second-growth timber in comparison with old growth, the trees comprising a second-growth stand frequently compete less severely with each other than do trees of a virgin forest. Many second-growth stands originate in such a way that sharp competition does not take place during initial periods of 50 to 100 years. Often some of the trees are practically isolated and are not obliged to compete with each other for growing space. The result is that among broadleaved species, second-growth stands may be expected to furnish heavier, harder, stronger, and tougher wood than old-growth stands in the same locality.

A familiar example of demand is for second-growth hickory for handles, for wagon spokes in the old days, for auto wheels in the early gasoline age, and more recently for many war uses requiring wood of high shock-resisting ability. A scarcity of hickory has led to attempts to use all classes of material, both old-growth and second-growth, of the various hickory species. Recently a number of hickory picker-sticks used in weaving were submitted to the Forest Products Laboratory for an explanation of the reasons for low strength of some, it being stated that both good and poor hickory originated in the same locality. Tests of the sticks showed wide differences in toughness. The narrow growth rings and low density of the weak ones indicated that they had been cut from slow-growing old trees, while the others had the characteristic toughness and high density of second-growth hickory. Such differences between old-growth and second-growth timber are more often recognized in species that are relied upon for exacting uses. Hickory and ash are species used when toughness and shock-resisting properties are required. In some other woods, hardness and wearing qualities are desired, as, for example, in the use of dogwood for shuttles, hard maple for floors, bearings, gears, or wood type.

A shortage of dogwood, the species formerly used almost exclusively for shuttles, has led to a search for substitutes. One of the promising replacements appears to be second-growth sugar maple of especially high density from thrifty open-grown trees.

Investigations of such open-grown sugar maple and comparison with former tests of old-growth maple, and comparison even with maple from typical second-growth woodlot stands, show a marked increase in the weight and hardness of the open-grown material. While results of earlier mechanical tests of sugar maple and dogwood gave dogwood much higher values for both these properties, recently the wood from the open-grown sugar maple trees has been found practically equal to the average weight and hardness of dogwood. Although such trees afford only relatively short, usable log-lengths per tree, the number of shuttles obtainable per tree may be much higher than from dogwood because of the larger diameter attained by the sugar maple trees.

Many other examples might be given of large differences between old growth and second growth. Sometimes the second growth manifests undesirable qualities; this is frequent in second-growth coniferous species of rapid initial growth.

Research in wood that reveals the characteristics of all types of growth helps in the selection of material best adapted to critical wartime uses. In peacetime this knowledge will make it possible, through appropriate silvicultural measures applied in the forest, to grow timber having the special qualities that are most desirable.

PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN. XXXI. BORAGINACEAE

EMIL P. KRUSCHKE
Milwaukee Public Museum

The following report is based on the study of herbarium specimens and also on field observations made by the author. The specimens on which this report is based are deposited in the following herbaria: University of Wisconsin, Milwaukee Public Museum, Field Museum, Marquette University, University of Wisconsin in Milwaukee (Extension Division), Milwaukee State Teachers College, Ripon College, Lawrence College, St. Norbert College, and the private herbaria of Mr. S. C. Wadmond, Delavan, Wisconsin, Mr. Chas. Goessl, Sheboygan, Wisconsin, and my own. The author gratefully acknowledges the loan of specimens by Dr. N. C. Fassett, Mr. Chas. Goessl, Mr. Walter E. Rogers, Mr. S. C. Wadmond, Dr. A. M. Keefe, and Dr. J. F. Groves. The author is most appreciative for suggestions and information given by Dr. N. C. Fassett and Dr. Lloyd Shinners of the University of Wisconsin, and Mr. Albert M. Fuller of the Milwaukee Public Museum, especially for their reading the manuscript, and also to Mr. I. M. Johnston of the Gray Herbarium at Harvard University for the verification and determination of a few specimens whose identifications were doubtful.

The family Boraginaceae was monographed in 1924 by Mr. I. M. Johnston.[1] This monograph has been of great help in the study of this group of plants. Other scientific reports on separate genera and species of this family have also been helpful in this study. These articles are referred to in the text of this report.

The keys and text of this report are based primarily on the author's own observations. Separate flowering and fruiting keys for the genera and for the species of Lithospermum are given so as to make possible the identification of these plants in both the flowering and fruiting stages.

[1] I. M. Johnston: A synopsis of the American native and immigrant borages of the subfamily Boraginoideae. Contr. Gray Herb. Harvard Univ. 70: 1-55. 1924.

Flower Key to Genera

a. Corolla regular.
  b. Style as long as the corolla or longer, conspicuous.
    c. Throat of corolla closed by 5 scales ....5. *Symphytum*
    cc. Throat of corolla open or merely with crests or folds.
      d. Corolla trumpet-shaped or tubular-campanulate, with shallow, rounded, and spreading lobes. Flowers not in the axils of bracts; flowers blue ....9. *Mertensia*
      dd. Corolla tubular, with erect and acute sawtooth-like lobes. Flowers all in the axils of bracts; flowers yellow or whitish ....11. *Onosmodium*
  bb. Style shorter than the corolla.
    e. Flowers, at least the lowest ones, in the axils of bracts.
      f. Throat of corolla closed by 5 scales.
        g. Corolla 9-10 mm. long; calyx 5-7 mm. long; style 5.5-7.5 mm. in length; flowers deep blue or purplish-blue ....7. *Anchusa*
        gg. Corolla 2-4 mm. long; calyx very small, not over 3 mm. in length; style less than 3 mm. long; flowers light blue or forget-me-not blue.
          h. Inflorescence abundantly bracteate throughout; leaves ribbon-like, less than 1 cm. wide ....2. *Lappula*
          hh. Inflorescence sparsely bracteate at base or only the lowest flowers in the axils of bracts; leaves mostly more than 1 cm. wide ....3. *Hackelia*
      ff. Throat of corolla open or merely with crests or folds.
        i. Flowers all in the axils of bracts; plants hispid-pubescent ....10. *Lithospermum*
        ii. Only the lowest flowers in the axils of bracts; rough herbs densely covered with white, bristly hairs ....4. *Amsinckia*
    ee. Flowers not in the axils of bracts.
      j. Throat of corolla closed by 5 scales; lower stem-leaves comparatively large, more than 8 cm. long; venation of leaves fairly distinct. ...1. *Cynoglossum*
      jj. Throat without scales, merely with transverse crests; lower stem-leaves comparatively small, less than 8 cm. long; venation of leaves not distinct ....8. *Myositis*

aa. Corolla irregular
  k. Stamens and style included; throat of corolla closed by 5 scales; stigma simple ....6. *Lycopsis*
  kk. Stamens and style exserted; throat of corolla open; stigma 2-cleft ....12. *Echium*

Fruit Key to Genera

a. Nutlets attached laterally to the receptacle.
  b. Nutlets armed with barbed prickles.

c. Nutlets inclined horizontally, armed all over with short, barbed prickles; attached near the end ....1. *Cynoglossum*

cc. Nutlets erect or ascending, with barbed prickles on their backs or margins; attached at least half their length along the median ventral keel.

d. Pedicels stout and not sharply bent downward in fruit; nutlets equalling the subulate gynobase, attached nearly their full length along the median ventral keel, lacking a well defined areole; style usually surpassing the nutlets ....2. *Lappula*

dd. Pedicels slender, bent sharply downward in fruit; nutlets twice surpassing the stout pyramidal gynobase, attached obliquely by a deltoid or ovate areole; ventral keel extending over only the upper half of the nutlet; style definitely surpassed by the nutlets ....3. *Hackelia*

bb. Nutlets wrinkled or granular-roughened, not armed with barbed prickles ....4. *Amsinckia*

aa. Nutlets attached to the receptacle at or very near the base.

e. Region of attachment of nutlet surrounded by an annular rim, leaving a pit-like depression upon the flat or slightly convex gynobase.

f. Nutlets nearly smooth; branch-veins of leaf conspicuous; leaves large, 3-7.5 cm. wide ....5. *Symphytum*

ff. Nutlets rough-wrinkled or rugose; branch-veins of leaf inconspicuous, only the midrib evident; leaves less than 2.5 cm. wide.

g. Style conspicuously longer than the fruiting calyx; margin of leaf unevenly undulate or sparsely and irregularly dentate ....6. *Lycopsis*

gg. Style about as long or only slightly longer than the fruiting calyx, not conspicuous; margin of leaf entire ....7. *Anchusa*

ee. Region of attachment of nutlet not surrounded by an annular rim and without a pit-like depression on the gynobase.

h. Style thread-like, long and conspicuous, persisting in the fruiting stage (occasionally broken off in mature fruits).

i. Nutlets ivory-like, bony, white, smooth or only slightly pitted ....11. *Onosmodium*

ii. Nutlets brown to brownish-gray, roughened, wrinkled, or with blunt, irregular ridges.

j. Pedicels very short, not over 2 mm. long; stigma 2-cleft; plants densely hispid-pubescent throughout ....12. *Echium*

jj. Pedicels mostly 5 to 15 mm. long; stigma simple; plants glabrous, or with inconspicuous short hairs ....9. *Mertensia*

hh. No long, conspicuous, thread-like style present or persisting in the fruiting stage; nutlets bony,

smooth (rough-wrinkled to densely tubercled in *Lithospermum arvense*, but nutlets definitely bony).
k. Nutlets over 1 mm. in length, more or less round in cross-section ..10. *Lithospermum*
kk. Nutlets less than 1 mm. in length and laterally compressed ....8. *Myosotis*

1. CYNOGLOSSUM (Tourn.) L.

a. Calyx-lobes more than 3 mm. long; nutlets sunken in or depressed dorsally, with a definite elevated margin; stems leafy throughout.
b. Flowers reddish-purple or maroon, rarely white; nutlets 5-7 mm. long ....1. *C. officinale*
bb. Flowers forget-me-not blue; nutlets small, not over 3 mm. in length ....2. *C. amabile*
aa. Calyx-lobes less than 3 mm. long; nutlets convex dorsally and without a definite elevated margin; upper part of stem leafless, terminating in a once- or twice-forked, bractless inflorescence ....3. *C. boreale*

1. CYNOGLOSSUM OFFICINALE L. (Common Hound's Tongue) (Map 1). Frequent, especially in the southern and eastern parts of the State. More extensive collecting in western and northern Wisconsin would no doubt show it to be more common than present collections indicate. The white-flowered form (*C. officinale* L. f. *bicolor* (Willd.) Lehm.) is very rare. A specimen of this form was collected by the author June 7, 1939, in Milwaukee Co., T. of Oak Creek, on the Tischendorf farm, at the border of a rich mesophytic woods. At this station there were three specimens growing with the typical maroon-colored form. Occurs chiefly in waste ground, pastures, along roadsides and railroads, and in shrubby thickets and open woods. Flowering from May 25 to July 15.

Native of Eurasia; naturalized in North America.

2. CYNOGLOSSUM AMABILE Stapf & Drummond (Map 2). The author collected several specimens of this perennial in a Wauwatosa city dump, where it was growing as an escape from garden cultivation. The plants were doing very well and there were indications of its spreading. Flowering season July and August. Native of S. W. China. Frequently cultivated in gardens in this country.

3. CYNOGLOSSUM BOREALE Fern. (Northern Wild Comfrey) (Map 2). This native American species is northern in its range, occurring chiefly in the northern part of the State. However, several collections have been made in the southern and

eastern parts. Dry woods and copses. Flowering from June 1 to July 15. Flowers pale blue.

2. LAPPULA (Rivin.) Moench

a. Fruits with a double row of stout, flattened prickles about the margin, these prickles little or not at all confluent at the base ......1. *L. echinata*

aa. Fruits with a single row of stout, flattened prickles or bristles about the margin, the prickles usually confluent at the base ....2. *L. Redowskii var. occidentalis*

1. LAPPULA ECHINATA Gilib. (Spiny or European Stickseed)

(Map 3). This species has been collected most frequently in the southeastern part of the State, but the eastern and northern parts are also fairly well represented in herbarium collections. Apparently it is rare in the western part of the State. Usually grows in dry, sandy-gravelly soil, in waste places, along roadsides, and in ballast along railroads. Flowering season June and July. Flowers blue to bluish-white.

Native of Eurasia; naturalized in North America.

2. LAPPULA REDOWSKII (Hornem.) Greene, var. OCCIDENTALIS (Wats.) Rydb.

(Map 4). Represented by specimens collected from four stations in the southwestern part of the State and a single specimen collected in Sheboygan, the latter made by Chas. Goessl in July, 1919. J. H. Schuette collected two specimens at Kewaunee, possibly of this species, but due to their immature fruits, making determination impossible, they are omitted from this report. In ballast along railroads, and in wasteplaces. Flowering season June and July.

Native of Asia and western America; adventive eastward.

3. HACKELIA Opiz.

(See I. M. Johnston. Restoration of the genus Hackelia. Contr. Gray Herb. Harvard Univ. 68: 43-48. 1923.)

a. Nutlets globose and equally short-glochidiate over the entire back. Leaves mostly 2 or more cm. wide ....1. *H. virginiana*

aa. Nutlets globular to pyramidal and not equally glochidiate over the entire back; leaves less than 2 cm. wide.

b. Nutlets with prickles only on the margin; back of nutlet deltoid-ovate ....2. *H. deflexa*

bb. Nutlets with prickles on the margin, with a few along the middle; back of nutlet deltoid in shape ....3. *H. deflexa var. americana*

1. HACKELIA VIRGINIANA (L.) I. M. Johnston. (Beggar's Lice or Virginia Stickseed)
Lappula virginiana (L.) Greene, (1891).
(Map 5). This is a typical woodland species occurring throughout the southern two-thirds of the State, north to Barron and Langlade Counties. I have found it to be most abundant in beech and sugar maple woods, rarely it can be found in shrubby thickets, waste ground, and along roadsides. Flowering season June 25 to July 31. Flowers small, blue.

2. HACKELIA DEFLEXA (Willd.) Opiz. (Nodding Stickseed)
Lappula deflexa (Wahl.) Garcke, (1893).
(Map 6). Occasional in the northeastern and southwestern parts of the State on limestone cliffs, bluffs and outcroppings, along roadsides, in waste places, and in open woods and thickets. Flowering throughout June and the first week of July. Flowers blue.
Native of Eurasia; naturalized in North America.

3. HACKELIA DEFLEXA (Willd.) Opiz. var. AMERICANA (Gray) Fernald & Johnston.
(See Rhodora 26: 124-125. 1924)
Lappula deflexa var. *americana* (Gray) Greene, (1891).
(Map 7). Rare in the State. Most of the collections were made in the northeastern part, with a few collections from the western part of the State along the Mississippi River. Open woods and thickets and on limestone cliffs and bluffs. Flowering throughout the month of June.

4. AMSINCKIA Lehm.

(See Macbride, J. F. A Revision of the North American species of Amsinckia. Contr. Gray Herb. Harvard Univ. n.s. xlix. 1-16 (1917))

1. AMSINCKIA LYCOPSIOIDES Lehm. Amsinckia
(Map 8). Introduced into Wisconsin from California, it has been collected at four stations in the State. Waste ground along railroad tracks. Flowers pale yellow. Flowering in June and the first two weeks of July.

5. SYMPHYTUM (Tourn.) L.

a. Stems and inflorescence glabrate or hirsute, the hairs not prickle-like or barb-like, but longer, more slender, and of more or less uniform thickness throughout; tips of corolla-lobes recurved; leaves decurrent, the well-developed wing extending down the stem ....1. *S. officinale*

aa. Stems and inflorescence covered with short, recurved, prickle-like or barb-like hairs laterally compressed and very much broadened at the base; tips of corolla-lobes erect; leaves not decurrent or obscurely so ....2. *S. asperum*

1. SYMPHYTUM OFFICINALE L. (Common Comfrey)

(Map 9). Rare; specimens have been collected at eight different stations, five of them within the city limits of Milwaukee. Along railroad tracks and bordering waste land, vacant lots, and fields. Flowering specimens have been collected from June 8 to August 11. Flowers rarely white, usually purple. The latter color-form was known in Europe, since it is mentioned in Hegi's Flora von Mittel-Europa as a distinct variety—*S. officinale* L. var. *purpureum* Pers. It seems preferable to rank it as a forma rather than a distinct variety. The colored form was collected at three stations where collections were also made for the white form.

Introduced from temperate Europe.

2. SYMPHYTUM ASPERUM Lepechin. (Rough Comfrey) (See Rhodora 18: 23-25. 1916).

Symphytum asperrimum Donn., (1806).

(Map 9). Only one station reported for the State. A single specimen was collected in Racine, Racine County, in 1915 by Mrs. F. J. Pope. This specimen is in the herbarium of the University of Wisconsin. Flowers purple.

Introduced into America from Europe.

6. LYCOPSIS L.

1. LYCOPSIS ARVENSIS L. (Small Bugloss)

(Map 10). Collected in three counties bordering Lake Michigan where it was found growing in dry, cultivated fields and waste places. Field data for the specimens collected are very incomplete, no mention being made as to its abundance in any one of the localities where it was collected. Flowers blue. Flowering season June 10 to July 25.

Adventive from temperate Europe.

7. ANCHUSA L.

1. ANCHUSA OFFICINALIS L. (Common Alkanet)

(Map 10). Mr. Fuller of the Public Museum collected this species in Milwaukee, in a vacant lot, where it was growing as a garden-escape. Flowering in July. Flowers deep blue to purplish-blue. Native of temperate Europe and of Asia Minor. Commonly grown in gardens in this country.

8. MYOSOTIS (Rupp.) L.

a. Fruiting pedicels as long or longer than the calyces; calyx not 2-lipped; corolla mostly more than 2 cm. broad.
  b. Calyx with few, short, closely appressed hairs, none of which are hooked or gland-tipped; flowers blue; aquatic or marsh plants.
    c. Calyx-lobes much shorter than the tube; limb of corolla 5-9 mm. broad; style much exceeding the nutlets and about as long as the calyx-tube ....1. *M. scorpioides*
    cc. Calyx-lobes about as long as the tube; limb of corolla rarely as much as 5 mm. broad; style definitely exceeded by the nutlets and shorter than the calyx-tube ....2. *M. laxa*
  bb. Calyx densely covered with spreading hairs, some of them hooked or gland-tipped, at least at the base of the calyx; fruiting-calyx open; flowers usually light blue, occasionally white; corolla 1.5 to 4 mm. broad; plants of well-drained soil ....3. *M. arvensis*
aa. Fruiting pedicels shorter than the calyces; calyx 2-lipped, unequally and deeply 5-cleft; flowers white and inconspicuous; corolla 1-2 mm. broad; calyx hairs hooked or gland-tipped; plants growing in dry soil ....4. *M. verna*

1. MYOSOTIS SCORPIOIDES L. (True Forget-me-not)

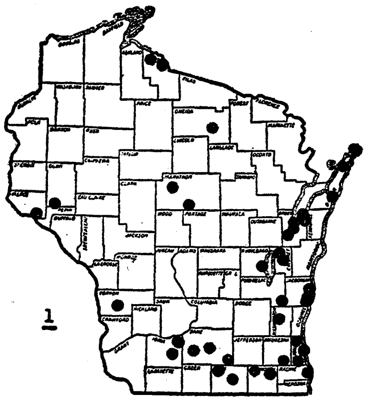
(Map 11). Most collections of this species have been made in eastern Wisconsin, especially in the counties bordering Lake Michigan. Several collections have, however, been made in the western and northern parts of the State. Common at all stations reported, growing in wet ground in swamps, sloughs, ditches, and borders of creeks, rivers, and lakes. On several occasions I have seen it growing in wet, alluvial soil on bottoms of dried-up streams. Flowering season extending throughout June, July and August.

Naturalized from Europe; frequently cultivated.

2. MYOSOTIS LAXA Lehm. (Smaller Forget-me-not)

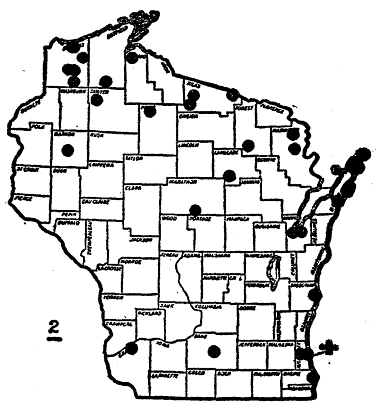
(Map 12). Rare in the State. This species has been collected only along the Wisconsin River as far east and north as Columbia County. It prefers wet shores and shallow water and also wet, marshy sloughs and ditches. Flowering season from May to August.

3. MYOSOTIS ARVENSIS (L.) Hill. (Field Scorpion Grass or Mouse Ear)



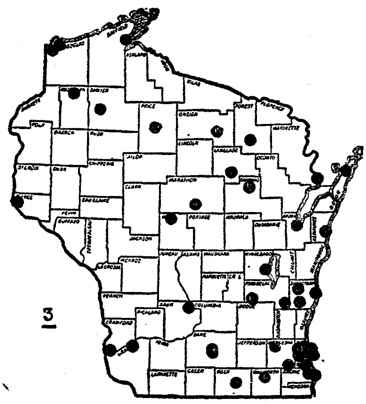
1

Cynoglossum officinale



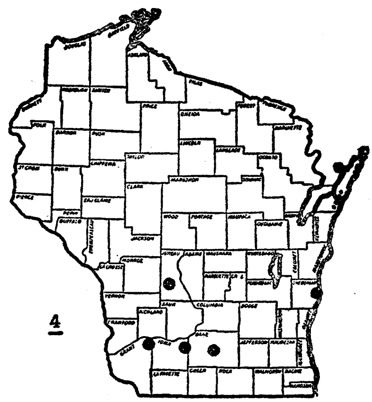
2

● Cynoglossum boreale
✚ Cynoglossum amabile



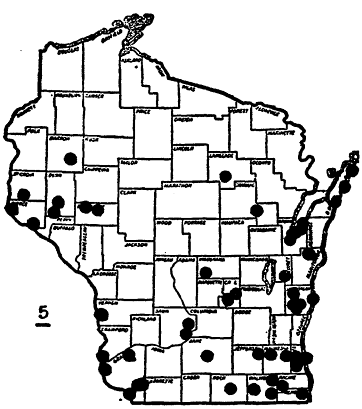
3

Lappula echinata



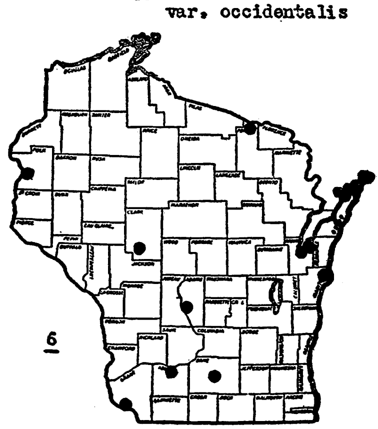
4

Lappula Redowskii
var. occidentalis



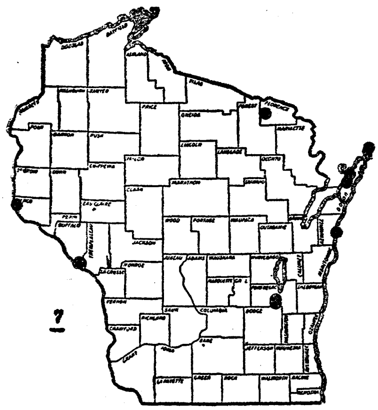
5

Hackelia virginiana



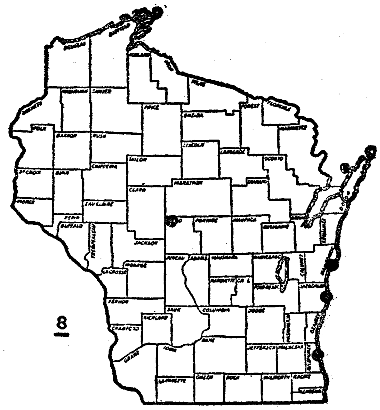
6

Hackelia deflexa



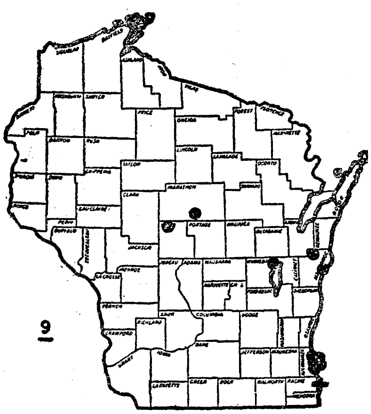
7

Hackelia deflexa
var. americana



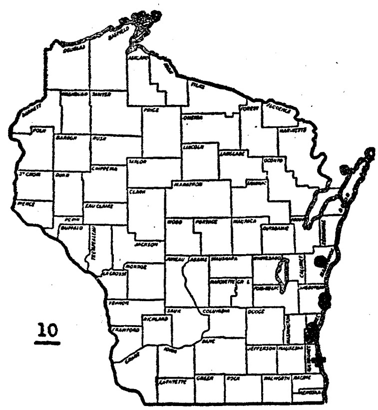
8

Amsinckia lycopsioides



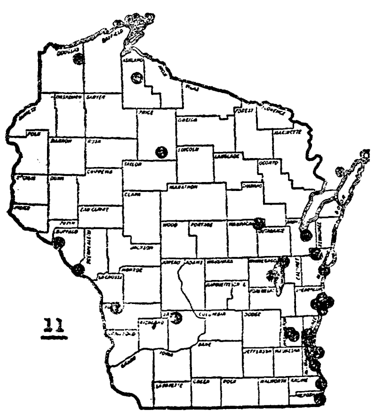
9

● Symphytum officinale
✚ Symphytum asperum



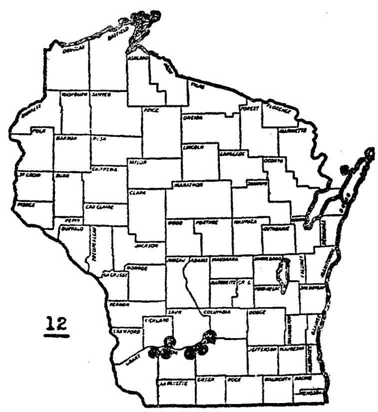
10

● Lycopsis arvensis
✚ Anchusa officinalis



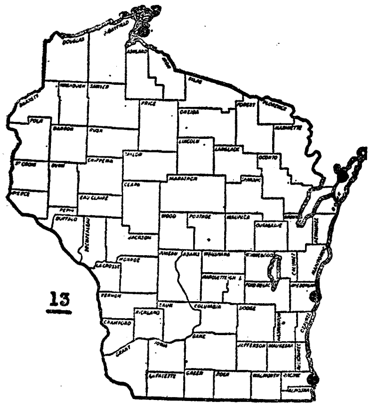
11

Myosotis scorpioides



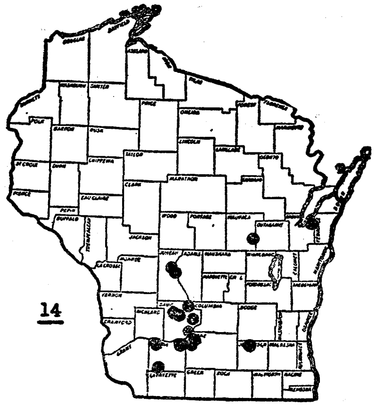
12

Myosotis laxa



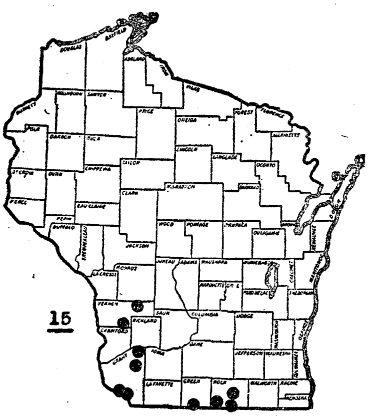
13

Myosotis arvensis



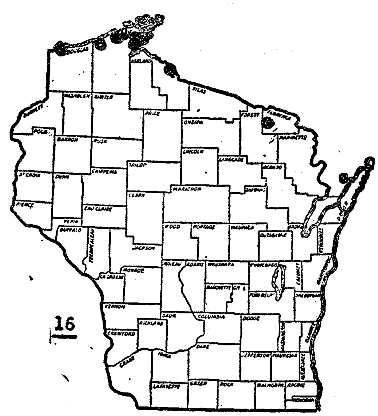
14

Myosotis verna



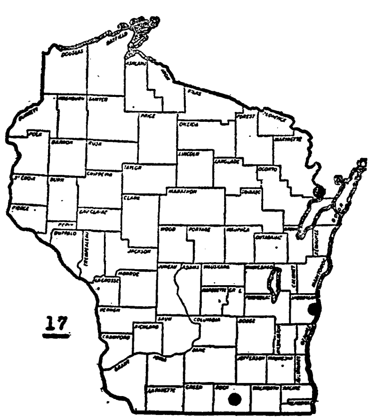
15

Mertensia virginica



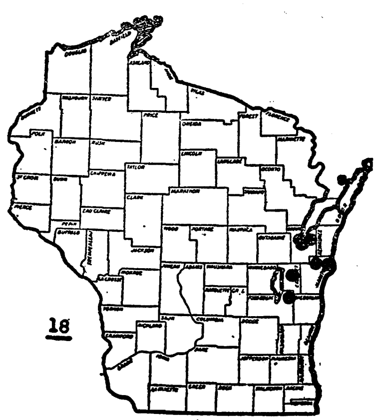
16

Mertensis paniculata



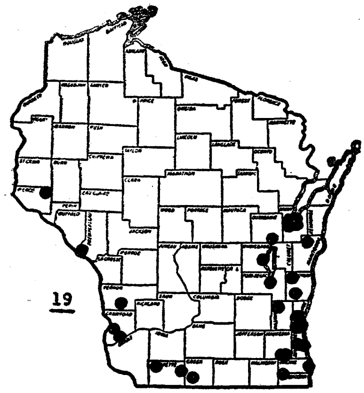
17

Lithospermum arvense



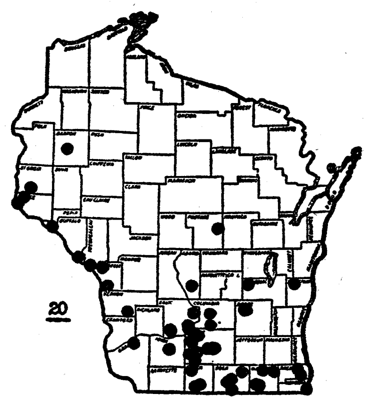
18

Lithospermum officinale



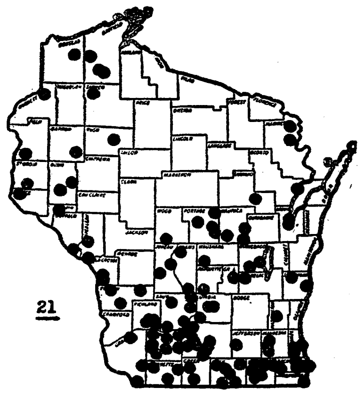
19

Lithospermum latifolium



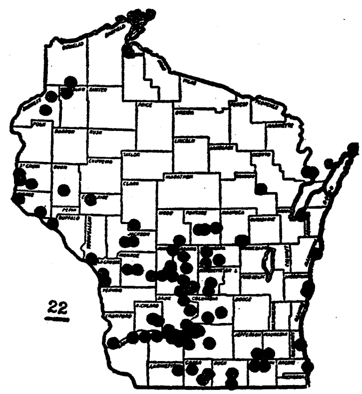
20

Lithospermum incisum



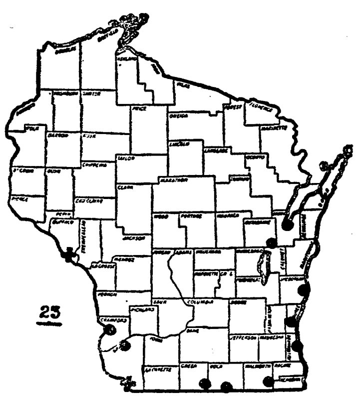
21

Lithospermum canescens



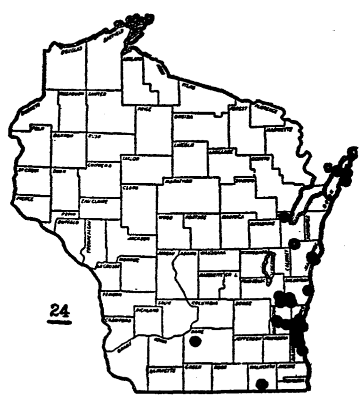
22

Lithospermum croceum



23

✚ Onosmodium molle var. occidentale
● Onosmodium hispidissimum



24

Echium vulgare

(Map 13). Collected in Racine, Sheboygan, and Door Counties and also on Madeline Island in Ashland County. Dry ground in old abandoned gardens, cemeteries, waste lots, and pastured meadows. Flowering the last week in May through June and July.

The white-flowered form was collected by C. F. Millspaugh at Ephraim, Door County, June 9, 1913, along with the typical form. Both types are mounted on the same herbarium sheet in the herbarium of the Field Museum.

Native of Europe; introduced into North America.

4. MYOSOTIS VERNA Nutt. (Spring or Early Scorpion Grass) (See Rhodora 43:636. 1941).

Myosotis virginica (L.) BSP., (1888).

(Map 14). This species is pretty well confined to four counties bordering the Wisconsin River from northern Juneau County south and west to Grant County. Waupaca, Brown, and Jefferson Counties are also represented by one collection each. Generally it seems to prefer sandstone or quartzite, since in all cases except one, it was found growing on quartzite cliffs and bluffs, on sandstone bluffs and hills, and in sandy plains and pastures. The exception is the Brown County station, located in a pasture just east of a limestone ledge. Flowering chiefly in May and during the first three weeks of June.

9. MERTENSIA Roth.

(Williams. A monograph of the genus Mertensia in North America. Ann. Missouri Bot. Gard. 24: 17-159, 16 fig. 1937)

a. Corolla trumpet-shaped, with limb barely 5-lobed, without crests in the throat; filaments slender and much longer than the anthers; leaves oblong to ovate, obtuse, glabrous on both surfaces; calyx glabrous ....1. *M. virginica*

aa. Corolla funnelform-campanulate, with crested throat and limb conspicuously 5-lobed; filaments flattened and as long or shorter than the anthers; leaves ovate-lanceolate and taper-pointed, pubescent on both surfaces; calyx pubescent ....2. *M. paniculata*

1. MERTENSIA VIRGINICA (L.) Link. (Virginia Bluebell)

(Map 15). Distribution of this species is confined to the southwestern part of the State where it grows chiefly in alluvial soils of wooded river bottoms (Mississippi, Wisconsin, Kickapoo, Sugar and Pecatonica Rivers). Fassett collected two specimens in Grant County, one growing on dry, wooded talus along the Mississippi River bluffs and the other growing in rock crevices on a bare limestone bluff. It is also reported from St. Croix Falls, and in Minnesota, opposite La Crosse. Flowers light blue, occasionally tinted with rose-purple, the latter being especially pronounced in the flower-buds. Flowering season May.

2. MERTENSIA PANICULATA (Ait.) G. Don. (Tall Lungwort) (Map 16). Fairly common on the south shore of Lake Superior. It has also been collected at two other stations in the northern part of the State: Hurley in Iron County and Long Lake in Florence County. All of the specimens are from wooded river bottoms, wooded banks of streams, and from wooded swamps. Flowers light blue, sometimes tinged with rose-purple. Flowering season June and the first three weeks of July.

10. LITHOSPERMUM (Tourn.) L.

FLOWER KEY TO SPECIES

a. Corolla as long as or slightly exceeding the calyx; flowers white to greenish-white or yellowish.
  b. Branch-veins of leaf inconspicuous, only the midrib evident; flowers white to yellowish-white; corolla-lobes glabrous on the outer surface ....1. *L. arvense*
  bb. Branch-veins of leaf conspicuous; flowers greenish-white to greenish-yellow or yellow; corolla-lobes pubescent on the outer surface.
    c. Only a few distinct veins, these somewhat obscured by the dense pubescence; leaves 6-12 (rarely -14 or more) mm. broad, firm, lanceolate, and acute; pubescence on upper leaf-surface of varying length, the bases of the larger hairs often expanded and scale-like; flowers greenish-white to greenish-yellow; corolla not over 4.5 mm. long; calyx-lobes 3.5 mm. or less long ....2. *L. officinale*
    cc. Veins more numerous and more prominent; leaves 12-45 (chiefly 15-35) mm. broad, thin, ovate, and acuminate; pubescence on upper leaf-surface consists of numerous shorter hairs with fewer distinctly longer hairs, the bases of the hairs occasionally expanded but rarely scale-like; flowers yellow; corolla 4.5-8.5 mm. long; calyx 3.5-6 mm. long ....3. *L. latifolium*

aa. Corolla several times longer than the calyx; corolla light yellow to deep orange-yellow.
    d. Leaves ribbon-like, acute, appressed canescent-pubescent; flowers light yellow; corolla-tube narrow, 14-35 mm. long; corolla-lobes finely toothed ....4. *L. incisum*
    dd. Leaves chiefly oblong to lanceolate or narrow-lanceolate, rarely ribbon-like, more or less obtuse; flowers light to deep orange-yellow; corolla-tube broader and less than 14 mm. long; corolla-lobes entire.
      e. Corolla-tube naked at the base inside; calyx-lobes 2-6 mm.

long; leaves closely appressed canescent-pubescent above; flowers sessile or nearly so; flowers orange-yellow .... 5. *L. canescens*

ee. Corolla-tube hairy at the base inside; calyx-lobes 6-13 mm. long; leaves loosely appressed-pubescent above; hairs fewer and more coarse and stiff than in the previous species, each hair with a more or less papillose base; flowers distinctly peduncled; flowers usually light yellow, occasionally light orange-yellow .... 6. *L. croceum*

FRUIT KEY TO SPECIES

a. Nutlets brown or dull gray, rough-wrinkled or densely tubercled .... 1. *L. arvense*

aa. Nutlets smooth and shining, white to ivory.

b. Branch-veins of leaf conspicuous.

c. Nutlets 2-3.5 mm. long; leaf-veins few and somewhat obscured by the dense pubescence; leaves 6-12 (rarely -14 or more) mm. broad, firm, lanceolate, and acute; pubescence on upper leaf-surface of varying length, the bases of the larger hairs often expanded and scale-like .... 2. *L. officinale*

cc. Nutlets 3.5-4.5 mm. long, broader and more plump; leaf-veins more numerous and more prominent; leaves 12-45 (chiefly 15-35) mm. broad, thin, ovate, and acuminate; pubescence on upper leaf-surface consists of numerous shorter hairs with fewer distinctly longer hairs, the bases of the hairs rarely expanded and rarely scale-like .... 3. *L. latifolium*

bb. Branch-veins of leaf not conspicuous.

d. Leaves linear or ribbon-like, mainly 3.5-4.5 mm. long, less than 5 mm. wide, acute, appressed canescent-pubescent; nutlets usually punctate .... 4. *L. incisum*

dd. Leaves chiefly oblong to lanceolate or narrow-lanceolate, rarely ribbon-like, more or less obtuse; fruits smooth.

e. Calyx-lobes 2-6 mm. long; fruit-clusters more or less sessile; nutlets 2-3 mm. long; leaves closely appressed canescent-pubescent above .... 5. *L. canescens*

ee. Calyx-lobes more than 6 mm. long; fruit-clusters distinctly peduncled; nutlets 3.5-4 (rarely 3-4.5) mm. long; leaves loosely appressed-pubescent above; hairs fewer and more coarse and stiff than in the previous species, each hair with a more or less papillose base .... 6. *L. croceum*

1. LITHOSPERMUM ARVENSE L. (Corn Gromwell)

(Map 17). Very rare, only three stations reported for the State: Marinette in Marinette County, Sheboygan in Sheboygan County, and Janesville in Rock County. The Marinette collection was made along a railroad embankment; the other two collections bore no data regarding specific habitat. Flowering season May and early June.

Native of Europe and adjacent Asia and Africa; introduced in North America.

2. LITHOSPERMUM OFFICINALE L. (Common Gromwell)

(Map 18). Rare; collections have been made in only four counties in eastern Wisconsin; roadsides, fields, and waste ground. Flowering season May and early June.

Native of Europe and the Mediterranean region; introduced in North America.

3. LITHOSPERMUM LATIFOLIUM Michx. (American Gromwell)

(Map 19). Eastern, southwestern, and western Wisconsin, as far north as Brown and Pierce Counties; in mesophytic woods, borders of woodlots, and open ground. An uncommon species, usually found growing in small, sparsely scattered colonies. On the several occasions that I have seen this species it seemed to prefer sandy loam banks and slopes. The fact that it branches so freely and reaches a height of 2 to 3 feet gives it an almost shrub-like appearance. Flowering season May 20 to August 5.

4. LITHOSPERMUM INCISUM Lehm. (Narrow-leaved Puccoon) (Kew Bull. 2: 59. 1934)

Lithospermum angustifolium Michx., (1803).

Lithospermum linearifolium Goldie, (1822).

(Map 20). North to Barron, Portage, and Sheboygan Counties. It is rather common in the southern part of the State, especially in Sauk, Dane, Rock, and Walworth Counties, less frequent in the Western part and rare in the eastern counties. Dry sandy soil of hillsides, bluffs, prairies, fields, and along railroads, in open ground. In southeastern Wisconsin I have seen several colonies on the Lake Chicago beach, growing in dry sandy soil at the border of open oak groves. Flowering season May and early June.

5. LITHOSPERMUM CANESCENS (Michx.) Lehm. (Hoary Puccoon)

(Map 21). Fairly common in southern and western Wisconsin and infrequent in the eastern part of the State. No collections have been made in the north central area north of Portage County, and between Sawyer and Marinette Counties. It prefers sandy soil, growing in prairies, open woods, roadsides, and along the railroad right of ways. Flowering season May and June and occasionally in early July.

6. LITHOSPERMUM CROCEUM Fernald. (Hairy Puccoon) (Rhodora 37: 329. 1935).
Lithospermum carolinianum Lam., (1791).
Lithospermum hirtum Lehm., (1818).
Lithospermum Gmelini Hitchc., (1894), of Gray, Man., ed. 7.
Lithospermum carolinense (Walt.) MacMill, (1892), of Britton and Brown, Illus. Flora, ed. 2.

(Map 22). Distribution quite similar to that of the previous species; infrequent to fairly common in the southern half and western parts of the State, especially in the counties bordering the Wisconsin River; rare in the eastern part of the State. In dry ground, especially sandy soil, in open woods, prairies, in hilly fields and on bluffs and hilly slopes bordering lakes and streams, and along roadsides and railroad right of ways. Flowering during the latter half of May and June, also in July, rarely during the month of August.

11. ONOSMODIUM Michx.

a. Leaves lanceolate-ovate, mostly 1-2 cm. wide; pubescence of numerous silky-gray to grayish-white, fine, short, appressed hairs, the individual hairs less than 1.5 mm. long and not conspicuous to the naked eye; nutlets rounded and not constricted at the base to form a collar ....1. *O. molle* var. *occidentale*

aa. Leaves mostly ovate, 1.5-4 cm. wide; pubescence of white to yellowish-white coarse bristles, mostly spreading (especially on stem, branches, and on the rib-like veins on under surface of the leaves), the bristle-like hairs more than 1.5 mm. long and very conspicuous to the naked eye (pubescence on the leaves consists of numerous long hairs with fewer distinctly shorter hairs); nutlets constricted at the base to form a short neck or collar ....2. *O. hispidissimum*

1. ONOSMODIUM MOLLE var. OCCIDENTALE (Mack.) I. M. Johnston. (Western False Gromwell)
Onosmodium occidentale Mack., (1905).

(Map 23). Only two stations reported for the State, one at Fountain City, Buffalo County, the other at Rutledge, Grant County. All specimens collected at these stations lacked date regarding habitat and frequency. Flowers sordid yellow. Flowering season the latter half of June and July.

2. ONOSMODIUM HISPIDISSIMUM Mack. (False Gromwell)

(Map 23). This species has been collected in the southern and eastern parts of the State. None of the collections bear any data as to frequency and habitat. Flowers sordid yellow. Flowering season late June and July, rarely in August.

12. ECHIUM (Tourn.) L.

1. ECHIUM VULGARE L. (Blueweed or Viper's Bugloss) (Map 24). Abundant in places in eastern Wisconsin in dry, gravelly to sandy-gravelly soil of morainal hills, sloping embankments, ridges and knolls, in fallow fields, waste ground, roadsides, pastures, hay fields, railroad right of ways and occasionally in farmyards. The largest colonies I had ever seen were south of Barton near the Milwaukee River in Washington County, and in Fond du Lac County four to five miles north of Kewaskum in fields bordering County Highway G, and in fields bordering the road entering the Kettle Moraine State Forest at Mauthe Lake. During the past four years I have made frequent trips to this central kettle moraine area when this species was in flower and have observed it to be spreading gradually in all directions. It has already spread to the extreme southwestern part of Sheboygan County.

This species has also been collected in Dane County, near Pine Bluff. The flowers are deep, brilliant blue in color, occasionally rose-pink to rose-purple. The flower-buds are more or less rose-pink in color. I have seen several plants where all the mature flowers had this roseate or rose-pink color. Smith and Fuller collected a specimen with white flowers at Mauthe Lake in Fond du Lac County, July 12, 1927. The specimen #1772 is in the herbarium of the Milwaukee Public Museum. This white-flowered form was known in Europe, since it is referred to in Hegi's Flora von Mittel-Europa V 3: 2193.1. Rydberg, in his Flora of the Prairies and Plains of Central North America, also mentions the white-flowered form. Flowering season the latter half of June and July.

Naturalized from Europe.

PARASITES OF NORTHERN WISCONSIN FISH

RALPH V. BANGHAM
College of Wooster

The data presented are the result of a fish parasite survey carried on during the spring and summer of 1943 as a joint project between the University of Wisconsin and the Biology Division of the Wisconsin Department of Conservation. Earlier studies by Cross (1933, 1934, 1935, and 1938) gave some idea of the parasitism of fish in certain of the lakes covered in the present survey. With the exception of this work by Cross and some earlier preliminary work by Dr. C. A. Herrick, the fish parasites of northern Wisconsin have not been investigated. Complaints to the conservation department concerning the presence of fish parasites, especially larval flukes encysted in the flesh or skin, led to the instigation of the present study.

Fish were obtained from over forty different locations, chiefly lakes. The parasites of 1,330 fish belonging to 38 different species are included in this report. These fish were obtained by several methods: by hook and line fishing, from gill and fyke nets, by seining, and by the use of minnow traps. Twelve hundred and thirty-nine, or 93.2 per cent of these fish carried at least one species of parasite. The number of individuals parasitized was rather high when compared to the results of previous surveys. Bangham and Hunter, (1939) reported a 60 per cent infection from a study of parasites of Lake Erie fish. During this survey of Lake Erie, 2,156 fish representing 79 species, were examined and included more minnows and young fish than the present investigation. In 1940 the writer examined 1,380 southern Florida fish belonging to 43 species and found 1,218 or 88.2 per cent parasitized with at least one form. In 1940 the author reported on a 1939 survey of the Algonquin Park lakes (Ontario). Here 560 fish belonging to 22 species were examined for parasites and 84.3 per cent were found to be infected.

In these last two surveys the numbers of parasitized fish were increased due to the presence of many strigeids belonging to several different species and having a metacercarial stage encysted in the flesh, skin, or visceral organs of the host. The definitive stage of these strigeids is carried by a fish-eating bird and the cercariae develop within a snail. In the present study encysted strigeids, encysted eye flukes and gill flukes accounted for the major portion of the fish infections.

The degree of infection varied widely in different lakes and also among species of fish. The chemical, biological and physical characteristics of the habitat of the host appear to have a rather marked effect on distributions of the parasites (Table III). In seepage lakes with soft water, snails were reduced or absent, and digenetic flukes were restricted probably as a result of the lack of their primary hosts. In these lakes Acanthocephala are reduced or absent but immature nematodes (*Camallanus* sp.) were frequently encountered. In lakes where walleyed pike were found, larval *Triaenophorus* sp. cysts were taken in large numbers, especially from yellow perch.

In this report a list of the areas from which fish were obtained giving location, size, type (seepage, flowage, or natural lake with inlet and outlet) and chemical data, especially with relation to the amount of carbonates, are included (Table III).

Most of the fish were examined while fresh or were placed on ice and examined the following day. Freezing relaxed the gill flukes which were then preserved in 5 per cent formalin. The exterior, skin, flesh, eyes, mouth, and visceral organs were examined. Parasites were picked out for future study under a binocular microscope. Then a 0.7 per cent solution of sodium bicarbonate was used which helped dissolve the mucus and aided in cleaning the worms remaining from the preliminary examination. The larger cestodes, nematodes, and leeches were killed in 10 per cent formalin then preserved in a 5 per cent formalin solution. Acanthocephala were allowed to die in water before being preserved. The parasites which were not recognized in the preliminary study were stained in Delafield's Haematoxylin.

This investigation was jointly supported by funds from the Wisconsin Alumni Research Foundation and the Wisconsin Conservation Department. The writer acknowledges the assistance and cooperation of Dr. Edward Schneberger, Chief Biologist of the State Conservation Department, in helping to plan the study and for his counsel and interest during its progress.

Assistance in collection of fish and information on the nature of lakes investigated was given by Mr. Thomas H. Flanigon, area

biologist of the State Conservation Department at Woodruff, Wisconsin, where most of the field studies were conducted. Several men in the fisheries division at Woodruff also assisted in the collection of fish used in the survey.

Mr. D. John O'Donnell, area biologist located at Spooner, Wisconsin, assisted in the collection of fish and offered facilities of his laboratory during the period spent in that region (northwestern Wisconsin).

Dr. Chancey Juday gave information useful to this study as the result of his long study of lakes from which many of the fish being reported on, were secured. The interest, advice, and assistance of Dr. C. A. Herrick is much appreciated.

All of the identifications in the present report are those of the author except for the parasitic copepods. Dr. Wilbur M. Tidd of Ohio State University assisted in determining the species of

TABLE I. Parasites frequently encountered.

	Number of species of fish
Trematoda	
Azygia angusticauda	12
**Clinostomum marginatum*	7
Cryptogonimus chyli	7
**Diplostomulum scheuringi*	5
**Diplostomulum* sp.	5
Gyrodactyloidae	18
**Neascus* sp.	19
**Posthodiplosomum minimum*	7
Cestoda	
**Proteocephalus ambloplitis*	8
***Proteocephalus pearsei*	7
Proteocephalus pinguis	5
**Triaenophorus nodulosus*	12
Nematoda	
**Agamonema sp.*	6
***Camallanus* sp.	9
Contracaecum sp.	5
Dichelyne cotylophora	5
Spinitectus carolini	5
***Spinitectus* sp.	6
Acanthocephala	
**Leptorhynchoides thecatus*	7
Leptorhynchoides thecatus	14
Neoechinorhynchus cylindratus	7
Pomphorynchus bulbocolli	7
Copepoda	
Ergasilus caeruleus	10
Protozoa	
Myxosporidia	8
Hirudinea	
Illinobdella sp.	6

the latter. The gill flukes were submitted to Dr. John D. Mizelle of Notre Dame University and have not yet been identified to species.

Thirty-three species of parasites were found in but a single host species of fish. These were mainly adult forms. In Table I which follows, parasites which were encountered in more than

TABLE II. Summary of hosts, habitats, and number of parasite species.

Fish	Number of Fish	Number of Locations	Species of Parasites
1. *Amia calva*	8	1	5
2. *Leucichthys artedi*	12	2	1
3. *Salmo trutta fario*	12	1	1
4. *Salmo gairdnerii irideus*	4	3	2
5. *Salvelinus f. fontinalis*	14	3	4
6. *Catostomus c. commersonnii*	77	14	20
7. *Moxostoma rubregues*	4	4	3
8. *Cyprinus carpio*	10	1	1
9. *Rhinichthys atratulus meleagris*	9	3	4
10. *Chrosomus eos*	10	1	3
11. *Notemigonus crysoleucas auratus*	2	1	0
12. *Notropis cornutus frontalis*	4	2	2
13. *Notropis anogenus*	1	1	0
14. *Pimephales p. promelas*	1	1	1
15. *Hyborhynchus notatus*	16	3	2
16. *Ameiurus m. melas*	3	1	8
17. *Ameiurus n. nebulosus*	49	6	15
18. *Ameiurus n. natalis*	1	1	6
19. *Schilbeodes gyrinus*	1	1	1
20. *Umbra limi*	20	3	3
21. *Esox lucius*	34	7	12
22. *Hybrid pickerel-musky*	3	1	5
23. *Esox m. masquinongy*	17	4	9
24. *Fundulus diaphanus menona*	1	1	5
25. *Perca flavescens*	269	29	27
26. *Stizostedion v. vitreum*	84	15	23
27. *Percina caprodes semifasciata*	1	1	0
28. *Bolesoma n. nigrum*	1	1	0
29. *Poecilichthys exilis*	2	2	1
30. *Micropterus d. dolomieu*	44	8	24
31. *Huro salmoides*	102	17	27
32. *Lepomis gibbosus*	76	15	26
33. *Lepomis m. macrochirus*	232	23	28
34. *Ambloplitis rupestris*	107	12	27
35. *Promoxis nigro-maculatus*	67	10	15
36. *Cottus bairdii bairdii*	2	2	0
37. *Eucalia inconstans*	28	4	7
38. *Lota L. maculosa*	2	2	7

Total fish examined	1,330	Number of different species—79 (more to be identified)
Total fish infected	1,239	
Total percent infected	93.2	

five species of fish are listed. As in later tables encysted larval forms are indicated by a single asterisk (*), while immature stages within the digestive tract are marked by a double asterisk (**). A moderate to heavy infection of cysts of *Neascus* sp.

TABLE III. Habitats from which fish were obtained.

Lake	County	Character	Area (Acres)	Bound Carbon Dioxide PPM	pH
Clear	Oneida	Seepage	922	2.5	6.5
Bullhead	Oneida	Seepage	36	0.7	5.8
Blue	Oneida	Seepage	470	9.8	7.2
Snake	Oneida	Drainage	15	7.0	6.1
Minocqua Thoroughfare	Oneida	Drainage	200	28.5	7.2
Bass Hatchery, Woodruff	Oneida	Drainage	30	1.4	5.9
Hatchery Marsh, Woodruff	Oneida	Drainage	80	15.5	6.2
Hatchery Pond, Woodruff	Oneida	Drainage	10	21.0	6.8
Madeline	Oneida	Drainage	251	21.0	8.8
Carroll	Oneida	Drainage	352	21.0	7.5
North Two	Oneida	Drainage	224	1.6	5.9
Mid	Oneida	Drainage	233	18.0	5.0
Sweeney	Oneida	Drainage	186	18.3	8.2
Big Carr	Oneida	Drainage	219	1.4	5.9
Squaw	Oneida	Drainage	950	6.0	7.0
Johnson	Vilas	Drainage	84	15.3	7.5
Muskellunge	Vilas	Drainage	271	15.5	7.6
Trout	Vilas	Drainage	3,934	18.8	7.5
Pinkeye	Vilas	Seepage	55	2.0	6.9
Big Arbor Vitae	Vilas	Drainage	1,066	22.5	7.9
Little John	Vilas	Drainage	156	17.8	7.5
Little John Jr.	Vilas	Seepage	25	1.3	5.8
Nebish	Vilas	Seepage	88	4.0	6.8
White Sand	Vilas	Drainage	744	14.0	7.6
Boot	Vilas	Drainage	271	14.5	8.9
Moose	Langlade	Drainage	134	59.0	9.0
Pickerel	Langlade	Drainage	1,200	34.0	9.2
Rolling Stone	Langlade	Drainage	645	26.5	8.4
Butternut	Price	Drainage	975	2.8	
Lake DuBay	Marathon	Drainage	6,700	18.0	6.8
Four Mile Creek	Marathon	Drainage		11.7	7.1
Tozer	Washburn	Seepage	41	very hard	
Island	Washburn	Seepage	231	hard	
Cable	Washburn	Seepage	175	medium hard	
Spooner	Washburn	Drainage	1,212	very hard	
Shell	Washburn	Seepage	2,409	hard	
Casey Creek	Washburn	Stream		medium hard	
Chetac	Sawyer	Drainage	2,249	hard	
Upper Holly	Sawyer	Seepage	34	very soft	
Brule River	Douglas	Stream	66 (Str. Mi.)		
Rocky Run Creek	Douglas	Stream			
Little Brule	Douglas	Stream			
Brule Hatchery Cr.	Douglas	Stream			
Big Lake (Brule)	Douglas	Wide Portion of River			

was obtained from fish of 19 species. These infected fish had the tiny pigmented cysts in their skin and flesh and were easily observed by fishermen as were the larger yellow "grubs" of *Clinostomum marginatum*, embedded in the flesh and about the gill region of the host. These disfiguring parasites are not capable of becoming established in man even though the fish were improperly cooked. No parasites which can be transferred from fish to man were encountered although it is possible that the broad tapeworm of man, *Diphyllobothrium latum* may be occasionally found in the area covered by the survey.

The gill flukes of which there were numerous species are tiny but often appear to cause considerable damage to the delicate gills of the host.

The remaining forms, listed as frequent parasites, were found within the digestive tract, as metacercariae in the eyes or as encysted stages in the gonads, liver or mesentery.

In Table II the species of fish are listed giving numbers examined, different habitats and the number of parasite species found in the course of the survey.

Table III gives the county, water area and character of the body of water from which fish were obtained for examination.

In the data which follow on distribution of parasites in the thirty-eight species of fish, the listing of parasites and degree of parasitism is indicated by asterisks and habitat is given in tabular summary. This is followed by a short discussion in cases where several fish were examined from different locations.

Key: * encysted state; ** immature form in digestive tract; [1] 1-9 parasites; [2] 10-49 parasites; [3] 50 parasites and over.

(1) *Amia calva* Linn. young
Bowfin

	Woodruff Hatchery Pond 11
Examined 8	8
Infected 8	8
***Bothriocephalus* sp.	1[1]
***Haplonema immutatum*	1[1]
Macroderoides typicus	8[2]
***Proteocephalus perplexus*	8[1]
***Spiroxys* sp.	1[1]

No adult bowfins were examined. The eight young specimens measured from 6.1 to 7.2 centimeters and all the parasites were immature except for flukes, *M. typicus*.

(2) *Leucichthys artedi clarensis* Koelz
Clear Lake cisco

	Johnson Lake	*Clear Lake*
Examined 12	10	2
Infected 10	10	
Proteocephalus laurei	6^3	
	4^2	

Cisco were only taken from two lakes during the survey and but one species of parasite, *P. laruei*, was taken. These small cestodes were very numerous in most of the Johnson Lake cisco, but the Clear Lake fish were negative. Cross (1938) reports on the parasites of 128 cisco taken from Clear Lake in 1931 and 1932. Fourteen of this number carried three species of parasites.

(3) *Salmo trutta fario* Linn.
Brown trout

	Rocky Run Creek—Brule River tributary
Examined 12	12
Infected 4	4
Crepidostomun cooperi	1^1

(4) *Salmo gairdnerii irideus* Gibbons
Rainbow trout

	Minocqua Thoroughfare	*Spooner Hatchery*	*Little Brule River*
Examined 4	1	2	1
Infected 2	1	1	
Phyllodistomum sp.		1^1	
***Proteocephalus pinguis*	1^1		

(5) *Salvelinus fontinalis fontinalis* (Mitchill)
Brook trout

	Marathon County Four-Mile Creek	*Little Brule River*	*Brule Hatchery Creek*
Examined 14	4	2	8
Infected 4	4		
Crepidostomum cooperi	3^2-1^3		
**Leptorhynchoides thecatus*	1^1		
Neoechinorhynchus sp.	1^1		
	1^2		
***Proteocephalus pinguis*	1^1		

The brook trout from Four-mile creek were young adults and those from the other two areas were smaller, from 3.9-12 cm. in length.

(6) ***Catostomus commersonnii commersonnii*** **(Lacépède)**
Common white sucker

		Bullhead Lake	Blue Lake	Trout Lake	Snake Lake	Minocqua Thoroughfare	Muscallonge Lake	Woodruff Hatchery Pond	Yellow River Flowage	Casey Creek	Brule River	Moose Lake	Lac du Bay	Pinkeye Lake	Big Lake Brule River
Examined	77	2	5	2	3	15	10	1	2	1	8	7	10	1	10
Infected	75	2	5	2	3	15	10		2	1	8	7	10		9
Argulus catastomi							2^{1}								
Cestode (liver cyst)						1^{1}									
Ergasilus caeruleus			1^{3}	1^{3}											
Ergasilus sp.							2^{1}								
Glaridacris catostomi		1^{2}	1^{1}	1^{3}		8^{1}					4^{1}	3^{1}	9^{1}		3^{1}
		1^{3}	1^{2}			2^{2}	2^{1}			1^{2}					
			1^{3}												
Glochidia						1^{3}									
Gyrodactyloidae						1^{2}									
Hepaticola bakeri										1^{1}					
Illinobdella sp.			1^{1}	1^{1}											
Myxobolus sp.			2^{3}			4^{2}				1^{2}		1^{2}			
Neascus sp.						2^{1}					2^{1}				2^{1}
											2^{2}				2^{3}
															5^{3}
Neoechinorhynchus crassus											6^{1}				
Nematode (larval) int.															1^{1}
Octomacrum lanceatum			1^{1}			2^{1}	4^{1}					4^{1}			
Octospinifer macilentus		1^{1}		1^{1}		5^{1}	6^{1}				3^{1}	3^{1}	5^{1}		
						1^{2}					4^{2}	4^{2}	2^{2}		
**Philometra nodulosa*			5^{1}												
Pomphorynchus bulbocolli						1^{1}									
						2^{1}			2^{3}						
***Proteocephalus* sp.		1^{1}				1^{1}								[illegible]	[illegible]
***Triaenophorus nodulosus**			1^{1}	2^{2}		6^{1}	2^{2}	2^{1}							
Triganodistomum attenuatum			1^{2}	1^{2}	3^{1}	1^{1}		8^{1}			3^{1}		1^{1}		

(6) Nine of the parasite species were only taken from common suckers in one location. Large numbers of glochidia were carried on the gills of the sucker from the Lake Minocqua Thoroughfare, examined May 25. All fish of other species with glochidia were secured in the early part of the survey. *P. nodulosa* was found in galleries in the connective tissue of the pectoral fins of 5 of the suckers taken from Blue Lake. There were from 1 to 4 in each host, 2 being female specimens full of eggs. *O. lanceatum* was found on the gills of common suckers from 4 lakes. This form has been previously reported from suckers taken at Frederick Creek, Constantia, N. Y. by Mueller (1934)

and from the same hosts in the Algonquin Park Lakes, Bangham (1940). *G. catostomi, O. macilentus, T. attenuatum,* and cysts of *T. nodulosus* were forms encountered with greatest frequency in suckers examined from the different areas. *P. bulbocolli* was the only parasite secured from the Yellow River Flowage at Spooner. From 200 to 300 individuals of this species were found in each of these fish with their spiny proboscides deeply embedded in the intestines of their host. Five of the 10 young suckers from Big Lake in the Brule River carried large numbers of black strigeid cysts, *Neascus* sp. These fish were liberally peppered with these cysts.

(7) *Moxostoma rubreques* Hubbs
Greater red horse

	Trout	*Snake*	*Clear*	*Pinkeye*
Examined 4	1	1	1	1
Infected 2	1		1	
Ergasilus caeruleus	1^2			
**Triaenophorus nodulosus*			1^1	
***Triganodistomum* sp.	1^1		1^1	

(8) *Cyprinus carpio* Linn.
Carp

	Lake-du-Bay (Marathon Co.)
Examined 10	10
Infected 1	1
Gyrodactyloidae	1^1

Two gill flukes were the only parasites secured from 10 young carp examined from Lake-du-Bay.

(9) *Rhinichthys atratulus meleagris* Agassiz
Western blacknose dace

	Woodruff Hatchery Marsh Pond	*Brule River Headwater*	*Brule River Ranger Station*
Examined 9	1	1	7
Infected 6	1		5
Acanthocephala	1^1		
**Neascus* sp.	1^1		
***Rhabodochonia* sp.			4^1
**Tetracotyle* sp.			2^1

(10) *Chrosomus eos* Cope
Northern redbelly dace

	Woodruff Hatchery Marsh Pond
Examined 10	10
Infected 6	6
**Clinostomum marginatum*	1^1
**Neascus* sp.	4^1
***Spiroxys* sp.	2^1

(11) *Notemigonus crysoleucas auratus* (Raf.)
Western golden shiner

	Moose Lake
Examined 2	2
Infected	

(12) *Notropis cornutus frontalis* (Agassiz)
Northern common shiner

	Trout Lake	Snake Lake
Examined 4	2	2
Infected 3	2	1
**Clinostomum marginatum*	1[1]	
**Neascus* sp.	2[1]	1[1]

(13) *Notropis anogenus* Forbes
Pugnose shiner

	Madeline Lake
Examined 1	1
Infected	

(14) *Pimephales promelas promelas* Raf.
Northern Fathead minnow

	Madeline Lake
Examined 1	1
Infected 1	1
**Neascus* sp.	1[1]

(15) *Hyborhynchus notatus* (Raf.)
Bluntnose minnow

	North Two Lake	Shell Lake	Johnson Lake
Examined 16	9	5	2
Infected 6	5	1	
**Cestode*	5[1]		
**Neascus* sp.	1	1[1]	

(16) *Ameiurus melas melas* (Raf.)
Northern black bullhead

	Moose Lake
Examined 3	3
Infected 3	3
Alloglossidium corti	1[1]
Azygia angusticauda	1[1]
Corollobothrium fimbriatum	1[1]
	1[2]
Dichelyne robusta	1[1]
Gyrodactyloidae	2[2]
Leptorhynochoides thecatus	1[1]
Myxobolus sp.	1[1]
Pomphorhynchus bulbocolli	1[1]

The three black bullheads were adults from 15-25 cm. in length. They were taken in fyke nets from Moose Lake in Langlade County. All parasites were found in small numbers; 1 to 3 per host except for 1 black bullhead that had 12 *C. fimbriatum* and 2 hosts that had 10-20 gill flukes.

(17) *Ameiurus nebulosus nebulosus* (LeSueur)
Northern brown bullhead

	Trout Lake	Minocqua Thoroughfare	Yellow River	Lake-du-Bay	Spooner	Chetac
Examined 49	1	13	14	19	1	1
Infected 49	1	13	14	19	1	1
Alloglossidium geminus	1^{1}	10^{1}	10^{1}			
		2^{2}	2^{2}	1^{1}	1^{1}	
***Bothriocephalus cuspidatus*		2^{1}				
**Clinostomum marginatum*			1^{1}			
Corallobothrium fimbriatum	1^{1}	4^{1}	2^{1}	13^{1}		
		1^{2}				
***Crepidostomum* sp.		1^{1}	1^{1}			
Dichelyne robusta		3^{1}	7^{1}			
			2^{2}			
			1^{3}			
Ergasilus versicolor				3^{1}	1^{1}	
Gyrodactyloidae		3^{1}	10^{2}	15^{1}	1^{1}	
		4^{2}	4^{3}	3^{2}		
Leptorhynchoides thecatus	1^{1}		1^{1}			
**Leptorhynchoides thecatus*			1^{1}			
Myxobolus sp.		1^{2}	3^{1}			
Phillodistomum staffordi	1^{1}	7^{1}	6^{1}		1^{1}	1^{2}
		1^{2}	1^{2}			
Pomphorhynchus bulbocolli			2^{1}			1^{1}
**Proteocephalus ambloplitis*			3^{1}	1^{1}		
***Proteocephalus* sp.		2^{1}				
Spinitectus sp.		1^{1}				

(17) The majority of brown bullheads came from three locations while single individuals were examined from three lakes. Four species of parasites made up the largest number of those taken; gill flukes, *A. geminus*, *C. fimbriatum*, and *P. staffordi*. The last named form, *P. staffordi* a fluke found in the urinary bladder was taken in 8 of 65 brown bullheads during the survey of Algonquin Park Lakes, Bangham (1940b). It was not secured from 23 Reelfoot Lake brown bullheads, Bangham and Venard (1942) or from 22 Florida bullheads, Bangham (1940). In one instance 25 *P. staffordi* were taken from a single brown bullhead from Minocqua Thoroughfare.

(18) *Ameiurus natalis natalis* (LeSueur)
Northern yellow bullhead

	Lake Minocqua Thoroughfare
Examined 1	1
Infected 1	1
Alloglossidium geminus	1[2]
***Camallanus* sp.	1[2]
Corallobothrium fimbriatum	1[1]
Dichelyne robusta	1[1]
Gyrodactyloidae	1[1]
**Proteocephalus ambloplitis*	1[1]

(19) *Schilbeodes gyrinus* (Mitchill)
Tadpole madtom

	Lake-du-Bay
Examined 1	1
Infected 1	1
Gyrodactyloidae	1[1]

(20) *Umbra limi* (Kirtland)
Mud minnow

	Woodruff Hatchery Marsh	*Bass Lake*	*Lake Minocqua Thoroughfare*
Examined 20	18	1	1
Infected 14	14		
Bunoderina eucaliae	9[1]		
Hepaticola bakeri	8[1]		
	1[2]		
**Neascus* sp.	1[1]		
	1[2]		

All infected mud minnows were secured from a small marsh pond above the Woodruff Hatchery. *B. eucaliae* has been previously reported as parasite of the brook stickleback Miller (1936) and Bangham and Hunter (1939). Brook stickleback from this pond also were infected with this small fluke. *H. bakeri* was taken from 8 of the 20 mud minnows from the Woodruff marsh pond. This small, delicate nematode was described by Mueller and Van Cleave (1932) from *Leucichthys artedi tullibee, Notemigonus crysoleucas* and *Catostomus commersonnii*. It was reported for a ling or burbot from Lake Opeongo (Ont.), Bangham (1940).

(21) ***Esox lucius*** **Linnaeus**
Northern pike

	Mid Lake	*Minocqua Thor.*	*Yellow River*	*Cable Lake*	*Spooner Lake*	*Little Brule fgl*	*Lake-du-Bay fgl*
Examined 34	10	5	4	1	4	2	8
Infected 34	10	5	4	1	4	2	8
Azygia angusticauda	5^1	3^1	2^1		2^1		
			2^2				
Contracaecum brachyurum					2^1		
Crepidostomum cooperi		1^1	1^1				
**Diplostomulum* sp.	4^1		2^2		3^1		
			2^2				
Gyrodactyloidae	1^1	3^2	1^2		2^2		1^1
			3^2		2^3		
***Haplonema* sp.					1^1		
					1^2		
Leptorhynchoides thecatus	1^1	1^1					
**Neascus* sp.	10^2	2^1	2^2		1^1		
			2^3		1^2		
Neoechinorhynchus tenellus	3^1						1^1
Proteocephalus pinguis	3^1	3^1	1^1	1^1	2^1	2^1	6^1
	3^2	2^2	1^2		2^2		2^1
	4^3						
Spinitectus gracilis			2^1				
			1^2				
Triaenophorus nodulosus					1^1		

(21) *P. pinguis* was the form most commonly encountered. This cestode was secured from all but 2 of the 34 northern pike. External strigeids, *Neascus* sp. were found encysted in the skin and flesh of 18 of the northern pike. Gill flukes were obtained from 13 of these fish. Hunter and Rankin (1940) report on the parasites of the northern pike and pickerel from Connecticut. They found in 11 *E. lucius* the following: *A. angusticauda, P. pinguis,* larval *P. ambloplitis* and Spiruidae. They summarize in this report the parasites found in recent New York State surveys, giving 11 different species for the northern pike. Six species not reported from the northern pike from New York were found in Wisconsin. These are, *C. brachyurum, Haplonema* sp., *N. tenellus, Diplostomulum* sp. *C. cooperi* and *T. nodulosus.* All of these were found in some other species of fish during the survey. *C. brachyurum, Haplonema* sp, and a single adult *T. nodulosus* were taken from Spooner Lake northern pike.

The tiny nematodes *S. gracilis* were found in this host in but one location, the Yellow River Flowage at Spooner.

(22) Hybrid northern pike-muskellunge

	Woodruff Hatchery
Examined 3	3
Infected 3	3
***Azygia angusticauda*	1[1]
**Clinostomum marginatum* (free in intestine)	1[1]
***Leptorhynchoides thecatus*	1[1]
**Neascus* sp.	1[3]
***Proteocephalus pinguis*	2[1]

(22) The hybrid northern pike-muskellunge were all secured from the Woodruff Hatchery pond. They measured from 55.7 cm. to 65 cm. in length and all but the encysted *Neascus* sp. were immature and in the digestive tract.

(23) *Esox masquinongy masquinongy* Mitchill
Great Lakes muskellunge

	Minocqua Thorough fare	*Woodruff Hatchery Pond # 4*	*Carroll Lake*	*Spooner Hatchery*
Examined 17	2	12	1	2
Infected 17	2	12	1	2
***Azygia angusticauda*	1[1]			
Crypotogonimus chyli		5[1]		1[1]
Leptorhynchus thecatus	1[1]			
Neoechinorhynchus tenellus	2[1]		1[2]	
**Philometra* sp.			1[1]	
***Proteocephalus pinguis*	1[1]	10[1]		1[1]
**Triaenophorus nodulosus*	2[2]		1[2]	
Trichodina renicola	1[3]			
Trichodina sp. (gills)	1[3]		1[3]	

All but three of the muskellunge were immature individuals from hatchery ponds at Woodruff and Spooner. These carried immature cestodes *P. pinguis* and adults of a small species of flukes, *C. chyli*. Two adults from Minocqua Thoroughfare and one from Carroll Lake had more numerous parasite species. In one muskellunge *T. renicola* were present in large numbers in the urinary bladder. Mueller (1931 and 1932) described this form from the urinary tract of the chain pickerel in Oneida Lake. Hunter and Rankin (1940) report *T. renicola* from *E. niger* and *E. americanus* in Connecticut. Another form belonging to the genus *Trichodina* was secured from the gills of the host of *T. renicola* and also from the Carroll Lake muskellunge. This appears to be a new species and if it proves to be it will be described elsewhere. A single large female *Philometra* sp. was taken from a cyst in the body cavity of the Carroll Lake fish. Two species of Acanthocephala, *L. thecatus* and *N. tenellus*, were present in small numbers in the intestines of the adult fish. *T. nodulosus* cysts were found in moderate numbers in the three adults.

(24) *Fundulus diaphanus menona* Jordan and Copeland

	Island Lake
Examined 1	1
Infected 1	1
**Clinostomum marginatum*	1^1
Gyrodactyloidae	1^1
**Neascus* sp.	1^1
**Nematode	1^1
***Neoechinorhynchus cylindratus*	1^1

(25) *Perca flavescens* (Mitchill)
Yellow perch

More yellow perch were examined during the survey than any other species of fish. These also came from a larger number of locations. From the 261 infected perch the following forms were most frequently encountered: *Neascus* sp. from 224, Gyrodactyloidae from 184, *Diplostomulum scheuringi* from 151, larval *P. pearsei* from 147, *C. marginatum* cysts from 118, *D. cotylophora* from 100 and *T. nodulosus* cysts from 77. All other parasite species listed on the table were secured in from 1 to 50 of the yellow perch examined.

Adult flukes with the exception of one species of gill fluke were less numerous than the larval forms. *A. angusticauda, B. sacculata, C. cooperi* were secured in a part of the perch from 14 to 16 lakes, while *C. chyli* and an unidentified form were taken from perch in one location.

Acanthocephala were not abundant in yellow perch. *L. thecatus* was found in perch from 9 lakes while 7 lakes yielded perch infected with *N. cylindratus*. *P. bulbocolli* was secured from 10 of the 21 perch examined from Sweeny Lake.

D. cotylophora was the species of nematode secured most often from the yellow perch. *Spinitectus* sp. was found in 32 perch from 8 locations and larval *Camallanus* sp. from 14 from 6 lakes. A mature encysted specimen of *P. cylindracea* was secured from a Trout Lake yellow perch.

(25) *Perca flavescens* (Mitchill)
Yellow perch

	Blue	Trout	Johnson	N. Big Two	Madeline	Carroll	Mid	Pickerel (Langlade Co.)	Arbor Vitae	Bass	Little John	Minocqua Thoroughfare	Snake	Nebish	Yellow River (Washburn Co.)	Cable (Washburn Co.)	Casey Creek (Washburn Co.)	Island (Washburn Co.)	Spooner (fgl) (Washburn Co.)	Chetac (Sawyer Co.)	Holly	Moose (Langlade Co.)	Lavedu Bay (Marathon Co.)	White Sand	Sweeny	Clear	Big Carr	Muskallonge	Pinkeye
Examined 269	1	5	27	5	41	11	3	1	3	6	12	7	16	10	1	1	1	7	9	10	4	4	9	12	21	18	2	5	17
Infected 261	1	5	27	5	41	11	3	1	3	5	12	7	16	10	1	1	1	7	9	10	4	4	2	12	21	18	2	5	17
Azygia angusticauda		1^1	3^1								1^1	1^1	2^1					1^1	2^1	1^1	1^1	2^1		1^1	1^1			3^1	2^1
***Bothriocephalus cuspidatus*			1^1				1^1	1^1	1^1	1^1	1^1	1^1						5^1	1^1	2^1	1^1				3^1	3^1		1^1	
Bunodera sacculata		2^1	2^1			1^1			1^1		7^1	2^1	3^1	8^1				4^1	8^1		3^1	1^1		1^1	1^1			1^2	1^1
***Camallanus* sp.			1^2				2^1	1^1		2^1				1^1						3^1									
			4^1																	2^2									3^1
**Clinostomum marginatum*		2^1	8^1		7^1	5^1	2^1	1^1	1^2		5^1		2^1	2^1	1^1	1^1	1^1	1^2		4^1	1^1	2^1		4^1	11^1			1^1	2^1
			6^2		21^2	3^2	1^2				7^2	1^1		1^2						3^2					5^2			2^2	2^1
					2^3															1^3					1^3				
Crepidostomum cooperi		1^1	3^2		6^1	1^1		1^1				2^1			1^1		1^1	1^1						2^1	8^1	4^1		1^1	5^1
																									3^2				8^1
Cryptogonimus chyli			2^1																										
Dichelyne cotylophora		1^1	17^1		9^1	4^1	1^1		2^1		1^1		4^1			1^1				5^1			1^1	8^1	13^1				
			2^2			6^2														1^2		3^1		2^2	5^2	1^1	1^1	1^1	7^1
**Diplostomulum* sp. (1)		4^1	12^1	1^1	15^1	8^1	1^1		1^1		4^1	5^1	3^1	6^1	1^2	1^1	1^2	5^1		4^1	2^1	3^1		8^1	7^1			3^2	1^1
			2^2		6^2		1^2				6^2	1^2								5^2	1^2	1^2		2^2	2^2	12^1		4^1	7^1
																													9^1
**Diplostomulum* sp. (2)		2^1	1^1		3^1	4^1														1^1	1^1								
					1^2	1^2														1^2	1^2				2^1				
Ergasilus caeruleus		1^1								1^2														2^1					
		1^2																						2^2					

**Fluke (gall bladder)					1^{1}																								
Glochidia					1^{2}																								
					1^{3}													**Contracaelum				1^{1}							
Gyrodactyloidae	1^{2}	1^{1}	3^{1}	2^{1}	10^{1}	5^{1}	1^{1}		2^{1}	2^{1}	8^{1}	4^{1}	12^{1}	6^{1}	1^{2}	1^{2}	1^{1}	4^{1}	5^{1}	3^{1}	1^{1}	2^{1}		5^{1}	15^{1}	5^{1}	2^{2}	5^{2}	2^{1}
			9^{2}	3^{2}	13^{2}	3^{2}			1^{2}		2^{2}		2^{2}	2^{2}				2^{2}		3^{2}	1^{2}	2^{2}		3^{2}	1^{2}	10^{2}			8^{1}
																					1^{3}			1^{1}					3^{2}
Ichthyophthirius multifiliis				2^{2}																									
Illinobdella sp.				1^{1}																									
Leptorhynchoides thecatus		2^{1}													1^{1}	1^{1}		1^{1}	3^{1}	1^{1}				1^{1}	3^{1}	1^{1}			
		1^{2}																											
Myxosporidia					1^{3}	1^{1}																							
**Neascus* sp.		3^{1}	21^{1}		6^{1}	6^{1}	2^{1}	1^{1}	2^{1}	1^{1}	9^{1}	5^{1}	13^{1}	8^{1}	1^{2}	1^{1}	1^{2}	4^{1}	4^{1}	6^{1}	2^{1}	3^{1}	2^{1}	7^{1}	10^{1}	12^{1}	1^{1}	3^{2}	11^{1}
		1^{2}	5^{2}		17^{2}	4^{2}	1^{1}		1^{2}		1^{2}	1^{2}	2^{2}	2^{2}				1^{2}		3^{2}	1^{2}			4^{2}	10^{2}	2^{2}			5^{1}
			1^{3}		11^{3}	1^{3}												1^{3}		1^{3}				1^{3}	1^{3}				
Neoechinorhynchus cylindratus	1^{1}	1^{1}			2^{1}														1^{1}	3^{1}				1^{1}	4^{1}				
Philometra cylindracea		1^{1}																											
Pomphorhynchus bulbocolli			1^{1}																						10^{1}				
**Posthodiplostomum minimum*											1^{1}	1^{1}																	
**Proteocephalus ambloplitis*						3^{1}						1^{1}		6^{1}				1^{1}											1^{1}
														2^{2}															
***Proteocephalus pearsei*	1^{1}	6^{1}			16^{1}	6^{1}	1^{1}		1^{1}	2^{1}	7^{1}	2^{1}	11^{1}	4^{1}			4^{1}	8^{1}	2^{1}		1^{1}	7^{1}	8^{1}	10^{1}	2^{1}	4^{2}		9^{1}	
		2^{2}				2^{2}					4^{2}	2^{2}	3^{2}	2^{2}								2^{2}	4^{2}	6^{2}				6^{1}	
Proteocephalus pearsei						2^{1}						1^{2}	1^{3}		1^{1}													3^{1}	
Spinitectus sp.	2^{1}	10^{1}	4^{1}		3^{1}			1^{1}														1^{1}		7^{1}	1^{1}				
		3^{2}																											
**Trianophorus nodulosus*	2^{1}	13^{1}			14^{1}	5^{1}	1^{1}			5^{2}		1^{1}	5^{1}						1^{1}				8^{1}		1^{1}				
					3^{3}							2^{2}							1^{2}			2^{1}	4^{2}	8^{1}	1^{2}				

P. pearsei was the only adult cestode obtained from the yellow perch. Many also carried immature forms belonging to this species.

B. cuspidatus was secured as immature forms from half of the lakes where yellow perch were examined. *T. nodulosus* was found in liver or mesentery cysts from perch in 13 lakes and *P. ambloplitis* cysts were taken from a portion of the yellow perch in five lakes.

The parasitic gill copepod *E. caeruleus* was secured from a few perch in three lakes.

The most abundant form, *Neascus* sp. was found as small integumentary cysts about the size of a pin head, deeply pigmented on or just under the scales. Others were often found deeper in the muscle septa. Some of the yellow perch were liberally peppered with these tiny cysts. *C. marginatum*, the yellow grub was found most frequently encysted about the gills. Some were in the flesh especially near the bases of the fins. Early in the survey only large metacercariae were encountered but about the middle of July many tiny cysts of this species were found. These were probably obtained this season while the larger forms represented an infection of the previous year. Late in July and in August many perch were found with larger metacercariae whose cyst walls were thin and the *C. marginatum* would emerge with slight handling of the fish. It is the opinion of the writer that many of these parasites may thus be lost from the host in this manner.

Two species of eye grubs were taken. The larger appeared to be *D. scheuringi* and the smaller *D. huronense*. Both were found in the aqueous and vitreous humor of the eye. Very few were secured from the lens.

P. minimum another strigeid was secured from but 11 perch in 4 lakes. The infection with this form was light in all of these fish.

(26) *Stizostedion vitreum vitreum* (Mitchill)
Walleyed pike perch.

All of 84 walleyed pike perch from 15 lakes carried parasites. *B. cuspidatus* was found in 79 of these fish. This cestode was usually adult and often many were found in one host. Along with this form was another cestode species, *P. stizostethi*, first described by Hunter and Bangham (1933) from the pike perch of Lake Erie. *T. nodulosus*, a third cestode, was found as encysted larvae in the liver and viscera of 3 hosts from different lakes.

Three species of Acanthocephala were found in pike perch during the survey. These were *N. tenellus, L. thecatus* and *P. bulbocolli, N. tenellus* was widely distributed and often many individuals were found in one host.

A. aculeatus a monogenetic fluke was taken from the gills of 36 pike perch while a second species of gill fluke was obtained from 2 hosts. Four species of larval encysted flukes were encountered, the most frequently found being skin cysts of *U. ambloplitis*. *D. scheuringi* was found in the eyes of 24 pike perch. *P. minimum* and *C. marginatum* were secured from 1 and 3 hosts, respectively. *B. pusilla* was the adult fluke most often found. This small form was secured while *Crepidostomum* sp. and *A. angusticauda* were found in a few of the pike perch.

Nematodes were not frequently taken. The three pike perch examined from Rolling Stone Lake in Langlade County had from 50 to 250 *Contracae-*

(26) *Stizostedion vitreum vitreum* (Mitchill)
Walleyed pike perch

	Minocqua Thoro.	Pickerel	Blue	Squaw	Mid	Arbor Vitae	Trout	Madeline	Cable	Snake	Rolling Stone	Butternut	Shell	Clear	Johnson
Examined 84	16	7	9	1	1	1	1	3	4	1	3	9	12	11	5
Infected 84	16	7	9	1	1	1	1	3	4	1	3	9	12	11	5
Ancyrocephalus aculeatus	7^{1}	1^{1}		1^{3}		1^{3}		3^{2}	1^{1}			1^{1}		7^{2}	2^{3}
	3^{2}														
Azygia angusticauda	2^{1}								1^{1}						
Bothriocephalus cuspidatus	11^{1}	2^{1}	1^{1}	1^{2}	1^{1}	1^{2}	1^{2}	1^{3}	2^{1}	1^{3}	1^{2}	4^{1}	4^{2}	6^{1}	3^{1}
	4^{2}	2^{2}	7^{2}					1^{1}	2^{2}		1^{3}	5^{2}	8^{3}	3^{2}	2^{2}
			1^{3}												
Bucephalopsis pusilla	7^{1}					1^{1}		1^{2}	1^{1}	1^{2}		2^{1}	2^{1}		
***Camallanus* sp.		2^{1}		1^{1}								1^{1}			
		2^{2}													
**Clinostomum marginatum*	3^{1}														
Contracaecum sp.		1^{1}									1^{2}				
											2^{3}				
Crepidostomum sp.	1^{1}														
Diplostomulum scheuringi	3^{1}	3^{1}	2^{1}				1^{1}	1^{1}	4^{1}	1^{a}			7^{1}	1^{1}	
													1^{2}		
Ergasilus caeruleus	1^{a}		5^{2}			1^{2}	1^{1}			1^{2}		2^{1}			
	1^{2}		4^{3}									2^{2}			
Glochidia	1^{2}														
Gyrodactyloidae (2)	1^{1}														1^{a}
Illinobdella moorei			1^{1}	1^{2}								2^{1}			
												2^{2}			
Leptorhynchoides thecatus			2^{1}								1^{1}	3^{a}	2^{1}		
**Leptorhynchoides thecatus*			1^{1}												
Lymphocystis johnstonei											1^{2}				
Myxobolus sp.			1^{2}							1^{3}					
Neoechinorhyncus tenellus	6^{1}	2^{1}	2^{1}	1^{2}	1^{1}	1^{2}		1^{1}			1^{1}	7^{1}	1^{1}		4^{1}
	3^{2}	4^{2}	7^{2}					2^{2}			1^{2}	1^{2}			
	1^{3}	1^{3}									1^{3}				
Pomphorhyncus bulbocolli			1^{1}												
**Posthodiplostomum minimum*														1^{1}	
Proteocephalus stizostethi	7^{1}	3^{1}	5^{1}		1^{a}			3^{1}	4^{1}	1^{1}	2^{1}	2^{1}	11^{1}	5^{a}	2^{1}
	1^{2}	3^{2}	3^{2}								1^{2}		1^{2}	4^{2}	
Spinitectus sp.	1^{1}											2^{a}	2^{1}	1^{1}	
												4^{2}	1^{2}		
												2^{3}			
**Trianenophorus nodulosus*	1^{1}							1^{a}						1^{1}	
**Uvulifer amblopliti*s	10^{1}		5^{1}	1^{2}	1^{1}	1^{a}		2^{1}	2^{1}	1^{1}		1^{1}	1^{1}	9^{1}	3^{2}
	5^{2}							1^{2}	1^{2}			2^{3}		1^{2}	

cum sp. free in their intestinal tracts. The only other place this nematode was encountered in pike perch was in 1 of 7 from Pickerel Lake, a lake next to Rolling Stone Lake. This infected host had 15 *Contracaecum* sp. Immature *Camallanus* sp. and *Spinitectus* sp. were other nematodes secured from pike perch.

The gill copepod *E. caeruleus* was taken from all of the pike perch from Blue, Arbor Vitae, Trout and Snake Lakes but only single specimens were examined from the last three lakes. Two of 16 from Minocqua Thoroughfare and 4 of 9 from Butternut Lake also carried this parasitic copepod.

A leech *I. moorei* was found in the mouth and pharyngeal cavities of pike perch from Blue, Squaw and Butternut Lakes. One host from Squaw and two from Butternut had from 10-17 of these leeches, while the remainder carried from 1-3 in the same part of the mouth cavity.

L. johnstonei, a filterable virus causing a disfiguring "Warty" skin, was found in a single pike perch from Rolling Stone Lake.

The first pike perch examined on May 22 carried a number of glochidia on its gills. No other glochidia were secured in pike perch examined later in the season.

(27) *Percina caprodes semifasciata* (De Kay)
Northern log perch

	Shell Lake—Washburn Co.
Examined 1	1
Infected	

(28) *Boleosoma nigrum nigrum* (Raf.)
Central Johnny darter

	Shell Lake
Examined 1	1
Infected	

(29) *Poecilichthys exilis* (Girard)
Iowa darter

	Madeline Lake	*Minocqua Thoroughfare*
Examined 2	1	1
Infected 1	1	
**Neascus* sp.	1^2	

(30) *Micropterus dolomieu dolomieu* (Lacépède)
Northern small mouth bass

Small mouth bass were obtained from 8 lakes in Vilas and Oneida Counties and all of 44 individuals examined were parasitized. Thirty were from Bass and Clear Lakes, which are seepage lakes with a low amount of bound carbon dioxide. Clear Lake has an area of 922 acres while Bass Lake contains about 30 acres. Eight species of parasites were carried by the 15 Bass Lake fish and there were 11 different parasite species in the Clear Lake small mouth bass. Five of these were the same in the two lakes. Digenetic trematodes were absent from the host in Bass Lake, as were Acanthocephala. There was found in the Clear Lake fish 1 specie of Acanthocephala and 4 species of digenetic flukes but usually in smaller numbers than in the small mouth bass from other lakes.

(30) *Micropterus dolomieu dolomieu* Lacépède
Northern small mouth bass

	Blue	Trout	Madeline	Little John	Bass	Clear	Nebish	White Sand
Examined 44	1	1	1	4	15	15	5	2
Infected 44	1	1	1	4	15	15	5	2
Achtheres micropteri		1^{1}		2^{1}	7^{1}			
Azygia angusticauda			1^{1}					
***Bothriocephalus cuspidatus*	1^{1}							
***Camallanus* sp.	1^{2}				7^{1}			
Capillaria catenata				2^{1}				
Clinostomum marginatum						2^{1}		
Contracaecum sp.							1^{1}	
Crepidostomum sp.				1^{1}		1^{1}		
Cryptogonimus chyli	1^{3}	1^{3}	1^{3}					2^{3}
Dichelyne cotylophora			1^{1}					
**Diplostomulum* sp.						2^{2}		
Ergasilus caeruleus	1^{2}	1^{3}	1^{2}					2^{3}
Gyrodactyloidae	1^{2}		1^{2}	4^{2}	2^{1}	9^{1}	2^{1}	1^{2}
					2^{2}	2^{2}	1^{2}	1^{3}
Illinobdella sp.		1^{1}						
Leptorhynchoides thecatus	1^{2}	1^{2}	1^{1}	1^{2}		5^{1}		2^{1}
**Neascus* sp.	1^{1}	1^{1}	1^{2}	2^{1}		9^{1}	3^{1}	2^{1}
				2^{2}		1^{2}		
Neoechinorhynchus cylindratus	1^{1}		1^{1}					1^{1}
								1^{2}
Paramphistomum stunkardi						1^{1}		
Philometra sp.						1^{1}		
Proteocephalus ambloplitis					5^{1}		1^{1}	
					1^{2}			
**Proteocephalus ambloplitis*		1^{2}	1^{1}	3^{2}	7^{1}	9^{1}	1^{1}	2^{1}
					3^{2}	2^{2}	1^{2}	
Proteocephalus fluviatilis					1^{1}			
Proteocephalus pearsei	1^{3}							
***Proteocephalus pearsei*	1^{1}			1^{1}	2^{1}	10^{1}	2^{1}	1^{1}
				3^{2}				
Spinitectus carolini				1^{1}	1^{1}	5^{5}		
				1^{2}				
**Triaenophorus nodulosus*					4^{1}			
					3^{2}			

From all areas larval *P. ambloplitis* was the parasite most frequently encountered. Liver and visceral cysts were found in bass from all but one of the lakes. Adults belonging to this species were secured from small mouth bass from Nebish and Bass Lakes. *P. fluviatilis*, a cestode usually found only in stream bass, were secured from one Bass Lake specimen. Larval *P. pearsei* were found in 20 small mouth bass from 6 lakes. The bass examined from Blue Lake and from 60-70 adult *P. pearsei* as well as many larvae. Both the *P. fluviatilis* and *P. pearsei* mature in one fish after the procercoid has been taken in with an infected copepod. Early *B. cuspidatus* larvae were found free in the intestinal tract of the Blue Lake bass while 7 fish from Bass Lake carried cysts of *T. nodulosus.*

Black cysts of *Neascus* sp. were found in the skin and flesh of 22 small mouth bass out of the 29 examined from all of the lakes except Bass Lake. Encysted *C. marginatum* and *Diplostomulum* sp. were only taken from Clear Lake bass. *P. stunkardi* was secured from one Clear Lake host, *C. chyli* a small delicate fluke was found in large numbers in the pyloric caeca and intestine of 5 bass from 4 areas. These were all of the bass examined from those lakes. *A. angusticauda* was taken from the Madeline Lake bass while two hosts from Little John and Nebish Lakes yielded *Crepidostomum* sp. Gill flukes were found on 20 bass from 7 lakes.

Two species of Acanthocephala were found: *L. thecatus* in a part of the bass from 6 areas and *N. cylindratus* from the bass of 3 lakes. Nematodes were not found in large numbers. Immature *Camallanus* sp. were taken from Blue and Bass Lake fish while *S. carolini* were found in small mouth bass from Little John, Bass and Clear Lakes. A single infection was observed for *D. cotylophora* from a Madeline Lake host, *Contracacecum* sp. from Nebish Lake and an eye cyst with *Philometra* sp. from a Clear Lake host. Two bass from Little John carried small numbers of *C. catenata.*

Two species of gill copepods were taken, *A. micropteri* on 10 hosts from 3 lakes and *E. caeruleus* on 5 hosts from 4 lakes.

(31) *Huro salmoides* (Lacépède)
Large mouth bass

All of the large mouth bass carried parasites except four yearling fish from Bullhead Lake. Almost one-third of the large mouth bass were fingerlings.

A majority of the parasites belonged to the same species as those found in the small mouth bass. The hosts were examined from a wider area. With the exception of 4 bass bearing small numbers of *Neascus* sp. cysts, no digenetic flukes or acanthocephalan species were obtained in 34 bass from soft water seepage lakes. These lakes North Two, Little John Jr., Bass, and Bullhead had a pH of 5.8-5.9 and the bound carbon dioxide ranged from .7-1.6 P. P. M. It is possible that the first intermediate hosts of the missing parasites had difficulty in survival.

The cestodes were the same as found in the small mouth bass; *P. ambloplitis* encysted larvae in the viscera and immature forms in the intestine, immature *P. pearsei* in the intestine, immature and adult *P. fluviatilis* in the intestine of 11 hosts from Bass Lake and Minocqua Thoroughfare, immature *Bothriocephalus* sp. from the intestine of 2 Bass Lake fish and encysted

(31) *Huro salmoides* (Lacépède)
Large mouth bass

	Madeline	N. Big Two	Minocqua Thoro.	fgl.	Bass	Carroll	Clear	Tozer	Chetac	Spooner fgl.	Woodruff fgl.	Little John	Little John Jr.	Snake	Big Carr	Pinkeye	Johnson	Bullhead
Examined 102	6	1	13	12	25	2	9	2	2	4	3	1	2	1	2	7	1	6
Infected 98	6	1	13	12	25	2	9	2	2	4	3	1	2	1	2	7	1	2
Achteres micropteri					1^{1}													
**Agamonema* sp.																		1^{1}
***Azygia angusticauda*	1^{1}		4^{4}	1^{1}										1^{1}				
***Bothriocephalus* sp.					2^{1}													
***Camallanus* sp.			1^{1}		8^{4}			2^{1}					1^{1}					
Capillaria catenata							1^{1}											
**Clinostomum marginatum*	1^{1}		3^{1}				1^{1}	1^{4}										
Crepidostomum sp.	1^{1}						3^{1}		1^{1}			1^{1}				2^{1}		
Cryptogonimus chyli	2^{2}		2^{1}	4^{4}			2^{2}							1^{2}			1^{1}	
	1^{3}		3^{2}															
			5^{3}															
Dichelyne cotylophora			1^{1}									1^{1}						
**Diplostomulum* sp.			4^{1}	4^{4}				1^{1}	1^{4}									
Ergasilus caeruleus			4^{1}			1^{1}								1^{2}				
			2^{2}															
Gyrodactyloidae (1)	5^{2}		1^{1}	7^{1}	1^{4}	2^{2}	3^{1}	2^{2}	2^{2}	4^{2}	3^{1}	1^{2}	2^{2}		2^{2}	3^{2}	1^{2}	
	1^{3}		8^{2}		18^{2}		5^{2}											
			1^{3}		2^{3}													
Gyrodactyloidae (2)				5^{1}			2^{1}		2^{1}					1^{2}	1^{1}			
Leptorhynchoides thecatus	1^{1}		4^{1}			1^{1}			2^{1}					1^{1}	1^{1}			
						1^{2}												
Myxobolus sp.			1^{2}	2^{1}				1^{2}										
				1^{2}														
**Neascus* sp.	1^{4}		5^{1}															
	4^{2}		3^{2}		4^{1}	2^{2}	3^{1}	2^{3}	1^{1}	1^{1}		1^{2}		1^{2}	1^{4}	5^{2}	1^{1}	
							5^{2}		1^{2}									
Neoechinorhynchus cylindratus	1^{1}		7^{1}			2^{1}			1^{2}					1^{1}				
									1^{3}									
**Neoechinorhynchus cylindratus*				2^{1}														
Philometra cylindraca								1^{1}										
**Posthodiplostomum minimum*	1^{2}		2^{3}											1^{2}				
**Proteocephalus ambloplitis*	3^{1}		5^{1}		6^{1}	1^{4}	5^{1}	1^{1}	2^{2}	1^{1}			2^{2}	1^{4}	1^{1}	5^{1}	1^{1}	
			3^{2}				1^{2}	1^{2}							1^{3}			
**Proteocephalus ambloplitis*	1^{1}		1^{1}		1^{1}		3^{1}								1^{1}			
Proteocephalus fluviatilis			5^{4}		3^{1}													
			3^{2}															
**Proteocephalus pearsei*	1^{1}	1^{1}		4^{1}	1^{1}	1^{1}	1^{1}	1^{4}		1^{1}	1^{1}			1^{1}		2^{3}	1^{1}	
Scyphidia micropteri		1^{2}																
Spinitectus carolini	2^{1}	1^{1}	5^{4}		2^{1}	1^{4}	1^{1}			1^{1}								2^{1}
			1^{2}															
**Triaenophorus nodulosus*	1^{1}		3^{1}		13^{1}													
					3^{2}												1^{1}	

T. nodulosus. Sixteen of the 21 bass infected with this last form came from Bass Lake.

Gill flukes were commonly found on the majority of large mouth bass, at least 2 species being present on some of the hosts. Many of the older bass bore infections with *Neascus* sp. and a few were found to carry *C. marginatum* and *P. minimum.* Light infections with *Diplostomulum* sp. were found in the eyes of 10 bass. The most common adult fluke was *C. chyli. A. angusticauda* and *Crepidostomum* sp. were also secured from a few individuals.

The following nematode species were taken from 1 to 16 bass during the survey: *S. carolini, Camallanus* sp., *C. catenta., D. cotylophora, P. cylindraca* and *Agamonema* sp.

L. thecatus and *N. cylindratus* were obtained from several of the bass. In many instances both species were carried by the same host. The infections were lighter and distributions more scattered than found in large mouth bass studied by the investigator in other regions.

Gill copepods were scarce, *A. micropteri* being found on one host from Bass Lake and *E. caeruleus,* on 8 bass from 3 areas.

(32) *Lepomis gibbosus* (Linnaeus)
Pumpkinseed, common sunfish

All of the 76 common sunfish from 15 areas bore parasites. Many larval flukes were found in these fish. The black grubs, *Neascus* sp. were encysted in 62 common sunfish taken from all of the areas except Bullhead Lake. *P. minimum,* the white grub of the liver was found in 46 sunfish from all but 3 lakes. *C. marginatum,* the yellow grub was encysted about the gill cavities and in the flesh of 30 fish from 9 areas and *D. scheuringi* was taken from the eyes of 39 sunfish in 8 areas. Adult flukes were less frequently encountered. The following species were secured from a portion of the sunfish examined: *C. cooperi, C. cornutum* and *A. angusticauda.* Gill flukes were present in many of the hosts.

Five species of cestodes were recorded for the common sunfish. One adult *B. claviceps* was taken from a Nebish Lake sunfish. Immature *B. cuspidatus* were secured from single hosts in Lake Minocqua Thoroughfare and Johnson Lake. *P. pearsei* adults were found in sunfish from 2 areas and larvae of this species in the intestinal tracts of common sunfish from 4 areas. *P. ambloplitis* cysts were taken from 7 sunfish in 3 areas. *T. nodulosus* cysts came from 4 of the 24 fish examined from Lake Minocqua Thoroughfare.

S. carolini was the nematode species most frequently encountered, being secured from 24 host while *S. gracilis* was taken from 5 individuals. *D. cotylophora, Contracaecum* sp., *Camallanus* sp., *C. catenata* and *Agamonema* sp. were found in a few hosts.

Acanthocaphala were not frequently taken, *L. thecatus* being taken from 15 common sunfish in 6 areas as adults and in addition an Island Lake host yielded the encysted stage of this form. *N. cylindratus* was found in 2 hosts and *P. bulbocolli* in a Johnson Lake sunfish. *E. caeruleus* was found on the gills of 11 sunfish from Minocqua Thoroughfare, Island Lake and Johnson Lake.

(32) *Lepomis gibbosus* (Linnaeus)
Pumpkinseed, common sunfish

	Minocqua Thoro.	Bullhead	Madeline	Clear	Yellow River	Casey Creek	Island	Spooner	Chetac	Holly	Little John	Nebish	Moose	Big Carr	Johnson
Examined 76	24	8	3	7	9	1	7	1	3	1	1	1	3	2	5
Infected 76	24	8	3	7	9	1	7	1	3	1	1	1	3	2	5
**Agamonema* sp.	1^{1}				1^{1}										
Azygia angusticauda	2^{1}				2^{4}										
Bothriocephalus claviceps												1^{1}			
***Bothriocephalus cuspidatus*	1^{2}														1^{4}
***Camallanus* sp.							1^{1}			1^{1}					
Capillaria catenata							1^{1}								
**Clinostomum marginatum*	6^{1}			3^{1}	3^{4}		1^{1}	1^{2}	3^{2}		1^{4}		2^{1}		2^{1}
	8^{2}														
***Contracaecum* sp.						1^{1}									
Crepidostomum cooperi	4^{1}	1^{1}	1^{2}	1^{1}	2^{4}								1^{1}	1^{4}	
				2^{3}											
Crepidostomum cornutum	6^{1}	2^{1}		1^{1}	4^{4}		1^{1}				1^{1}				1^{1}
	1^{2}			2^{2}											
Dichelyne cotylophora	3^{1}		1^{1}										1^{1}		1^{1}
**Diplostomulum scheuringi*	9^{1}			1^{4}	2^{1}	1^{4}	5^{1}	1^{1}	3^{1}	1^{1}					
	10^{2}				5^{2}										
	1^{3}														
Ergasilus caeruleus	2^{2}						4^{2}								5^{2}
Gyrodactyloidae (1)	10^{2}	5^{2}	1^{2}	1^{1}	3^{2}	1^{1}	5^{2}		2^{3}	1^{2}			1^{2}	1^{2}	2^{2}
	7^{3}	3^{3}	1^{3}	4^{2}	5^{3}										
Gyrodactyloidae (2)	2^{2}			1^{2}						1^{1}	1^{1}				
Illinobdella sp.			1^{1}												
Leptorhynchoides thecatus	1^{1}				4^{1}	1^{4}	5^{1}				1^{1}				3^{1}
**Leptorhynchoides thecatus*							1^{1}								
**Neascus* sp.	17^{2}			3^{3}	4^{2}	1^{4}	1^{1}	1^{2}	2^{2}	1^{1}	1^{1}	1^{4}	2^{4}	1^{1}	1^{1}
	3^{3}			3^{2}	5^{3}		6^{2}		1^{3}				1^{3}		3^{2}
				1^{3}											2^{3}
Neoechinorhynchus cylindratus	2^{1}														
Pomphorhyncus bulbocolli															1^{1}
**Posthodiplostomum minimum*	7^{2}		3^{3}	1^{2}	1^{2}	1^{2}	2^{1}	1^{3}	1^{2}		1^{2}		2^{2}		2^{1}
	11^{3}				3^{3}		4^{3}		2^{3}						2^{2}
															2^{3}
**Proteocephalus ambloplitis*	3^{1}								1^{1}						2^{1}
	1^{2}														
Proteocephalus pearsei	1^{1}													2^{1}	
***Proteocephalus pearsei*	2^{1}	2^{1}		2^{1}	2^{1}										
	2^{2}														
Spinitectus carolini	9^{1}	3^{1}	1^{1}	2^{1}	1^{1}		3^{1}								1^{1}
	1^{3}														2^{2}
Spinitectus gracilis	1^{1}	1^{1}		1^{1}			1^{1}								1^{1}
**Triaenophorus nodulosus*	3^{4}														
	1^{2}														

(33) *Lepomis macrochirus macrochirus* Rafinesque
Common bluegill

		Blue	N. Two	Trout	Minocqua Thoro.	Madeline	Big Carr	du Bay	Carroll	Bass	Clear	Tozer	Yellow River	Cable	Casey Creek	Island	Chetac	Holly	Shell	Spooner	Johnson	Nebish	Little John	Little John Jr.
Examined	232	9	5	6	15	34	12	1	17	30	11	7	13	1	8	7	10	10	2	6	10	5	1	12
Infected	232	9	5	6	15	34	12	1	17	30	11	7	13	1	8	7	10	10	2	6	10	5	1	12
Achtheres micropteri			1^{1}													1^{1}	2^{1}							
**Agamonema* sp.			1^{1}																					
Azygia angusticauda					1^{1}											1^{1}	1^{1}							
Bothriocephalus claviceps																				1^{1}				
***Bothriocephalus cuspidatus*				1^{1}							1^{1}							1^{1}						
***Camallanus* sp.							1^{1}			21^{1}		3^{1}	1^{1}		1^{1}	4^{1}	1^{1}	4^{1}		1^{1}		1^{1}		4^{1}
																		1^{2}						
**Clinostomum marginatum*				1^{1}	1^{1}	1^{1}						1^{1}	5^{1}							1^{1}				
Contracaecum sp.											1^{1}													
Crepidostomum cooperi		2^{1}	4^{1}		5^{1}	14^{1}	1^{1}		7^{1}		3^{1}	1^{1}	4^{1}			1^{1}	1^{1}	1^{1}	2^{1}			1^{1}		
		4^{2}				6^{2}			1^{2}		3^{2}													
Crepidostomum cornutum		2^{1}				2^{1}																		
Cryptogonimus chyli		3^{2}			2^{1}	1^{1}																		
						1^{2}																		
**Diplostomulum scheuringi*					9^{1}	1^{1}			1^{1}			2^{1}	7^{1}	1^{1}	7^{1}	3^{1}	8^{1}	1^{1}	1^{1}	5^{1}	1^{1}	1^{1}		
					3^{2}								3^{2}			1^{2}								
Ergasilus caeruleus		1^{1}		1^{2}				1^{2}								1^{1}					2^{1}			

	1^{2}														2^{2}					7^{2}			
Glochidia	1^{2}																						
Gyrodactyloidae (1)	2^{2}		2^{2}	7^{2}	18^{2}	6^{2}	1^{1}	4^{2}	24^{1}	4^{4}	3^{2}	8^{2}	1^{2}	1^{1}	2^{1}	7^{2}	4^{1}	1^{1}	1^{1}	1^{1}	3^{4}	1^{2}	10^{1}
			2^{3}	6^{3}	3^{3}			12^{3}	5^{2}	4^{2}	3^{3}	4^{3}		3^{2}	5^{2}	2^{3}	5^{2}		1^{2}	5^{2}			2^{2}
Gyrodactyloidae (2)				5^{2}				4^{2}				6^{1}		2^{2}		6^{1}	9^{1}	1^{1}	2^{1}	1^{1}		1^{1}	
												2^{2}				3^{2}							
Illinobdella sp.	1^{1}				1^{4}																		
Leptorhynchoides thecatus		1^{1}	1^{1}		1^{1}			2^{1}				7^{1}		1^{1}		6^{1}			6^{1}	1^{4}			
**Leptorhynchoides thecatus*								1^{1}															
Myxobolus sp.											1^{2}												
**Neascus* sp.	2^{1}	4^{1}	3^{4}	1^{1}	13^{1}	6^{1}		15^{2}	2^{1}	9^{1}	3^{1}	5^{1}	1^{1}	8^{1}	2^{1}	8^{1}	7^{1}	1^{1}	5^{1}	9^{1}	5^{1}	1^{4}	
	2^{2}	1^{2}		9^{2}	8^{2}			2^{3}		1^{1}	4^{2}	6^{2}			5^{2}	2^{2}	3^{2}			1^{2}			
	4^{3}			1^{3}	5^{3}							2^{3}											
**Neascus* sp. (internal)					1^{1}			2^{1}															
Neoechinorhynchus cylindratus								1^{1}															
Pomphorhynchus bulbocolli														2^{1}									
														1^{2}									
**Posthodiplostomum minimum*	3^{2}		4^{2}	5^{2}	6^{1}	1^{3}		4^{2}		1^{1}	4^{2}	10^{2}	1^{2}	2^{2}	1^{3}	2^{1}	3^{1}	1^{4}	4^{1}	2^{1}		1^{1}	
	4^{3}		2^{3}	6^{2}	14^{2}			12^{3}				2^{3}		4^{3}	3^{2}	1^{2}		1^{2}	2^{2}	3^{2}			
					11^{3}											4^{3}							
**Proteocephalus ambloplitis*	1^{4}	1^{1}		1^{1}	3^{1}	4^{1}		2^{1}			2^{1}		1^{1}		1^{1}	1^{1}	1^{4}			2^{1}	2^{1}		4^{1}
															1^{2}								
***Proteocephalus pearsei*	1^{4}	1^{1}		1^{1}	2^{1}					1^{1}				1^{4}							1^{1}	1^{4}	
***Proteocephalus stizostethi*										1^{1}													
Spinitectus carolini	5^{2}	4^{1}		3^{1}	16^{1}			9^{1}		1^{1}	2^{1}	4^{4}	1^{1}	6^{1}	2^{4}	7^{1}	1^{1}	2^{2}	3^{1}	2^{1}			1^{4}
	3^{3}			8^{2}	4^{2}			5^{2}			2^{2}	1^{2}			4^{2}	3^{2}							
					2^{3}			3^{3}															
**Triaenophorus nodulosus*	1^{1}	1^{1}		2^{1}	4^{1}	5^{1}		3^{4}	19^{1}							5^{1}	1^{1}						
					1^{2}				1^{2}								1^{2}						

(33) All of 232 bluegills from 23 locations carried at least one species of parasite. *P. minimum* the white grub of the liver was found in 133 bluegills. The livers of 39 were riddled and many cysts were attached to the hearts of these fish. Cysts were also found near the surface of the spleen and kidneys of the heavily infected bluegills. *Neascus* sp. were found in pigmented cysts in 166 bluegills, 14 of these hosts being heavily infected. Another larval strigeid species was secured from mesentry cysts of 4 bluegills. *D. scheuringi* was taken from the eyes of 55 hosts. *C. marginatum* was not often found in bluegills, being taken in small numbers in 10 hosts from 6 areas. *C. cooperi* was the adult fluke most frequently observed, being obtained from 61 bluegills. *C. cornutum, C. chyli* and *A. angusticauda* were found in a few hosts.

Cestodes were not abundant in these fish, encysted *P. ambloplitis* being secured from 27 hosts in 14 areas. One adult *B. claviceps* was secured from a Spooner Lake bluegill. Larval *B. cuspidatus* were taken from 3 bluegills and larval *P. pearsei* from 9. *S. carolini* was the only species of adult nematode frequently taken, being found in 104 bluegills from 17 locations. Immature *Camallanus* sp. were found in 43 of these fish while *Contracaecum* sp. and a larval encysted form were obtained from single hosts.

L. thecatus was secured from the intestine of 26 bluegills and as a larval encysted form from a Carroll Lake host. *N. cylindratus* was found in 1 Carroll Lake bluegill while 4 of 8 bluegills from Casey Creek carried *P. bulbocolli.* Gill copepods were not frequently taken, *A. micropteri* being observed and *E. caeruleus* on 15 from 5 areas.

(34) *Ambloplitis rupestris* (Raf.)
Rock bass

		Blue	Madeline	Trout	Little John	Arbor Vitae	Nebish	White Sand	Pinkeye	Yellow River	Shell	Carroll	Clear
Examined	107	11	13	1	4	2	5	10	16	6	5	13	21
Infected	107	11	13	1	4	2	5	10	16	6	5	13	21
Achtheres micropteri								1^{1}					2^{1}
Azygia angusticauda												1^{1}	
Bothriocephalus claviceps								1^{1}					
***Bothriocephalus* sp.											2^{2}		
***Camallanus* sp.		2^{1}					3^{1}		2^{1}		1^{1}		
											1^{2}		
Capillaria catenata													15^{2}
													5^{3}
**Clinostomum marginatum*		5^{1}	5^{1}		2^{1}			5^{1}	3^{1}	2^{1}		5^{1}	3^{1}
			1^{2}		2^{2}								3^{2}
***Contracaecum* sp.								5^{1}	10^{1}				5^{1}
Crepidostomum cooperi		1^{1}	1^{1}						1^{1}	1^{1}	1^{1}		3^{1}
													2^{2}

(34) *Ambloplitis rupestris* (Raf.) (continued)
Rock bass

	Blue	Madeline	Trout	Little John	Arbor Vitae	Nebish	White Sand	Pinkeye	Yellow River	Shell	Carroll	Clear
Cryptogonimus chyli	3^2	3^2	1^3	1^2	2^2	1^2	6^2		1^2	1^2	3^1	
	6^3	7^3		3^3			2^3		3^3	1^3	3^2	
											2^3	
Dichelyne cotylophora								1^1		1^1	1^1	
**Diplostomulum scheuringi*	7^1	10^1	1^1		1^1		3^1	2^1	2^1	4^1	6^1	6^1
	2^2	1^2							2^3	1^2	2^2	
Ergasilus caeruleus	1^2	7^2			2^2		4^2			2^2	1^1	
	1^3	1^3					5^3				10^2	
Ergasilus elegans		1^2										
Gyrodactyloidae	1^2	5^2	1^2	3^2	2^2	2^1	9^2	2^1	2^2	3^2	11^2	4^1
	1^3							5^2	3^3			2^2
Illinobdella sp.					1^1				1^1			
Leptorhynchoides thecatus	6^1	4^1		2^1			5^1		3^1	3^1	9^1	2^1
	3^2	1^2					1^2		1^2	2^2	2^2	
**Leptorhynchoides thecatus*	1^1				2^2		1^1					
Myxosporidia	1^2			1^3								
**Neascus* sp.	4^2	4^1	1^2	3^2	2^2	5^1	7^1	12^1	2^2	2^1	9^1	13^1
	7^3	4^2		1^3			3^2	4^2	4^3	2^2	2^2	8^2
		5^3									2^3	
Neoechinorhynchus cylindratus	2^1	1^1			1^1		1^1			1^2	5^1	
		2^2									1^2	
**Posthodiplostomum minimum*	1^1	2^1		3^2	2^2	1^2	2^1		1^2	2^1	7^2	4^1
	3^2	9^2		1^3			2^2			1^3		12^2
												3^3
Phyllodistomum sp.	1^1											
**Proteocephalus ambloplitis*				1^1		1^1	1^1	11^1	1^2	1^1	1^1	1^1
								4^2		1^2		
***Proteocephalus ambloplitis*								2^1	2^1			
Proteocephalus pearsei	1^1	1^1						2^1	1^1		2^1	
***Proteocephalus pearsei*	3^1	1^1										
		4^2		1^1		2^1	1^1	3^1		2^2	2^1	
Spinitectus carolini	3^1			3^1						1^2	1^2	3^1
											1^1	2^2
Spinitectus gracilis				2^1						2^1		1^1
Spinitectus sp.										2^3	3^1	3^1
												1^3

(34) All of 107 rock bass from 12 lakes were infected and the individuals carried more parasites than were present in most other species of fish.

All but one carried cysts of *Neascus* sp. and 19 from 5 lakes were heavily parasitized with these black cysts. *P. minimum* was found in fewer rock bass, being secured from 56. Light to moderate infections of *C. marginatum* were found in 36 hosts. Fifty rock bass yielded *D. scheuringi* and 56 carried at least one species of gill fluke. *C. chyli* was secured in 49 rock bass from all but two of the lakes. All of the fish bore large numbers of this small fluke. *C. cooperi* was found in 10 rock bass from 6 lakes while single hosts yielded *A. angusticauda* and *Phyllodistomum* sp.

P. pearsei was the cestode most frequently encountered. This small form has both larval and mature stages within the intestinal tract of the host. Adult *P. pearsei* were taken from 7 hosts and immature forms from 25. Immature *P. ambloplitis* were secured from 4 hosts and encysted stages of this form in 23 fish from 8 lakes. Pinkeye Lake yielded the majority of these. An adult *B. claviceps* was taken in a rock bass from White Sand Lake and 2 Shell Lake hosts carried immature *Bothriocephalus* sp.

Immature *Spinitectus* sp. nematodes were found in 13 rock bass from 6 lakes, *S. carolini* adults in 9 hosts from 5 lakes and *S. gracilis* in 2 Shell Lake hosts. Immature *Contracaecum* sp., probably *C. brachyurum*, were taken from 20 rock bass at Clear, Carroll and Pinkeye lakes. *C. catenata* was found in all but one of the 21 Clear Lake specimens. Five were heavily infected with this delicate form. *D. cotylophora* was taken in 3 hosts from different lakes.

Of the Acanthocphala *L. thecatus* was most frequently encountered, being obtained in 44 rock bass in 8 lakes as adults and from 4 as encysted, immature forms. *N. cylindratus* was taken from 14 rock bass.

Three species of parasitic copepods were secured; *A. micropteri* from 3 individuals in 2 lakes, *E. elegans* from a single Madeline Lake host and *E. caeruleus* on 34 rock bass from 6 lakes.

(35) *Promoxis nigro-maculatus* (LeSueur)
Black crappie

The black crappies from 10 areas were less heavily infected than any other species of Centrarchidae. Many of the same species of parasites were found but in fewer hosts and with a low degree of infection. Gill flukes were the most common parasitic form. Larval encysted flukes were not frequently taken. *D. scheuringi* was secured from the eyes of 12 black crappies from 5 areas.

The 10 hosts from Lake-du-Bay yielded few parasites. This same condition was true for many other species of fish examined from this large, newly impounded, area. Many of the life cycles are not yet established. All black crappies from this area have gill flukes and all but one had gill copepods, *E. caeruleus*. A single host carried 4 eye flukes.

(35) *Promoxis nigro-maculatus* (LeSueur)
Black crappie

	Blue	Mid	Carroll	Arbor Vitae	Madeline	Bass	Yellow River	Chetac	Moose	Lake-du-Bay
Examined 67	3	10	22	1	2	7	1	7	4	10
Infected 63	2	10	21	1	2	5	1	7	4	10
**Agamonema* sp.		1^{1}								
***Camallanus* sp.		2^{1}						5^{1}		
Cryptogonimus chyli	2^{2}						1^{1}			
**Diplostomulum scheuringi*			1^{1}				1^{2}	6^{1}	2^{1}	1^{1}
								1^{2}		
Ergasilus caeruleus										9^{2}
Gyrodactyloidae (1)	1^{1}	2^{1}	16^{1}		2^{2}			3^{1}	1^{1}	10^{2}
			4^{2}					3^{2}	2^{2}	
Gyrodactyloidae (2)			2^{1}	1^{1}						
Leptorhynchoides thecatus								7^{1}		
**Leptorhynchoides thecatus*			1^{1}					1^{1}		
**Neascus* sp.			8^{1}	1^{1}				1^{1}		
Neoechinorhynchus cylindratus			1^{1}							
**Posthodiplostomum minimum*								1^{1}		
								2^{2}		
**Proteocephalus ambloplitis*			4^{1}				1^{1}	5^{1}		
			1^{2}							
***Proteocephalus pearsei*		1^{1}				4^{1}				
Spinitectus sp.	1^{1}	5^{1}						1^{1}		
**Triaenophorus nodulosus*						2^{1}				

(36) ***Cottus bairdii bairdii* Girard**
Millers thumb

	Little Brule river	*Brule hatchery creek*
Examined 2	1	1
Infected		

(37) *Eucalia inconstans* (Kirtland)
Brook stickleback

	Woodruff Hatchery Pond	*Woodruff Hatchery Marsh*	*Brule Hatchery Creek*	*Bass*
Examined 28	13	10	4	1
Infected 20	6	10	3	1
**Agamonema* sp.	1^{1}			1^{1}
Bunoderina eucaliae		4^{1}		
		6^{2}		
*Cestode	1^{1}		3^{1}	
Gyrodactyloidae				
**Neascus* sp. (viscera)				
Neoechinorhynchus sp.	4^{1}			
**Triaenophorus nodulosus*	2^{1}			1^{1}

(38) *Lota lota maculosa* (LeSueur)
Burbot

	Trout	Boot
Examined 2	1	1
Infected 2	1	1
Acanthocephala		
Abothrium crassum	1^{2}	1^{1}
Azygia angusticauda	1^{1}	
**Diplostomulum* sp.	1^{2}	
Haplonema hamulatum	1^{2}	1^{1}
Hepaticola bakeri	1^{1}	
Leptorhynchoides thecatus	1^{1}	1^{1}

Check List of Parasites

Trematoda

Alloglossidium corti (Lamont, 1921)
Alloglossidium geminus (Mueller, 1930)
Ancyrocephalus aculeatus Van Cleave and Mueller, 1932
Azygia angusticauda (Stafford, 1904)
Bucephalopsis pusilla (Stafford, 1904)
Bunodera sacculata Van Cleave and Mueller, 1932
Bunoderina eucaliae Miller, 1936
Clinostomum marginatum (Rud., 1819)
Crepidostomum cooperi Hopkins, 1931
Crepidostomum cornutum (Osborn, 1903)
Crepidostomum sp.
Cryptogonimus chyli Osborn, 1903
Diplostomulum scheuringi Hughes, 1929
Diplostomulum sp.
Gyrodactyloidae
Macroderoides typicus (Winfield, 1929)
Neascus sp.
Octomacrum lanceatum Mueller, 1934
Paramphistomum stunkardi Holl, 1929
Phyllodistomum sp.
Phyllodistomum staffordi Pearse, 1924
Posthodiplostomum minimum (MacCallum, 1921)
Tetracotyle sp.
Triganodistomum attenuatum Mueller and Van Cleave, 1932
Triganodistomum sp.
Uvulifer ambloplitis (Hughes, 1927)

Cestoda

Abothrium crassum (Bloch, 1779)
Bothriocephalus claviceps (Goeze, 1782)
Bothriocephalus cuspidatus Cooper, 1917
Bothriocephalus sp.

CESTODA (continued)

Corallobothrium fimbriatum Essex, 1928
Glaridacris catostomi Cooper, 1920
Proteocephalus ambloplitis (Leidy, 1887)
Proteocephalus fluviatilis Bangham, 1925
Proteocephalus laruei Faust, 1919
Proteocephalus pearsei La Rue, 1919
Proteocephalus perplexus La Rue, 1911
Proteocephalus pinguis La Rue, 1911
Proteocephalus sp.
Proteocephalus stizostethi Hunter and Bangham, 1933
Triaenophorus nodulosus (Pallas, 1781)

NEMATODA

Agamonema sp.
Camallanus sp.
Capillaria catenata Van Cleave and Mueller, 1932
Contracaecum brachyurum (Ward and Magath, 1917)
Contracaecum sp.
Dichelyne cotylophora (Ward and Magath, 1917)
Dichelyne robusta (Van Cleave and Mueller, 1932)
Haplonema immutatum Ward and Magath, 1917
Haplonema hamulatum Moulton, 1931
Haplonema sp.
Hepaticola bakeri Mueller and Van Cleave, 1932
Philometra cylindraca (Ward and Magath, 1917)
Philometra nodulosa Thomas, 1928
Philometra sp.
Rhabdochonia sp.
Spinitectus carolini Holl, 1928
Spinitectus gracilis Ward and Magath, 1917
Spinitectus sp.
Spiroxys sp.

ACANTHOCEPHALA

Leptorhynchoides thecatus (Linton, 1891)
Neoechinorhynchus crassus Van Cleave, 1919
Neochinorhynchus cylindratus (Van Cleave, 1913)
Neoechinorhynchus sp.
Neoechinorhynchus tenellus (Van Cleave, 1913)
Octospinifer macilentus Van Cleave, 1919
Pomphorhynchus bulbocolli Linkins (in Van Cleave, 1919)

COPEPODA

Achtheres micropteri Wright, 1882
Argulus catostomi Dana and Herrick, 1837
Ergasilus caeruleus Wilson, 1911
Ergasilus elegans Wilson, 1914

COPEPODA (continued)

Ergasilus sp.
Ergasilus versicolor Wilson, 1911

PROTOZOA

Ichthyophthirius multifiliis Fouquet, 1876
Lymphocystis johnstonei Woodcock, 1904
Myxobolus sp.
Scyphidia micropteri Surber, 1940
Trichodina renicola Mueller, 1932
Trichodina sp.

MOLLUSCA

Glochidia

HIRUDINEA

Illinobdella moorei Meyer, 1940
Illinobdella sp.

LITERATURE CITED

Bangham, R. V.
1940. Parasites of fresh-water fish of Southern Florida. Proc. Fla. Acad. Sci., 5:289-307.
1940. Parasites of fish of Algonquin Park lakes. Trans. Am. Fish Soc., 70:161-171.
1941. Parasites from fish of Buckeye Lake, Ohio. Ohio Jour. Sci., 41:441-448.

Bangham, R. V. and Hunter, G. W., III
1939. Studies on fish parasites of Lake Erie. Distribution studies. Zoologica. 24:385-448.

Bangham, R. V. and Venard, C. E.
1942. Studies on parasites of Reelfoot Lake fish. IV. Distribution studies and checklist. Tenn. Acad. Sci., 17:22-38.

Cross, S. X.
1933. Some host parasite relationships of the Trout Lake region of Northern Wisconsin. Jour. Parasitol., 20:132.
1934. A probable case of non-specific immunity between two parasites of ciscoes of the Trout Lake region of northern Wisconsin. *Ibid.*, 20:244.
1935. The effect of parasitism on growth of perch in the Trout Lake region. *Ibid.*, 21:267-273.
1938. A study of the fish parasite relationships in the Trout Lake region of Wisconsin. Trans. Wis. Acad. Sci., 31: 439-456.

Hunter, G. W. III and Rankin, J. S.
1940. Parasites of northern pike and pickerel. Trans. Am. Fish. Soc., 69: 268-272.

Miller, M. J.
1936. *Bunoderina eucaliae* gen. et sp. nov., A new papilose Allocreadiidae from the Stickelback. Canad. Jour. Res., 14:11-14.

Mueller, J. F.

1931. A new species of Cyclochaeta from the uterus and urinary bladder of *Esox reticulatus* (Abstract) Jour. of Parasitol. 18:126.

1932. *Trichodina renicola* (Mueller, 1931), a ciliate parasite of the urinary tract of *Esox niger*. Roosevelt Wild Life Annals 3(2): 139-154.

1934. Additional notes on parasites of Oneida Lake fishes, including descriptions of new species. *Ibid.*, 3:335-373.

Mueller, J. F. and Van Cleave, H. J.

1932. Parasites of Oneida Lake fishes Part 2. Descriptions of new species and some general taxonomic considerations especially concerning the trematoda family Heterophyidae. *Ibid.*, 3: 77-137.

Pearse, A. S.

1924. Observation on parasitic worms from Wisconsin fishes. Trans. Wis. Acad. Sci., 21:147-160.

1924. The parasites of lake fishes. *Ibid.*, 21:161-194.

SYRPHID FLIES OF THE GENUS *CHEILOSIA*, SUBGENUS *CHILOMYIA* IN NORTH AMERICA (PART II) *

C. L. FLUKE

University of Wisconsin

F. M. HULL

University of Mississippi

This subgenus was erected by Shannon (Ins. Insc, Menst., 10: 121) to separate out those hairy-eyed species that have pile on the slopes of the face in addition to that on the facial strips. The antennal pits are separated by a distinct chitinized projection. Sometimes the pile of the face is not so conspicuous on the female, and may be entirely absent, as happens in *Cheilosia hirsuta* Hull and Fluke and apparently in *Cheilosia nigrovittata* Lov. These two species are very closely related and *hirsuta* may be only a variety. For this reason these two are included in the key to the species of *Chilomyia*. Other members of the genus are readily placed in this group, as far as we have observed. *C. occidentalis* Will. has been selected by Shannon as type of the subgenus.

Most of the species of *Chilomyia* occur in Western North America, only two so far being found along the Eastern sections of North America, namely: *primoveris* Shannon and *pontiaca* Shannon. In the higher altitudes of the Rockies they are quite common in midsummer. Since a few species are known to be of economic importance, a careful study of the group is necessary. They are difficult to determine but due to the relatively few species in this subgenus no particular trouble should arise in making determinations.

Both sexes are not always known and since the two differ so materially it will be a long time before all synonomy is cleared up. Collections of large series at the same time and place will help to associate the sexes. Even then difficulties may arise. When Lovett described his species *chintimini* he did not recog-

* Goffe, 1944, Ent. Mont. Mag. 80: 238. This important paper on generic synonomy was received after the manuscript was submitted for publication.

Explanation of Figures

All drawings were made with the aid of the camera lucida. Basal segment omitted on the antennal drawings.

FIG. 1—*Chilomyia variseta*, n. sp., profile of head of female with lines added to show tubercle angles.

FIG. 2—*Chilomyia hoodiana* Bigot, antenna of male.

FIG. 3—*Chilomyia hoodiana* Bigot, profile of head of female.

FIG. 4—*Chilomyia yukonensis* Shannon, profile of head of male.

FIG. 5—*Chilomyia variseta*, n. sp., profile of head of male.

FIG. 6—*Chilomyia varipila*, n. sp., profile of head of male.

FIG. 7—*Chilomyia pontiaca* Shannon, profile of head of female.

FIG. 8—*Chilomyia burkei* Shannon, profile of head of female.

FIG. 9—*Chilomyia burkei* Shannon, antenna of male.

FIG. 10—*Chilomyia chintimini* Lovett, profile of head of male.

FIG. 11—*Chilomyia fuma*, n. sp. profile of head of female.

FIG. 12—*Chilomyia primoveris* Shannon, antenna of female.

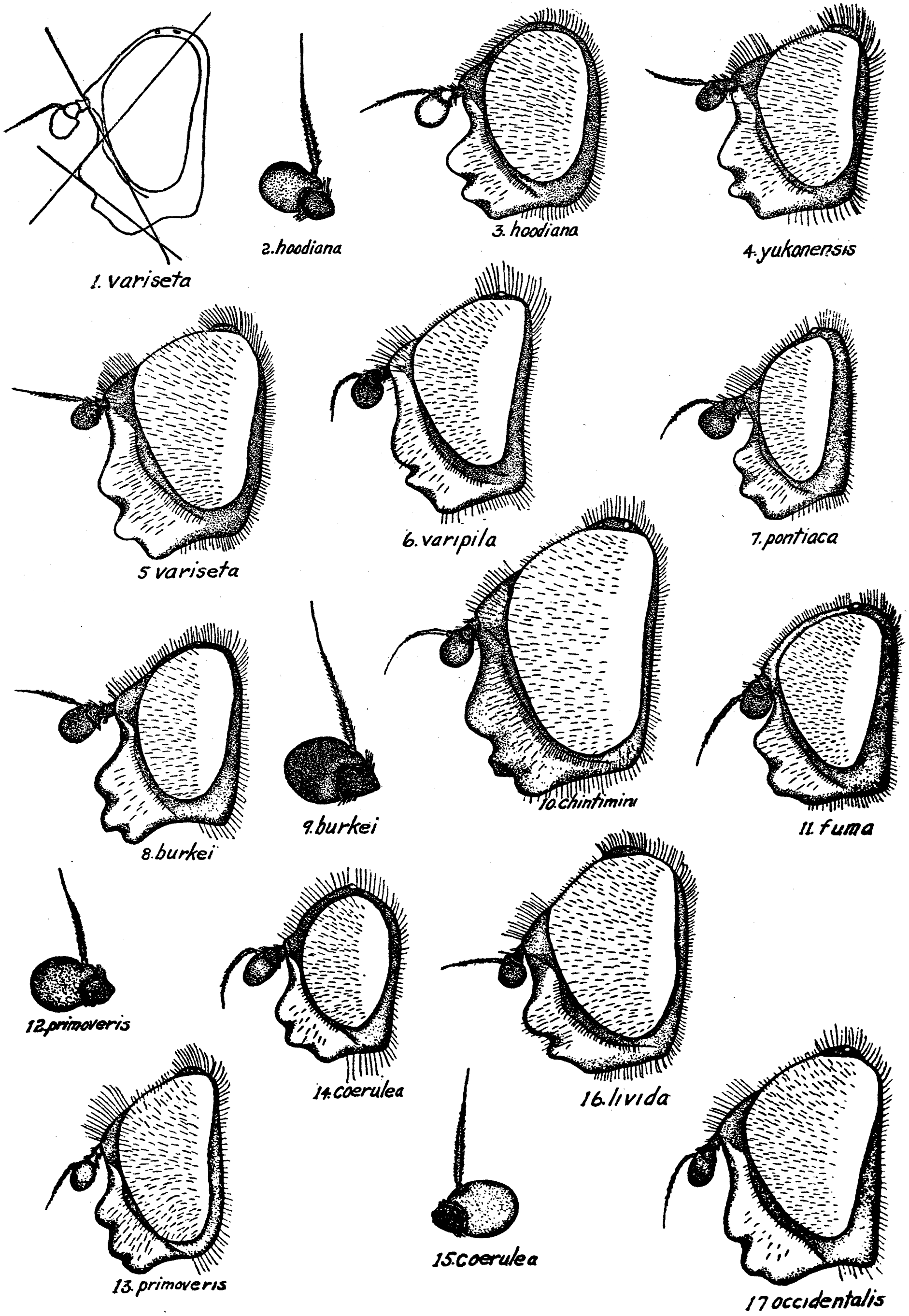
FIG. 13—*Chilomyia primoveris* Shannon, profile of head of male.

FIG. 14—*Chilomyia coerulea*, n. sp., profile of head of female.

FIG. 15—*Chilomyia coerulea*, n. sp., antenna of female.

FIG. 16—*Chilomyia livida* Wehr, profile of head of male.

FIG. 17—*Chilomyia occidentalis* Williston, profile of head of male.


1. variseta
2. hoodiana
3. hoodiana
4. yukonensis
5 variseta
6. varipila
7. pontiaca
8. burkei
9. burkei
10. chintimini
11. fuma
12. primoveris
13. primoveris
14. coerulea
15. coerulea
16. livida
17 occidentalis

nize the female, as a subsequent study of his material shows, even though he had it before him at the time.

It has always been difficult to describe the facial tubercle, whether prominent or low, and the amount of the excavation above. Figure 1 has been drawn with lines to help in determining the angles made by the various shapes of the tubercle. It should be remembered that the two sexes often differ in the prominence of the tubercle but the general trends can be indicated by this method.

Those who have been of special aid in these studies were mentioned in Part I but for this Part we wish especially to thank Dr. H. A. Scullen of Oregon State College and Dr. C. H. Curran of the American Museum.

Table of Species—Males

1. Dorsum of thorax entirely covered with dark brown or black pile, rarely a few pale hairs along the anterior margin 2
   Dorsum of thorax with at least some pale, whitish brassy, or silvery pile visible, sometimes mixed with black or brown pile 3
2. Thorax anteriorly with two obscure gray vittae, visible from behind (Western) ....*hoodiana* Big.
   Thorax non-vittate 7
3. Thorax with a distinct band of black pile (Oregon) ....
   ....*Cheilosia nigrovittata* Lov.
   Thorax not banded, though the black pile may be concentrated just before the scutellum 4
4. Thick white pilose species 5
   At least considerable black pile upon mesonotum or abdomen or hind legs; often predominantly brassy pilose 6
5. Scutellum with black bristles on the margin, pile of front black (California) ....*pacifica* Hunt.
   Scutellum covered entirely with silky yellowish white pile, pile of front white (Colorado) ....*livida* Wehr.
6. Legs black, the bases of the tibia sometimes very dark brown (Alaska)
   ....*yukonensis* Shan.
   Legs with the bases of the tibia and their apices and the tarsi light in color or yellowish-red to reddish 11
7. Pile along the lateral margins of the abdomen everywhere dense and long, black in color; sometimes with yellowish hair in the basal corners of the tergites 8
   Pile of those areas chiefly pale; sometimes with a few black hairs on the margin of the fourth tergite and all black on the margins of the second tergite 9
8. Downward projecting pile below the rim of the scutellum yellow in color, halteres brown (Oregon) ....*chintimini* Lov.
   This pile black, halteres yellow (Washington) ....*burkei* Shan.

9. Fourth tergite with thick, long, pale yellow pile; only the central part with black pile; thorax red-brown pollinose viewed from in front, a little pale pile mixed with the black along the anterior and posterior margins (Western) .... *variseta* n. sp.
   Pile of the fourth tergite less dense, black in the middle and on the apical corners 10
10. Pile on the scutellum white and black mixed, tip of arista black .... *yukonensis* Shan.
   Pile of the disk of the scutellum wholly black, tip of arista yellow (Alberta) .... *varipila* n. sp.
11. Rather large flies; the facial strips wide, densely pale pubescent, pale pilose; facial pile pale with some black hairs intermixed; sometimes largely black pilose, lighter areas of legs tending usually towards brown, stigma and veins brownish; apical and hypopygial pile black; pile of basal ventral half of hind femora golden (California) ....*occidentalis* Will.
   Medium sized flies, the facial strips narrow, sparsely pubescent, apparently bare; facial pile chiefly pale; lighter areas of legs tending towards pale orange; stigma and the veins largely yellow; terminal pile of abdomen golden; femoral ventral pile black almost to base 12
12. Mesonotum almost wholly pale yellow pilose including area before scutellum and disc of scutellum; middle and hind tarsi light yellow; abdominal pile pale yellow, antennae light brown to orange; wing base pale yellow brown (Maryland) .... *primoveris* Shan.
   Mesonotum with some black pile mixed all over, especially before the scutellum, some on scutellar disc; antennae dark brown; wing base smoky (Western) ....*Cheilosia hirsuta* Hull and Fluke

Table of Species—Females

1. Thorax with gray vittae upon the anterior half, seen from behind, third antennal segment bright orange 2
   Thorax non-vittate 6
2. Pile of mesonotum mostly pale yellow or whitish; greenish black flies (Oregon) .... *hoodiana* Big.
   Pile of mesonotum black 3
3. Deep, shining blue in color, abdomen more robust, thoracic vittae obscure 4
   Shining bluish-black, pile of face white and black, abdomen more elongate; vittae median and distinct; thoracic pile quite appressed, wholly black except for pleura and sides of notopleura; subapical cross vein quite arcuate; third antennal segment bright orange (New Mexico) .... *sonoriana* Shan.
4. Scutellar discal pile mostly white (Washington) ....*coerulea* n. sp.
   Scutellar pile all black or nearly so 5
5. Tibiae yellowish at base, antennae orange, wing veins yellow (New Hampshire) .... *pontiaca* Shan.
   Legs darker, antennae darker, wing veins brownish yellow (Washington) .... *burkei* Shan.
6. Pile of thorax quite flat, extremely appressed 7

Pile of thorax erect or suberect, not obviously appressed 10
7. Scutellum with black bristles on margin 8
Scutellum without bristles, or if present, they are pale yellow in color ..9
8. Scutellar bristles quite short (Washington) ....*variseta* n. sp.
Scutellar bristles long and slender (California) ....*pacifica* Hunt.
9. Third antennal segment wholly brownish black; front with at least as much black pile as pale pile; mesonotal pile quite short, brassy, black in the middle. Scutellar margin with a few quite short golden bristles (Washington) ....*variseta* n. sp.
Third antennal segment reddish-brown, especially below, often rather light, its dorsal margin always blackish. Scutellar margin without any trace of short bristles (Alaska) ....*yukonensis* Shan.
10. Pile of hind tibia partly or wholly black, at least on outside 11
Pile of hind tibia wholly pale 14
11. Small, blue-black species; third antennal segment bright orange; facial, frontal, mesonotal pile black (Eastern) ....*pontiaca* Shan.
Usually larger; black aeneous or greenish-black species; this pile in part pale; third antennal segment dark brown or black on dorsal third or less 12
12. Scutellar margin with pale bristle like hairs (Alberta) .....*varipila* n. sp.
Scutellar margin with strong black bristles 13
13. Front swollen, pile of thorax mostly pale in color, rather short; small to medium sized species (Oregon) ....*fuma* n. sp.
Large, quite robust greenish or brassy-black flies, the front not swollen; front with a conspicuous shallow transverse impression in the lower portion; pile of thorax golden, with longer, fine black erect hairs intermixed (Oregon) ....*chintimini* Lov.
14. Scutellar bristles conspicuously differentiated from the golden discal pile, black in color; rather large, brassy-black flies 15
Scutellar bristles not well differentiated 16
15. Pile of front and mesonotum yellowish, usually a few black hairs intermixed (California) ....*occidentalis* Will.
Pile of front white, of mesonotum short and white, pile of abdomen white, short, dense and appressed except along the sides (California) ....*pacifica* Hunt.
16. Pile of greater and terminal part of abdomen erect; all pile everywhere light yellow to brassy; small flies, the tibia and tarsi and wing veins extensively light orange; one or two black notopleural bristles 17
Pile of fourth segment flattened posteriorly; pile white; larger flies, the tibia and tarsi less conspicuously orange; wing veins brown, no black notopleural bristles (Colorado) ....*livida* Wehr.
17. Tubercle of face distinct, but broad and low in profile. Front flattened and microrugulose (Maryland) ....*primoveris* Shan.
Tubercle small and short, (abrupt above and below) front trisulcate ....*primoveris* var.

Cheilosia (*Chilomyia*) *hoodiana* (Bigot)
Figures 2 and 3

Cartosyrphus hoodiana Bigot, 1883, Ann. Soc. Ent. France, No. 32, part 23, p. 552.

Chilosia petulca Williston, 1886, Bul. U. S. Natl. Mus. No. 31, p. 39.

Chilosia hoodiensis Williston, *Ibid.*, p. 292.

Chilosia hoodiana Shannon, 1922, Ins. Insc. Menst., 10: 131, 138.

A dark species with a pair of gray almost white pollinose vittae on the anterior half of the mesonotum, best seen from behind. Antennae of the male rather dark, somewhat reddish brown below, of the female characteristically yellowish. Pile of the mesonotum on the male black and erect; on the female partly appressed, mostly pale except for a setigerous black patch just above the wing base. Scutellum of the female with strong black bristles. Length 9 to 10 mm.

Distribution: OREGON (Type in Brit. Mus.)

Material reviewed: IDAHO—Craig Mts. 1 male July 8, 1918 (Melander); Moscow Mt. 3 females July 4-5, 1919 (Melander), 2 females July 10, 1920 (Shannon). OREGON—Ashland, Dead Indian Road 2 females July 19, 1943 (Scullen); Corvallis 1 male April 6, 1936 (Rieder); Mt. Hood 1 male July 29, 1921 (Downes), 2 females July 18, 1933 (Wilcox). WASHINGTON—Mt. Rainier 1 female July 14, 1914 (Fox), 1 male and 7 females July 7, 1926, 1 female July 17, 1926 (Darlington), 2 females August 14, 1932 (Baker), 1 male and 1 female July 25, 1936 (Baker); Paradise Inn 5 females July 19, 1931.

Records of others: British Columbia, Colorado, New Hampshire (error), New Mexico and Wisconsin.

Cheilosia (*Chilomyia*) *sonoriana* Shannon

Chilosia sonoriana Shannon, 1922, Ins. Insc. Menst., 10: 136.

A shining blue black species; pile of the face short, white below the tubercle, black next to the facial strips; tubercle prominent; antennae nearly round, bright orange (female). Mesonotum with short appressed black pile which is longer on the sides, a small tuft of black pile on the upper edge of the mesopleura; disc of the mesonotum with a pair of white vittae on the anterior half; in this respect quite similar to *hoodiana*. Scutellum with strong black bristles on the rim, pile on the disc white.

Distribution: NEW MEXICO (Type, a female in the U. S. National Museum).

Material reviewed: A single female from Moscow Mountains IDAHO (Hull Collection).

This specimen agrees in all essential details with the type except for the more whitish squamae and somewhat paler halteres.

Cheilosia (*Chilomyia*) *yukonensis* Shan.
Figure 4

Chilosia yukonensis Shannon, 1922, Ins. Insc. Menst., 10: 129.

Dark aeneous species with black and white pile. Scutellum with no prominent, strong bristles. Length 10 to 11 mm.

MALE:—Face shining, lightly pubescent, more heavily so below the antennae and along the facial strips. The pile on the sides of the face black, on the cheeks and facial strips white. Front somewhat inflated with a deep sulcus, pubescence white and confined mostly to the ocular border; the pile all black, the arch above the antennae shining orange colored. Antennae dark orange, first two segments almost brownish and the upper third of the third segment brown, sometimes nearly all brown; the arista brownish and pubescent. The ocellar tringle shiny black with long, black pile; the occiput shiny, white pubescence on lower half next to the eyes; the upper cilia black with a few white hairs near the vertex; pile on the lower half white. Pile of the eyes moderately heavy, whitish below becoming light brown above.

Thorax:—Mostly shiny, somewhat dulled on the disc of the mesonotum. Pile of the mesonotum is black and white mixed, mostly black on the notopleura; pile of the pleura mostly whitish with black hairs on the upper edges of the mesopleura and the pteropleura. Scutellum shiny with long yellow and black hairs on the discs and margins, shorter white hairs intermixed; the ventral fringe long and white. Legs dark brown, somewhat reddish brown on the tibiae; pile mostly black, a few white hairs at the base and outer sides of the femora; there are some exceptionally long hairs both black and white on the outer surfaces of the femora. Wings hyaline with light brownish tinge, the veins dark brown, stigma yellowish. Squamae whitish with yellowish border; plumule yellowish; halteres dark brown, the stalks light brown.

Abdomen:—Shining aeneous, opaque on the discs of the second and third tergites; the pile is mostly yellowish white and erect, except on the discs where they are partly black and flat. There are two or three black hairs on the anterior corners of the second tergite. Ventral hairs white.

FEMALE:—Mostly shining; hairs on the lower half of the front mostly pale, almost whitish; on the upper half of the front the white hairs are intermixed with black hairs, becoming all black around the ocelli. Just above the arch is a flat, shiny, slightly depressed area; there is also a shallow depression on the sides near the eye borders; on each side of the front a sulcus. The pile of the face is shorter and practically all white. Pile of mesonotum appressed and nearly all black, whitish along the sides. Pile of scutellum whitish sometimes with a few longer black hairs on the sides near the edge. There are about three or four black bristles on the postalar callosities, one on the notopleura, and four or five short ones just above the wing base. Legs lighter in color at the knees, the pile much shorter and paler in color. Pile of the abdomen mostly appressed beyond the second tergite.

Distribution: Type ALASKA. This species was named by Shannon but he gave no description and did not designate any types but a recent letter from Washington states that he did label a holotype.

Material reviewed: ALASKA—Firth to Lat. 69, June 27, 1920 (Jessup). COLORADO—Cameron Pass, 10 males, 7 females, (10,-500 feet), July 7, 1931; Pingree Park, 13 females (9,000 feet), July 9, 1931; North Park, 1 male, 2 females, July 1, 1932; Creede, 1 male, 6 females, June 24, 1926 (E. G. Anderson); Westcliffe, 2 males, June 12, 1926 (E. G. Anderson); Sargent, 1 male, June 24, 1929, (E. G. Anderson); Granite Peaks Camp, Bayfield, 2 females, July, 1928, (Bequaert); Rainbow Lakes, Boulder Co., 1 female June 15, 1936, (Rodeck); Long's Peak, 1 female, June 19, 1922; Grand Mesa, 1 female, July 8, 1938, (Rodeck); Lake City, 4 females, August 8-21, 1938, (Fluke). ALBERTA, Can.—Nordegg 2 males June 10, 1921 (McDunnough); Waterton 4 females June 24, 1923 (Seamans). BRITISH COLUMBIA—Hedley 3 males and 1 female July 3, 1923 (Garrett); Kootapnic Valley 1 female July 1, 1925 (MacDougall); Lilloet 1 female July 1, 1924 (MacDougall), 1 male July 10, 1916 (Phair), 1 female July 28, 1933 (McDunnough), 1 male July 12, 1926 (Buckell); Mt. Lolo, Kamloops 1 male June 2, 1938 (Jacob); Revelslake Mt. (6000 ft.) 1 female August 12, 1923 (Vroom).

Cheilosia (*Chilomyia*) *variseta* n. sp.
Figures 1 and 5

Shining black, the mesonotum of the male with faint brownish vittae. Scutellum of the male with long black bristle-like hairs on the margins; on the female the bristles are very short and nearly all black, occasionally a pale one. Length 10 to 11 mm.

MALE:—Front, face and cheeks shining black, very lightly whitish pollinose on the occular borders of the front, below the antennae, below the tubercle, and on the cheeks. Facial pile black, more whitish near the mouth and white on the cheeks; facial strips with white pile. There is a prominent patch of whitish pollen next to the eyes on the cheeks. Front shining with black pile; rather strongly inflated, but with a very deep median sulcus. Ocellar triangle semi-shining black with black pile. Occiput black and with black pubescence except very narrowly gray next to the eyes below; the pile all black above becoming yellowish on the lower third. Antennae dark reddish-brown, the arista black with short pubescence. Eyes brownish pilose becoming almost whitish on the lower half.

Thorax:—Mesonotum, scutellum and pleura shining black, with three faint brownish vittae which are seen best from the sides; the pile all black with a few whitish hairs near the scutellum. Pile of the pleura black, a few yellowish hairs on the sternopleura, and all white just above the front coxae. Pile of the scutellum rather long and mostly black with a few white hairs along the fore margin, the bristles of the edge not very strong; ventral fringe long and yellowish white.

Legs:—Dark reddish-brown to black, the tibiae slightly less darkened than the femora; the pile mostly black with the exception of a few white hairs at the base and outer sides of the femora, a few at the base of the coxae and golden on the undersides of the posterior metatarsi. Wings translucent, slightly yellowish on the anterior half, stigma yellow; squamae yellowish, the fringe long and yellow on the lower lobe, shorter and black on the upper lobe; plumule light brown; the halteres dark brown.

Abdomen:—Shining, very broadly opaque on the discs of the first three tergites and rather expanding on the posterior border of the second and third tergites. Pile entirely yellowish along the sides, but flat and black on the opaque areas; a patch of rather long black hairs at the basal corners of the first and second segments. Venter shining with pale pile.

FEMALE:—Front shining aeneous, pile black with shorter yellowish hairs intermixed; the usual depressed area above the shining arch and along the sides next to the eyes; pile of the face white. The median sulcus practically absent although present just below the median ocellus. Pile of the mesonotum flat, appressed and mostly all black, a few yellowish hairs both anteriorly and posteriorly; short black bristles all along the sides. Pile of the scutellum flattish, mostly yellow, but with short setous hairs bordering the rim, which are all black; the bristles on the rim are short and usually black in color although on some specimens a pale bristle or two appears. Pile of the abdomen nearly all appressed, more erect anteriorly and in the corners of the segments, pale whitish along the sides, practically all black on the opaque areas of the discs. The fringe of hairs on the upper lobe of the squamae are yellow and the halteres are often yellowish brown.

Types:—Holotype, male, Mt. Rainier, Wash., Sunrise, 6,318 ft., VII-24-1932, (J. Wilcox). Allotype, female (same date as Holotype), collected VII-27-1932, (6,318 ft.). Paratypes, *males*: one, Mt. Rainier, Wash., Sunrise, 6,380 ft., VII-23-1932, (J. Wilcox); one, Mt. Rainier, Wash., Sunrise, 6,400 ft., VII-29-1933, (J. Wilcox); one, Mt. Rainier, Wash., Shadow Lake, 6,200 ft., VII-25-1932; one, Mt. Tallac, Tahoe, Calif., VII-19-1916, (E. P. Van Duzee). *Females*: two, Mt. Rainier, Wash., Sunrise, 6,380 ft., VII-27-1932, (J. Wilcox); one, Mt. Rainier, Wash., Sunrise, 6,380 ft., VII-31-1932, (S. E. Crumb); one, Mt. Rainier, Wash., Sunrise, 6,400 ft., VII-30-1933, (C. H. Martin); one, Mt. Rainier, Wash., Tipsoo Lake, 5,400 ft., VII-30-1927, (M. C. Lane); one, Toppenish, Wash., V-10-1927, (M. C. Lane); one, Mt. Rainier, VII-7-1926; two, Grand Mesa, Colo., VII-8-1928, (Lanham), VII-10-1938, (Bauer); Holotype in the American Museum.

There is considerable variation in the females, especially as to the amount and length of the bristles on the scutellum and the amount of black pile on the front. The antennae of the Colorado specimens are also more orange. The males, however, are fairly homogeneous, while the amount of brown pollen on the mesonotum constitutes the principal variable.

It is possible that this species will grade into *yukonensis* which according to our understanding of the female does not have black bristles on the rim of the scutellum. It is possible that specimens from Alaska may be found that will come within the scope of *variseta*. The males of the two species appear to be quite uniformly distinct.

Cheilosia (*Chilomyia*) *varipila* n. sp.
Figure 6

Similar to *variseta*; the mesonotum of the male less densely brown pollinose and the pile is more generally black especially on the mesonotum, scutellum, and fourth abdominal tergite. The female is more readily separated on the erect pile of the mesonotum and all pale bristles on the scutellum. Tips of the aristae of both sexes yellow. Length 9 to 9.5 mm.

MALE:—Head shining reddish-brown to black, a reddish spot on the lower oral angles and almost yellowish on the cheeks. Pile on the front, face, ocellar triangle, lower strips, and occiput black; on the cheeks, upper four-fifths of the facial strips, and eyes yellow. Pubescence very sparse, heavier on the strips, in the corners by the antennae, and very narrowly next to the eyes on the occiput. Antennae dark brown, the first two segments shining black; the aristae brown, pubescent, the extreme tips yellow.

Thorax:—Shining black, dorsum of the mesonotum lightly brownish pollinose on the disc; pile all dark brown to black; scutellar pile all black, the marginal hairs longer and stouter; downward hanging hairs yellow. Legs dark brown to black, the pile all black except for a few yellow hairs on the femora and the usual cushion of yellow hairs on the underside of the hind tibiae and tarsi. Wings tinged with yellow, the stigma light brown, the veins brown. Squamae yellow, lower fringe yellow, upper shorter and black. Plumule yellow, halteres black.

Abdomen:—Shining black, dulled on the discs of the second and third tergites; pile yellow along the sides but nearly all black on the sides of the first and second tergites and posterior corners of the fourth tergite; black and yellow down the middle of the abdomen; pile black on the genetalia. Venter shining with yellow pile.

FEMALE:—Facial pile white; frontal pile black with numerous shorter yellow hairs; antennae larger and partly orange. Menonotal pile shaggy, almost erect, covered with longer black and shorter yellow hairs; pile of the pleura pale, a patch of bristle-like hairs on the upper edges of the mesoplura and pteropleura; pile of the scutellum appressed, all yellow including the short bristle-like hairs on the margin. Squamae white with yellow fringe, halteres yellow. Abdominal pile closely appressed beyond the second tergite, white to yellow along the sides, black down the middle.

Types:—Holotype, male and allotype, female, Laggan, Alberta, Lake Agnes, 6,800 feet, July 10, 1925 (O. Bryant), (Hull collection). Paratype *Male*, Waterton Lakes, Alberta, June 24, 1923 (J. McDunnough) in Can. Nat. Mus.

This species is closely related to both *yukonensis* and *variseta* but may be told from both of these by the yellow tips on the aristae, more pronounced on the female.

Cheilosia (Chilomyia) chintimini Lovett
Figure 10

Chilosia chintimini Lovett, 1921, Proc. Calif. Acad. Sci., 11: 277.

A large, generally shining black species; pile of the male mostly black, of the female mostly yellowish brown; legs black; rim of scutellum of female with black bristles. Length 10.6 to 12 mm.

MALE:—Lovett did not mention the hairs on the face which are numerous and black, otherwise his description is quite complete. Pile of the facial strips yellow. The arista is pubescent almost to the end; the squamae are whitish with golden fringe, the plumule golden; some specimens are almost entirely black pilose on the abdomen but others have patches of yellow pile on the basal corners of the third and fourth tergites.

FEMALE:—Quite similar to the male in body color but the pile is yellow to golden on the face, cheeks, anterior corners of the mesonotum, pleura, sides of the abdomen except the apical corners of the third and following tergites, and generally on the femora; the antennae are larger and orange except the upper fourth which is brown; front shining with a definite transverse depression just above the antennae and a longitudinal sulcus on each side; mesonotal pile mostly black and all erect, a few black bristles on the notopleura, calli, and just above the wings; 4 to 8 black bristles on the edge of the scutellum, pile on the disk golden with a few longer black hairs, pile underneath golden; about 4 or 5 black bristles on the upper edge of the mesoplura. Tibiae paler basally. Halteres yellow. Pile on the discs of the abdominal tergites black and appressed, becoming all black except the basal corners on the fourth tergite, otherwise yellowish to golden.

Allotype, by present designation, female, Vernonia, Ore., April 13, 1936 on willow (K. Gray and J. Schuh).

Distribution: OREGON (Type in Calif. Acad. Sci. Coll.).

Material reviewed: OREGON—Vernonia 9 males and 7 females April 13-21, 1936, April 1, 1938, and April 17, 1937 (Gray and Schuh); Astoria 1 female April 14, 1936 (Gray and Schuh); Mary's Peak 3 females April 19 (Lovett) and 1 female April 20, 1941 (Rieder).

Specimens from Vernonia were compared with the type and we have also had the privilege of studying a paratype.

Cheilosia (Chilomyia) burkei Shannon
Figures 8 and 9

Chilosia burkei Shannon, 1922, Ins. Insc. Menst., 10: 141.

Chilosia alaskensis coquillett, (Not Hunter) 1905, Bur. Ent. Cir. 61.

A dark blue species with black pile and orange antennae. The facial strips are very narrow. This is one of the few species in which the male has black pile on the underside of the scutellum.

Distribution: WASHINGTON (Type in U.S. Natl. Mus. Coll.)

Material reviewed: COLORADO—Grand Mesa 1 female July 7, 1938 (R. Bauer); Snow Mass, Pitkin Co., 11,200 ft., 1 female July 1, 1941, (F. M. Brown). OREGON—Florence 1 female April 14, 1931, (J. Wilcox). WASHINGTON—Dewatto 1 female June 7, 1906 (Aldrich). BRITISH COLUMBIA—Vancouver 1 male May, 1913 (Hopping). Records by others: Moscow, Idaho.

This is the species reared from Western Hemlock and causing a diseased condition called "Black Check." The female may be confused with *pontiaca* Shan. as there is very little general difference between them, but *burkei* is darker; wing veins, antennae, legs. The male of *pontiaca* is as yet unknown.

Cheilosia (Chilomyia) pontiaca Shan.
Figure 7

Chilosia pontiaca Shannon 1922, Ins. Insc. Menst., 10: 142.

Entirely like *burkei* Shan. except for paler wing veins, legs and antennae. Shannon has compared the head widths and heights but we are unable to note any differences. The geographical range will separate the two. It is possible that these two may prove to be the same. The male is unknown as the species was described from three females taken on Mount Washington, New Hampshire. Through the courtesy of the Museum of Comparative Zoology we have had the privilege of studying one of the paratypes.

Distribution: NEW HAMPSHIRE (Type female in Mus. of Comp. Zool. Cambridge).

Material reviewed: NEW HAMPSHIRE paratype female. QUEBEC, Laniel (P.Q.) 1 female June 11, 1937 (Atwood).

Cheilosia (Chilomyia) fuma n. sp.
Figure 11

A dark species with white erect pale pile on the mesonotum. Frontal pile white below and black near the ocelli. Scutellar bristles long and black. Abdominal pile mostly appressed, black on the discs of the tergites, yellow along the sides. Length 9 mm.

FEMALE. *Head*:—Eyes sparsely yellowish pilose; front somewhat protuberant, rather wide, the sides not parallel, shining brassy black; there is on either side suboccularly a longitudinal furrow, quite shallow, which is roughened and in which the pile seems to be somewhat thicker. There is a shallow pit before the antennae. Pile of front on lower half wholly light yellow, largely but not entirely fine and black upon the upper half and between the ocelli. Behind the ocelli are several, quite long, fine, black hairs and behind these the golden fringe of the occipital pile consisting of sparse long hair and more abundant shorter ones. Face black, highly shining; the tubercle small but prominent, deeply concave above; the pile on the sides of the face rather sparse, pale brassy in color, the pubescence on the face limited to the middle area on either side of the tubercle and between the epistoma and the eyes. The facial strips are of moderate width, apparently bare, their pile apparently consisting of a single row of brassy hairs. Antennae of moderate size, almost orbicular, slightly pointed at the apex, the first segment black, the second dark red, wholly pubescent and black pilose; the third rather thickened, brownish red with the outer margin blackish dorsally and apically. Arista short, dark brown, rather strongly thickened on the basal third, noticeably pubescent.

Thorax:—Strongly shining brassy, the pile short, erect, chiefly pale yellow. Over the middle of the mesonotum are a few scattered fine black hairs and posteriorly a few longer ones. On the notopleura, which is yellow pilose, is a single stiff black bristle; there are two to three bristles above the wing and two short ones and two much longer ones on the post calli. Pleura pale brassy pilose, two black bristles on the upper part of the mesopleura. Scutellum concolorous; the erect discal pile brassy; there are two slender black bristles (pairs) on the margin, basally a single long pale one and some shorter pale ones.

Legs:—Dark brown, almost black, the femoral apices very narrowly lighter brown. Tibiae likewise quite dark, their bases indistinctly brown on approximately the basal third, but dark. The apices of the tibia are also somewhat paler. All of the tarsi are black or very dark brown, their dorsal pile is black. Pile of the hind femora thick, abundant, golden on the basal and lateral halves; there are some long golden hairs reaching almost to the apex of the dorsum, the short black setate hairs confined to the ventral apical half. Pile of hind tibiae golden over the greater part of the inner surface, becoming black dorsally and entirely on the outer lateral surface.

Wings:—Somewhat obscured by poor preservation but uniformly light brown, the base of the subcostal and marginal cells paler, the stigma brown. Postical and subapical cross veins each gently sinuous, each heavily spurred, the latter making a right angle with the curvature of the third longitudinal vein.

Abdomen:—Long and slender but still much shorter than the wings, shining brassy black, the pile pale golden, erect on the sides of the second tergite, and in at least almost all of the third tergite; elsewhere it is at least subappressed. There are broad triangles located posteriorly in the middle of the second, third and fourth tergites of flat appressed black pile. Pile of fifth tergite almost wholly pale.

Holotype:—Female, Vernonia, Oregon; April 17, 1937, (on willow) (K. Gray and J. Schuh), in the American Museum.

The erect pile on the mesonotum relates this species to *varipila* and *livida*, the bristles on the rim of the scutellum will help to separate it.

Cheilosia (*Chilomyia*) *coerulea* n. sp.
Figures 14 and 15

A small shining aeneous species with four faint gray vittae on the anterior half of the mesonotum. Pile of the front and mesonotum black, appressed on the mesonotum. Antennae orange yellow with the narrow upper edge dark. Front very wide. Length 6.5 mm.

FEMALE. *Head*:—Eyes sparsely white pilose, the front broad and not quite parallel, with a strong sharp impression that does not quite reach the ocelli, through the middle of this impression from eye to eye runs a shallow transverse depression. On either side upon the end of the depression and adjacent to the eye is a silvery pubescent semi-circular area which does not connect with the pubescence below the antennae. Color of front black with a faint bluish cast, moderately shining, its pile almost wholly black, erect and abundant. There is a little pale hair on the lower part of the front; vertical and upper occipital hair black. Face shining black with a bluish cast, highly polished, the knob large, rounded but not conspicuous; practically bare of pubescence but with sparse white pile. Facial strips narrow, pubescent, the pile white and apparently confined to a narrow band of at most one or two hairs in width. Antennae of moderate size, the first segment dark brown, the second light brown, the third pale orange with a very narrow black dorsal border; arista black, thickened on the basal half, noticeably pubescent.

Thorax:—Mesonotum polished shining blue black; viewed posteriorly there are four gray pollinose vittae, the middle pair close together, shorter than the outer pair and pointed posteriorly. Mesonotal pile quite short, subappressed, chiefly black; some pale pile lies across the anterior margin. Notopleural pile somewhat longer, black and pale, a few of the hairs longer and stiffer. On the post calli there is both black and white pile and one long bristle. Scutellum concolorous with short whitish pile appressed towards the center; on the margin are two pairs of long slender black bristles and three or four small short ones.

Legs:—Dark brown, shining, the apices quite narrowly lighter brown; the narrow base of the hind tibiae, basal two-fifths of middle and anterior tibiae light brown; all of the tarsi brownish-black, the middle basi tarsi lighter along the sides; all dorsal basi tarsal pile black. Pile of hind femora rather short, pale along the sides except near the apex; black pile ventrally limited to the apical half; pile of hind tibiae almost wholly black, both inner and outer lateral surfaces largely silvery pubescent; hind femora similarly silvery pubescent.

Wings:—Pale brown, the veins light brown, the stigma yellow; the postical cross vein straight, the subapical cross vein gently sinuous, both with strong spurs. The subapical cross vein joins the third vein acutely with not over a 67 degree angle.

Abdomen:—Robust, a little wider than thorax; short, shining bluish black; the pile exceedingly short, white except in the center of the second and third tergites where along the posterior region are triangles of appressed short black pile. The pile of the fourth tergite is much more sparse and, except on the posterior margin, is nearly erect.

Holotype:—Female, Mt. Rainier, Washington, July 16, 1935, White River Camp, (J. Wilcox), in the American Museum.

Cheilosia (*Chilomyia*) *primoveris* Shan.
Figures 12 and 13

Chilosia primoveris Shannon 1915. Proc. Ent. Soc. Wash., 17: 168.

An Eastern *Chilomyia* which is easily distinguished from *pontiaca*, the only other known species in the east, by its brassy yellow pile on the mesonotum and abdomen. The antennae are yellowish orange; the tibiae bicolored; pile on the front of the male black, on the female yellow. Length 8 to 10 mm. The two females from Utah are identical with the eastern specimens.

Distribution: MARYLAND (Type in U. S. Nat'l. Mus. Coll.)

Material reviewed: MARYLAND—Cabin John 1 male April 14, 1916 (Shannon). MASSACHUSETTS—Hyde Park 1 female May 6, 1905. NEW YORK—Paterson 1 female April 21, 1939 (Dietrich). OHIO—Columbus 1 female May 9, 1925 (Painter). UTAH—Logan 1 female August 4, 1915; Salt Lake City 1 female. VIRGINIA—Fairfax Co. 4 females April 4 (Davidson); Great Falls 1 male April 15.

Cheilosia (Chilomyia) occidentalis Williston
Figure 17

Chilosia occidentalis Williston, 1882, Proc. Amer. Phyl. Soc. 20: 305; 1886, Bull. U. S. Natl. Mus. No. 31, p. 41.

A dark aeneous species. Male with the pile of the mesonotum long and mixed black and yellow; the hairs of the face quite long and black and yellow; entire face rather conspicuously pollinose; pile of the scutellum very long and black on the apical margin and almost bristle like, whiter at the base; pile of the pleura all yellowish, except for a large patch of black hairs on the mesopleura; the antennae dark brown to black. On the female the mesonotal pile is mostly whitish and on the abdomen erect, yellowish-white and appressed only on the discs of the segments; the scutellum with about eight bristles, some of which may be pale and some black; the antennae are mostly orange-yellow, darkened on the upper third.

Distribution: CALIFORNIA (Type in U. S. Nat'l. Mus.).

Material reviewed: CALIFORNIA—Berkeley 1 male and 2 females July 6, 1904, 1 male August 24, 1915 (Van Duzee), 1 female April 10, 1933 (Casier), 3 males March 12, 1936; San Francisco 1 male March, 1893; Walnut Creek 7 males and 6 females March and April, 1936 (Davidson). COLORADO—Grand Mesa 2 males July 7, 1938 (Lanham).

Records by others: Alaska, British Columbia, New Hampshire (error), New Mexico and South Dakota.

Cheilosia (Chilomyia) livida Wehr.
Figure 16

Chilosia livida Wehr 1922, Univ. Studies, Lincoln, Nebr., 22: 24.

A shining dark aeneous species with thick white to yellowish pile; scutellum without bristles; antennae orange colored, with the upper edge darkened, lighter on the female. Apparently related to *pacifica* Hunter. Length about 9 mm.

MALE. *Head*:—Face shiny, somewhat pubescent, the central knob bare, knob rather prominent and broad, semi-flat on apex; the oral edge less prominent; lower sides of the mouth devoid of pubescence and pile; pile of front, face, and cheeks is silky white. Front puffed with a medium sulcus, rather heavily pubescent, the arch above the antennae shining black; facial strips very broad almost bare of pubescence except near the eyes, the pile silky white. Antennae orange, the first two segments and upper fourth of the third darker; arista dark in color and very short pubescent, basal segment thickened. Ocellar triangle shiny with long white pile. Occiput gray pubescent, the pile everywhere whitish. Eyes white pilose below, yellowish above.

Thorax:—Everywhere shining aeneous, the pile everywhere white and erect. Scutellum with long silky white pile, without bristles. About four or five black bristles just above the wing base. Legs shining black with yellow areas as follows: the femora very briefly at the tips, the tibiae with their basal halves and apical fifths, basal three segments of the four front tarsi; the trochanters are somewhat reddish, especially on the fore margins; pile mostly whitish, a few black hairs on the outer apex of the hind femora and all black on the four hind tarsi. On the outer edge of the tarsi are numerous small black bristles; they are also quite prominent as a circlet at the tips of the four hind tibiae. Wings hyaline, the veins yellowish to brownish, stigma light yellow. Squamae white with light yellowish edge, plumule yellowish white, halteres light brownish.

Abdomen:—Shining aeneous, opaque on the disc of the second and third tergites; the pile whitish except broadly black on the dorsum of the second, third and fourth tergites, pile erect on the sides, flattened on the discs.

FEMALE:—Very similar in all respects, antennae slightly larger and more orange colored; front broad and shining; the tiny bristles on the under side of the metatarsus of the middle legs very strong; abdominal pile mostly erect, somewhat flattened on the discs of the segments both above and below.

Allotype:—By present designation, female, Lake City, Colorado, Aug. 8 to 21, 1938, 9,000 ft. elevation (Fluke); in the American Museum.

Distribution: COLORADO (Type in Univ. Nebraska).

Material reviewed: COLORADO—Cameron Pass 1 male, 1 female, July 7, 1931, Camp Creek R. Sta. 1 male June 19, 1920 (8700 ft.); Lake City 3 females August 8 to 21, 1938 (Fluke); Powderhorn 1 female June 23, 1926 (Anderson); Snow Mass Lake, Pitkin Co. 1 male July, 1941 (11,206 feet, Brown). ORE-

GON—Corvallis 1 female April 12, 1936 (Ferguson). WASHINGTON—Roy 1 female April 29, 1932 (Latta). ALBERTA—Medicine Hat 1 male May 2, 1925 (Carr).

We have examined two of the male paratypes and our male specimens are identical. The white pile of this species should easily identify it. The lack of black bristles on the scutellum will separate it from *pacifica* Hunter. It is much larger but more slender than the eastern pale pilose species, *primoveris*.

C. livida var. *lintea* n. var. differs from typical *livida* in the yellowish pile on the mesonotum. Holotype, male, Aspen, Colo., July 24-27, 1919 in the American Museum; paratype, male, Boulder, Colo., May 29, 1922 in the Hull collection.

Cheilosia (*Chilomyia*) *pacifica* Hunter

Chilosia pacifica Hunter, 1897, Can. Ent., 29: 127.

Extensively white pilose, the scutellum with black marginal bristles on both sexes. Front of the male black pilose, of the female white.

We have been unable to recognize this species and also unable to locate the types. They are not at the University of Nebraska collection. It has been placed in the keys from the descriptions; the female in two sections as we are unable to determine whether the mesonotal pile is erect or appressed. Hunter's description mentions the depressed pile on the abdomen which would indicate that the pile on the thorax is generally erect. If this is true the female should be compared with *occidentalis* Will., otherwise it appears to be related to *livida* Wehr, a species which does not have black scutellar bristles. The females of *pacifica* and *occidentalis* may be difficult to separate but the pile of *pacifica* is whitish and undoubtedly shorter than on *occidentalis*. The latter species usually has a few black hairs intermixed in the heavy yellow matt on the front; described as short and white on *pacifica*. The "short appressed pile" on the abdomen is not at all characteristic of *occidentalis*.

Distribution: CALIFORNIA (Types not located).

Material reviewed: None.

PRELIMINARY LIST OF THE HYDRACARINA OF WISCONSIN

REVISION OF PART I

RUTH MARSHALL
Rockford College

Part I of the *Preliminary List of the Hydracarina of Wisconsin* (Marshall, 1931) listed, with brief descriptions and drawings, 14 species of the so-called "red mites," belonging to seven genera then included in the Superfamily *Limnocharae*. This group has now been subdivided and other superfamilies recognized so that the genera have a new grouping as will be noted. The classification of Viets (1936) is followed. Former descriptions are supplemented with more drawings and notes, synonymies indicated, and seven more species and varieties added (new forms only in the Genus *Eylais*), bringing the list to 21.

GENUS *HYDRACHNA*

The Hydrachnae are among the largest of the hydracarina and are common in shallow waters throughout the world. They are usually soft bodied, rotund, red or orange, with papillose skin. Between the eyes lies the frontal organ whose function is unknown. On the dorsal side there are developed chitinous structures, usually paired, in a great variety of forms and sizes. The epimera are in four groups which increase in size posteriorly. The genital organ lies between the posterior groups of epimera; it has a pair of united plates, somewhat movable, and covered with fine acetabula. The maxillary organ has a long, curved rostrum at the end of which is the mouth. The mandibles are awl shaped. The palpi are broadest at the base, the segments decreasing in width distally. The legs have swimming hairs.

The genus is now placed with the small African genus *Bergena* in a single family, *Hydrachnidae*, of the Superfamily *Hydrachnae*. Five subgenera are recognized (Viets, 1936:58), distinguished chiefly by the character of the dorsal structures, three represented here by six species and one variety.

Hydrachna canadensis Mar.
Pl. I, Fig. 1-4

The anterior dorsal chitin structures are represented by a pair of irregularly shaped hair-bearing plates a short distance behind each eye capsule; between each plate and the capsule is also a small fleck of chitin. In epimera III there is a small spur-like process on the anterior inner side of each; in IV the inner posterior margins are blunt, with thin subcutaneous processes. In the palpi the proportions of the segments are shown in Fig. 4. The genital organ is broadly heart-shaped in the female; the male is unknown. The male described for this species (Marshall, 1929:63) is now recognized as another species, *H. marshallae* (Lundblad, 1934:34). The nymph is now known; the anterior dorsal structures resemble those of the adult and the epimera IV are similar.

This species belongs to the Subgenus *Rhabdohydrachna*, characterized by a pair of chitin bars or small plates behind each eye capsule. It has been found in Ontario, Manitoba and Michigan as well as in Wisconsin.

Hydrachna miliaria Berl. (= *H. bilunata* Mar.)
Pl. I, Fig. 5-8

Behind each eye capsule is a small, somewhat lunate but sometimes angular plate followed by a smaller, likewise variable, rounded or elongated plate; these plates are alike in adult and nymph. Characteristic of the epimera is the narrow prolongation on the inner posterior margin of IV which is even more pronounced in the nymph. In the palpi the 1st segment is large and broad; the 3rd is longer than the 2nd with a concave outline on the inner proximal side.

The male is now known; the length is about 2.50 mm. The genital organ is very large, fully one-third of its length extending beyond the limits of epimera IV, the anterior margin with a large indentation. Epimera IV have the characteristics of those of the female but they are not as elongated, relatively broader, the posterior inner prolongations shorter.

This species is believed to be the same as one described earlier for South America (see Marshall, 1943b:404). It has been found in British Columbia and appears to be widely distributed throughout the United States.

Lundblad (1934:25) erected a new Subgenus *Tetrahydrachna*, evidently designating this species as the type; later the same author (1941b:360) gave the new name as a synonym for *Scutohydrachna!* Viets (1936:58) considers it a synonym for *Rhabdohydrachna.*

Hydrachna cruenta Müll. (= *H. schneideri americana* Mar.)
Pl. II, Fig. 13-17

This species is recognized by the very large dorsal shield which has a projection extending forward between the eyes; the posterior margin is wavy, more or less convex, the whole outline subject to much variation. The length of the body is 2.00-3.00 mm. In epimera IV the posterior inner border is broadly expanded, especially in the female; in the male the medial border is longer, the entire plate shorter. The genital organ in the female is very broad; in the male, elongated, hardly filling the space between the posterior epimeral groups. The palpi are rather slim; the characteristics of the segments are best shown in Fig. 16. In the nymph there is a large elongated plate immediately behind each eye capsule; epimera show the characters of the adult.

This is the type species of the Subgenus *Hydrachna* with the large unpaired dorsal plate reaching the eye region and enclosing the frontal organ. It is a cosmopolitan species and has been found in widely separated areas in Canada and the United States.

Hydrachna cruenta diminuata Lund.
Pl. II, Fig. 18, 19

In the original description (Lundblad, 1934:10) based on the study of one male (Connecticut), this variety has as its chief character a diminished dorsal shield which does not have a process extending between the eyes; nor does it enclose the anterior hair plates; also, the posterior outline of the shield is distinctly concave. In the former description of the main species (Marshall, 1931:314), Fig. 22 should probably be referred to this variety, although not conforming closely to Lundblad's Fig. 4A. A few specimens from Ontario as well as Wisconsin material (Adams County) are also placed here. Both sexes were represented and the female is now known (Fig. 19). However, in the inclusion of the hair plates between the eyes in the dorsal plate they do not all conform to the original description but they do show the posterior concavity. In view of the great degree of variability in this respect in the species, the first description of this variety may have to be revised.

Hydrachna magniscutata Mar.
Pl. I, Fig. 9-12

This species resembles *H. cruenta* but is smaller (about 1.15 mm.), the large dorsal plate has but a slight projection between the eyes, irregular in outline or concave; in epimera IV the inner posterior outline is rather short and blunt; the palpi are relatively stouter. In the nymph there are two obovate anterior plates, well removed from the eyes.

It has been found in over twenty bodies of water in Wisconsin and across the United States from New England to Washington as well as in Ontario and Alberta.

Mr. C. O. Berg*, working at the Biological Station of the University of Michigan at Douglas Lake, found several individuals of this species in a pool at Sedge Point. Some of these were blue, a feature already reported (Marshall, 1927:271). Mr. Berg (unpublished correspondence) kept specimens in the laboratory and observed the oviposition in *Potamogetan richardsonii*, many egg galleries being easily visible in the stem. The emergence and development of the larvae were followed and their attachment to *Belostoma flumenium* was seen.

Hydrachna crenulata Mar.
Pl. II, Fig. 20; Pl. III, Fig. 24, 25

The body is almost circular, about 1.90 mm. long, deep red. In the live specimen the anterior dorsal aspect shows two low scallops between the eyes. The dorsal surface is entirely covered, except in the eye region, by a finely porous chitinous plate which extends over on the posterior ventral side; this feature was unfortunately overlooked in the original description (Marshall, 1930:247). In this plate are embedded two small irregularly crescent-shaped chitin pieces directly below the eyes, down about one-third of the body length; near the usual gland openings with accompanying hairs are flecks of chitin. Epimera IV show a pro-

* Publication of the complete record of these observations has been delayed. Unable to communicate with Ensign Berg for permission, the author has taken the liberty of including here this brief summary of his studies.

longed curved posterior inner outline. The male genital organ is cordate and nearly fills the space between the last pair of epimera. Below it lies the large inverted triangular area not covered by the extension of the dorsal shield. The female is unknown. In the palpus is to be noted the considerable size of the 1st segment, the concavity on the inner border of the 2nd, the position of the hairs (Fig. 20).

The species has been found in Wisconsin and Michigan.

This species belongs to the Subgenus *Scutohydrachna* (Viets, 1933:162) characterized by the development of a great unpaired plate covering the dorsal surface and part of the ventral, *H. dorsoscutata* of Brazil being described and designated as the type species. Lundblad (1934:16) in his review of the author's description of *H. crenulata* gave Viets' species as a synonym, although noting the somewhat longer and slimmer inner posterior border in epimera IV, these processes of either side being connected by a small strand of subcutaneous chitin. It should also be noted that the male genital organ is shorter and broader in the Brazilian form. Dr. Viets who examined the type specimen of *H. crenulata* stated (unpublished correspondence) that "*H. dorsoscutata* must be considered a variety of *H. crenulata,*" differing only in the connecting chitinous line behind the genital area. However, in a later paper (Viets, 1940:193) he again lists it as a species. In the opinion of the present author it should probably be considered a variety, certainly not a synonym for *H. crenulata.*

Hydrachna rotunda Mar.
Pl. II, Fig. 21-23; Pl. III, Fig. 26

The body is almost circular, 1.10–1.12 mm. long, deep red. Over the entire dorsal surface, except around the eyes, is developed a finely porous chitinous plate which extends also over on the ventral side to cover most of the surface outside of the epimera, as in *H. crenulata,* but somewhat more extensively. This character was unfortunately not given in the original description of the species (Marshall, 1930:246). In this dorsal shield behind each eye capsule is a small irregularly curved piece of chitin together with gland openings and hairs very much as in the related species. In epimera IV there is a slender prolongation of the inner posterior border. The male genital organ is very large, broader than long, almost filling the area between the posterior groups of epimera. The palpi are rather stout; the proportions of the segments and the disposition of the hairs are shown in Fig. 26.

The female is now known. The epimera are like those of the male but somewhat longer, the last pair having a similar but shorter prolongation of the medial posterior angle. The genital organ is very large, much broader than long, the anterior lateral border closely pressed upon epimera III and the anterior border of IV.

This species, like the preceeding, belongs to the Subgenus *Scutohydrachna*; it has been found in Wisconsin, Illinois and Tennessee.

GENUS *LIMNOCHARES*

Mites of this genus are large, red, soft bodied, papillose, wrinkled, changeable in form. The circular mouth lies at the end of a protruding rostrum. The eye capsules are close together on a ligulate plate in the medial dorsal line. The epimera are very small, in four groups, beset with long hairs: pair I, somewhat rectangular, meet in the anterior medial corners; II are triangular. The posterior groups are smaller, widely separated, elongated. The genital orifice is small, without plates, lying between the last pair of epimera and guarded by bristles; the sexes are much alike. The palpi are very small, especially the 5th segment. The legs are short with many bristles; in the Subgenus *Cyclothrix* they have swimming hairs.

The Superfamily *Limnocharae* is now limited to three families of which *Limnocharidae* is one, with few species. The genus *Limnochares* is represented in Wisconsin by two species.

Limnochares aquatica (L.)
Pl. III, Fig. 27-29

Under this species was first included (Marshall, 1931:312) all specimens of the genus; it was soon apparent that two species were present, of which *L. aquatica* was the less common. Lavers (1941) made a study of available material and clarified the matter. The body has a length up to 5.00 mm.; it is somewhat shouldered, tapering to the snout-like rostrum. Epimera III and IV are triangular. The legs are very short with many bristles but no swimming hairs. These mites are slow moving, often crawling on the bottom of shallow waters. Lundblad (1941c:155) uses the older specific name, *L. holosericea.*

This species is one of the first water mites to be described. It is widely distributed over Europe and now known for Siberia, Japan, and South America. In North America it has been found and reported in small numbers, sometimes in collections with the next species, in Washington by Lavers; and in Michigan, Indiana and Wisconsin (Vilas County) by the author where it appears to be usually a bog form. Lavers (p. 3, 5) is in error concerning certain previous records.

Limnochares americana Lund. (= *L. natans* Lav.)
Pl. III, Fig. 30-33

The body closely resembles that of *L. aquatica*; it measures up to 4 mm. in length. The ocular plates of the two species differ in some details, being here wider. Epimera III are elongated, while IV are boot-shaped. The legs, which are relatively slim, have swimming hairs as well as long bristles on all legs; the former are long and numerous on the middle segments of III and IV. In consequence it is an active swimmer and the body is very mobile. This places it in the Subgenus *Cyclothrix.*

The late C. H. Lavers made a detailed study of available Limnochares material in American collections in connection with his own material from the state of Washington. He wrote to several hydracarinologists in Europe requesting identified specimens of *L. aquatica* for comparison. Dr. Viets responded with several individuals from Germany. Lavers also studied the habits and development of his specimens. He gave the name *L. natans* to the heretofore recognized but undescribed species. His paper (1941), unfortunately delayed in printing, gave his principle findings; some of his unpublished notes contain other material. In the meantime Dr. Lundblad secured a small collection from Michigan and published a brief account, without drawings, of what appears to be Lavers' *L. natans* under the name *L. americana* (Lundblad, 1941c:155). Since this was published a few months before the earlier and more complete paper, *L. natans* must be considered a synonym.

L. americana is more common and widely distributed than the older species. It has been found in British Columbia, Ontario, Washington, Colorado, Illinois, Michigan, Nebraska, Massachusetts, New Hampshire, New York; and in Wisconsin in waters near Green Lake, Green Bay, Waupaca, Cable, in Storr Lake and a pool near Lake Winnebago.

GENUS *EYLAIS*

Mites of this genus may attain a length of 5 mm. The skin is soft, red, smooth or showing wavy lines. The two eyes of each side are enclosed in a capsule; with rare exceptions the latter are connected by a bridge of very variable outline. The maxillary organ encloses the circular, hair-fringed mouth. The epimera are elongated and lie in the anterior half of the posterior surface, pairs I and II of each side approximated, III and IV joined only in the median line. The genital orifice lies between the medial ends of the anterior epimera; the sexes are difficult to distinguish. The palpi are slender with many bristles; the 4th segment is the longest, the 2nd and 3rd not completely chitinized. Legs I-III have swimming hairs.

The genus is now placed, with the small genus *Piersigia*, in the Family *Eylaidae* of the Superfamily *Limnocharae*. These mites are common in quiet shallow waters of all continents. Over 100 species have been described but many of these should probably be regarded as varieties. Descriptions are based almost entirely on the characters of the small ocular plate and this is very variable. Four species and two varieties, three of them new, have been determined for Wisconsin.

Eylais desecta Koen.
Pl. IV, Fig. 39-41

In spite of some variation, the shape of the ocular capsules and of the intercapsular bridge is fairly constant (Koenike, 1912:283). On the latter are two anterior rounded projections each bearing a large bristle but they do not project beyond the capsules; between and below them is a rounded process. The bay below the bridge is deep and of varying width, reaching at least as far as the middle of the capsules. A specimen reported by the author from Winnipeg (Marshall, 1929:62), then unidentified, is now referred to this species.

E. desecta is probably widely distributed, since it has been identified in Ontario, Manitoba, North Carolina, Tennessee and Michigan as well as several places in Wisconsin.

Eylais rimosa Piers.
Pl. IV, Fig. 48

This is a species closely resembling *E. desecta*, but the two anterior projections on the short intercapsular bridge are more pronounced with a deep incision between them, while the bay posterior to the bridge is somewhat larger. It is "eine sehr variable Form" (Viets, 1936:89) described under several names. It has been found throughout Europe and North Africa, reported also from Siberia and India.

In Wisconsin a few specimens have been found in Fox and Boulder Lakes.

Eylais infundibulifera bakeri n. var.
Pl. IV, Fig. 37, 38

The species *E. infundibulifera* Koen. is widely distributed over Europe and reported also from Turkestan and Siberia; several varieties are recognized. It is also known for Ontario.

The intercapsular bridge in the main species is short and very broad with a large, more or less, irregular anterior central projection and a shallow posterior bay. In the new variety, *E. bakeri*, the bridge is longer so that the eye capsules are farther separated, the anterior projection is shorter and more irregular; the posterior bay is deeper, the sides showing a more or less conspicuous bulge midway on either side. The palpi are rather stout; the distal inner process on the 3rd segment is small and only sparingly provided with short bristles. The body is 3.50–4.00 mm. long.

Specimens were found in Findley and South Turtle Lakes, Vilas County, and in Lake Winnebago; the latter collection was made by Dr. F. C. Baker, for whom this variety is named.

Eylais gibberipons hirsutipalpis n. var.
Pl. IV, Fig. 42, 43

In *Eylais gibberipons* (Viets), of central Europe, and this new variety the intercapsular bridge has an anterior-posterior measurement about twice as great as the distance between the eye capsules, an anterior projection with an indentation, while the posterior bay is relatively small. The variety, *E. hirsutipalpis*, conforms to this general plan of the ocular plate, but the palpi differ from the stem species, the 4th segment being longer and the 4th and 5th having many more short bristles.

Only one specimen has been identified; this came from Boulder Lake, Vilas County.

Eylais robusta n. sp.
Pl. IV, Fig. 44-46

The average length of the three specimens identified is about 3.00 mm. The eye capsules are broadly reniform. The intercapsular bridge is short, with a large rounded anterior process, which may be somewhat irregular and indented (as in Fig. 45), projecting beyond the capsules; between the attachment of the two bristles is a large irregularly oblong surface. Posterior to the bridge is a deep narrow bay, nearly the same width throughout, more than half the length of the capsules or contracted a little by processes from the capsules. The palpi are long, especially the 4th segment which bears but a few bristles; the 3rd segment bears distally a small area of weak bristles on the concave side, with more and stouter bristles on the outside; the 2nd segment has a large bristle on the inner distal corner. In the form of the intercapsular bridge with its anterior process the new species resembles *E. infundibulifera*; but the posterior bay is much deeper and narrower.

The specimens came from Trout and Boulder Lakes.

Eylais falcata Koen.
Pl. IV, Fig. 47

Characterized by Koenike (1912) as a species which "appears to vary strikingly, particularly in the form of the eye plate," yet several individuals are here assigned to it on the basis of the fairly constant and unusual features. The eye capsules are very broad, oval or slightly reniform, sometimes broadest anteriorly, the bases of the two large bristles on the capsules rather than on the intercapsular bridge. The latter is short and narrow, set well back from the anterior end of the capsules; it has an indentation on the anterior margin, the posterior side more or less projecting. The palpi agree well with Koenike's Fig. 3.

The original material was found near Ottowa, Canada. In a paper by the present author (Marshall, 1929:61) a specimen from Manitoba (Fig. 17) was described but the name withheld; it is now assigned to this species. In Wisconsin specimens have been found near Green Lake and Madison.

GENUS *CALONYX*

This genus is a group of soft bodied, papillose red mites without chitin plates. The maxillary organ has a rostrum; the palpi are chelate. The epimera are in four groups, well separated, the posterior in about the center of the under surface. The genital orifice lies between the medial ends of epimera III, shorter in the male, with slightly chitinized valves surrounded by numerous stalked acetabula. The legs are short, without swimming hairs, and end in scoop-shaped toothed claws.

This genus with the closely related Genus *Protzia* and four other genera is now placed in the Family *Protziidae* in the Superfamily *Limnocharae*; they are bottom forms, more common in alpine waters.

Calonyx ovata (Mar.) (= *Protzia ovata*)
Pl. V, Fig. 59-62

The body is obovate; largest specimens are 1.20 mm. long. The large genital organ occupies most of the area between the epimeral groups, the orifice in the male with a cluster of fine hairs; it is surrounded by about thirty acetabula, irregularly placed, the posterior with longer stalks.

This species has been found as an alpine form in California (Marshall, 1943a:322); in Wisconsin it is known only for Green Lake.

GENUS *HYDRYPHANTES*

The body of this genus is of moderate size, somewhat compressed dorsally, papillose and red. Between the eye capsules is a chitinized plate in which lies the frontal organ. The maxillary structure has a rostrum. The epimera are in three groups, the last pair somewhat triangular. The genital organ has elongated laterally hinged plates, each with three or more acetabula. The palpi are cheliform. The legs are long, pairs II-IV with swimming hairs. The genus is very large, with many species, active mites living in small bodies of shallow water in many parts of the world.

The Superfamily *Hydryphantae*, Family *Hydryphantidae*, includes this genus; under it are three subgenera, distinguished chiefly by the number of genital acetabula. Specific descriptions are based largely on the form of the dorsal plate; three species have been found in Wisconsin.

Hydryphantes ruber (de Geer)
Pl. V, Fig. 52, 53

The body may reach a length of 2.00 mm. in the female. The dorsal plate is large, very variable in form but compact, the anterior end convex, and wider than the posterior which ends in two lateral prolongations. The palpi are stout. The genital plates have each three acetabula characteristic of the Subgenus *Hydryphantes.*

Viets (1939:75) questions the identity of the North American specimens with Old World forms (Marshall, 1930:247; 1931:315), and states that the figures for the dorsal plate place them nearer to *H. planus* Thon, and proposes *H. novus* nov. nom. for them. In view of the great variability of the plate as shown by various writers and the essential agreement of these specimens with them the author sees no justification for another name.

The species is found throughout Europe where also several varieties have been described, and in Kamtschatka; in Canada, Ohio, Michigan, Illinois, Wyoming and in several localities in Wisconsin.

Hydryphantes tenuabilis Mar.
Pl. V, Fig. 49-51

The body is ovate, largest specimens about 1.00 mm. long, the anterior slightly projecting. The dorsal plate is distinctive and quite constant in form: an anterior piece between and above the eye capsules with two diverging posterior limbs which bifurcate to end in thin pieces. The epimera are heavy, the groups close together, pair IV with a large median bulge on the posterior border so that it lies close to the genital organ; the latter is broader than in *H. ruber,* with three acetabula. Like the latter species it belongs to the Subgenus *Hydryphantes.*

Daday (1905:279) described a new species from Paraguay, *H. ramosus,* with a dorsal plate closely resembling that of *H. tenuabilis* (Marshall, 1926:33). Lundblad (1938:7) described another Paraguayan species, *H. schadei* (without figures) with a similar dorsal plate, pointing out also differences in the palpi between the new species and "der von Marshall abgebildeten Form von *H. ramosus*"! Later the same author (Lundblad, 1941a:56) made *H. schadei* a variety of *H. ramosus* (giving figures) and again referred to Marshall's finding of the latter species omitting the name given by her, *H. tenuabilis.* In private correspondence (1941) Lundblad stated that he regarded the two species as identical. It is difficult to decide the matter from Daday's account; until the South American form can be studied more fully the author will continue to use the present name. It is possible that it should be regarded as a variety of the older species.

This species has been found in several north-east central states and in many waters in Wisconsin.

Hydryphantes multiporus Mar.
Pl. V, Fig. 54, 55

The body is about 1.50 mm. long, orange red. The dorsal plate is large, the anterior part convex and reaching nearly to the eye capsules; it then narrows abruptly and passes over into two long large pieces which taper and thin out, a large rounded bay lying between them. The epimera are heavy, the groups close together. The anterior end of the genital organ lies close to the last epimera pair and is distinguished by the large number of acetabula, 14 to 18, on the outer border of each plate, variable in number even on the two sides. In the numph the number is smaller, the plates shorter. The palpi are very stout, the first three segments much shorter than broad on the concave side, the 5th very short. The legs are stout, IV about the length of the body; there are abundant bristles and numerous swimming hairs.

The large number of genital acetabula places this species in the Subgenus *Polyhydryphantes.* It has been found only in two small bodies of water in Adams County.

GENUS *DIPLODONTUS*

The body in this genus is soft, papillose, red, with no dorsal chitin plates nor frontal organ. The two eyes of each side are separated, not enclosed in a capsule. The maxillary organ has a rostrum and mouth disk. The epimera are in four groups. At its anterior end the genital organ lies between epimera IV; its ovate plates bear many small acetabula. The palpi are slim, chelate. The legs have swimming hairs.

This genus with the small African genus *Oxopsis* make up the Family *Diplodontidae* of the Superfamily *Hydryphantae.*

Few species have been found but the one to be described is cosmopolitan.

Diplodontus despiciens (Müll.)
Pl. V, Fig. 56-58

The body is nearly circular, compressed, reaching a length of 2.00 mm., covered with small tapering papillae. The color is deep red with a large dark central scalloped area. The epimera are elongated, bordered with hairs, occupying a relatively small part of the ventral surface; pairs I and II are slightly attached medially. The sexes are difficult to distinguish except for the smaller size of the male. The palpi are small and slim; the 5th segment with a similar process from the 4th form a long delicate chela. The 1st and 2nd palpal segments have feathered bristles, the 3rd, two long coarse bairs.

One of the first water mites to be described, this species is perhaps the commonest of the water mites. It has been found in all continents (except Australia?), in about half of the states of the Union and in Wisconsin in practically all waters where collections have been made.

GENUS *SPERCHONOPSIS*

In this genus the skin is thick, papillose, with small paired dorsal chitin plates and large wart-like elevations, likewise papillose, near the skin gland openings. The maxillary organ has a slender rostrum. The epimera are in four groups, the last pair somewhat triangular. The genital organ has lateral elongated plates each with three acetabula on the inner margins. The palpi have on the 2nd and 4th segments a large hair-bearing peg on the concave side. The legs are without swimming hairs.

It is a small genus with one large species, next to be described. It belongs to the Family *Sperchonidae*, now placed in the Superfamily *Lebertiae.*

Sperchonopsis verrucosa (Protz) (= *Pseudosperchon verr.*)
Pl. III, Fig. 34-36

Largest females may reach a length of 1.00 mm.; males are smaller. The body is elliptical, yellow brown. The large wart-like elevations of the dorsal side are found also on the posterior ventral margin. The rostrum is long and slim. The medial anterior ends of epimera I project and bear each a tuft of hairs. The middle palpal segments are of about the same length, the peg on the 2nd and 4th conspicuous. The genital organ lies close to epimera IV; the two anterior acetabula are elongated, the last rounded. A small plate of chitin lying above the orifice distinguishes the female.

This species is a bottom form and is cosmopolitan. It has been found in Wyoming and California; in Wisconsin only in Green Lake.

Literature Cited

Daday, E.

1905. Untersuch. Über die Susswasser Mikrofauna Paraguays. Zoologica, 18: 272-326.

Koenike, F.

1912. A Revision of my "Nordamerikanische Hydrachniden". Trans. Canadian Inst: 281-296. Univ. Press, Toronto.

Lavers, C. H.

1941. A New Species of Limnochares from North America. Univ. Washington Pub. in Biology, 12,No.1: 1-6.

Lundblad, O.

1934. Die Nordamerikanischen Arten der Gattung Hydrachna. Arkiv f. Zoologi, 28 A,3: 1-44.

1938. Neue Wassermilben aus Paraguay. Zool. Anz., 122: 7-19.

1941. Die Hydracarinenfauna Südbraziliens und Paraguays. Kungl. Sv. Vet. Akad. Handlingar, 19,7: 1-183.

1941. Eine Uebersicht des Hydrachnellensystems etc. Zool. Bidrag. Uppsala, 20: 359-379.

1941. Neue Wassermilben aus Amerika, etc. Zool. Anz., 133: 155-160.

Marshall, R.

1926. Water Mites of the Okoboji Region. Univ. Iowa Studies in Nat. His., 11,9: 28-35.

1927. Hydracarina of the Douglas Lake Region. Trans. Am. Micros. Soc., 46,4: 268-285.

1929. Canadian Hydracarina. Univ. Toronto Studies, Biol. Ser. Pub. O.F.Res.Lab.39: 57-93.

1930. The Water Mites of the Jordan Lake Region. Trans. Wis. Acad. Sci., 25: 245-253.

1931. Preliminary List of the Hydracarina of Wisconsin. Part I. Trans. Wis. Acad. Sci., 26: 311-319.

1943. Hydracarina from California. Part I. Trans. Am. Micros. Soc., 62,3: 306-324.

1943. Hydracarina from California. Part II. Trans. Am. Micros. Soc., 62,4: 404-415.

Viets, K.

1933. Neue Hydrachna- und Eylais-Arten, etc., aus Porto Alegre, Brasilien. Zool. Anz., 103: 161-171.

1936. Die Tierwelt Deutschlands. Teil VII, 31,32 Teil, 574 pp. Jena.

1939. Wassermilben aus den Bayrischen Alpen, etc. Arch. Hydrobiol., 36: 72-93.

1940. Neue Hydrachnellae (Acari) aus Südamerica. Zool. Anz., 131: 90-101.

PLATE I

1. *Hydrachna canadensis*, anterior dorsal structures
2. *Hydrachna canadensis*, left genital plate and epimera III, IV, nymph
3. *Hydrachna canadensis*, genital organ and right epimera III, IV, female
4. *Hydrachna canadensis*, right palpus, female
5. *Hydrachna miliaria*, anterior dorsal region, male
6. *Hydrachna miliaria*, genital organ and right epimera III, IV, male
7. *Hydrachna miliaria*, right genital plate and epimera III, IV, nymph
8. *Hydrachna miliaria*, right palpus, female
9. *Hydrachna magniscutata*, right palpus, female
10. *Hydrachna magniscutata*, genital organ and right epimera III, IV, female
11. *Hydrachna magniscutata*, anterior dorsal region, nymph
12. *Hydrachna magniscutata*, dorsal plate

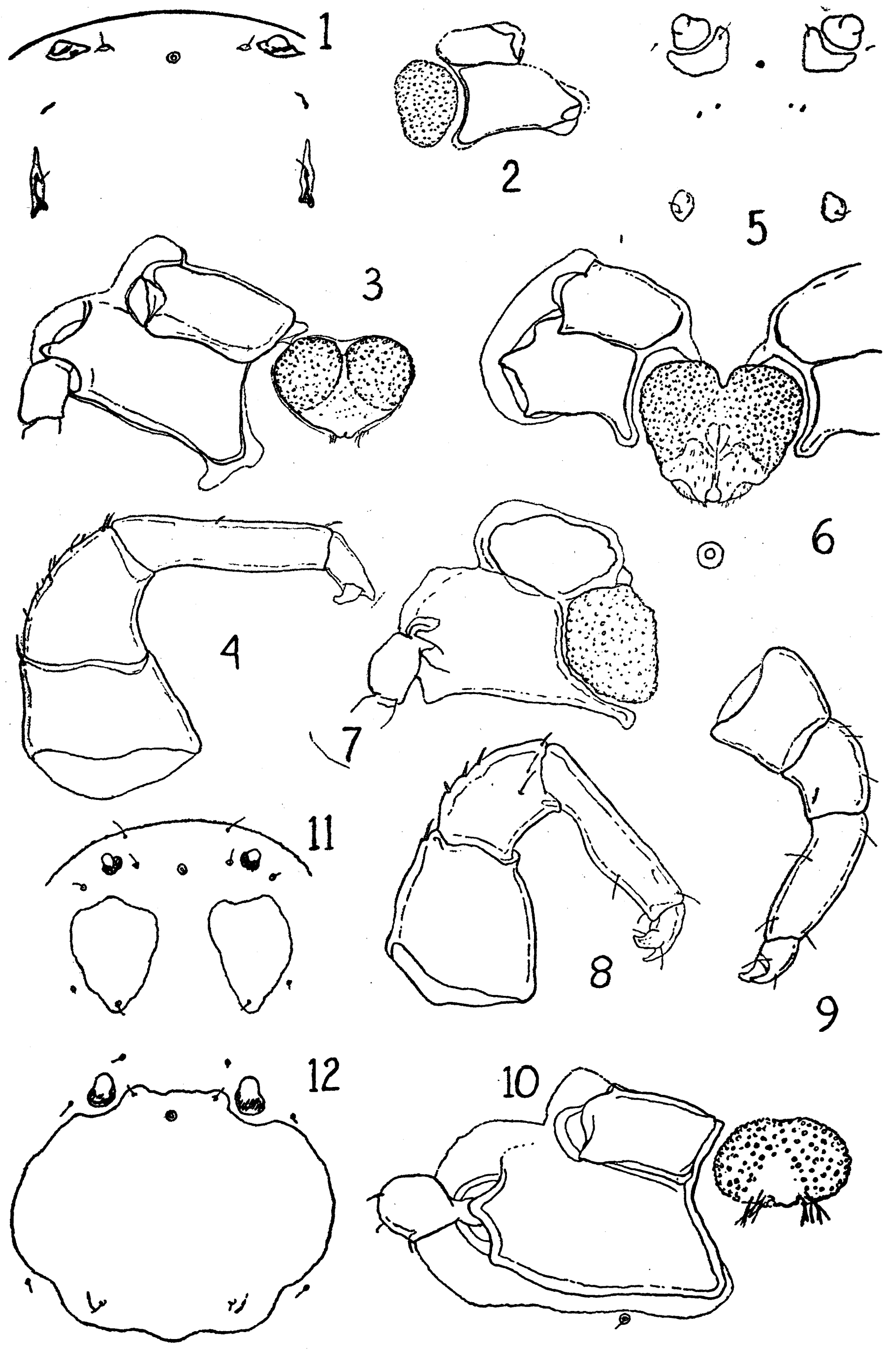

1
2
5
3
6
4
7
11
8
9
12
10

PLATE II

13. *Hydrachna cruenta,* dorsal plate
14. *Hydrachna cruenta,* genital organ and left epimera III, IV, female
15. *Hydrachna cruenta,* dorsal plates, nymph
16. *Hydrachna cruenta,* right palpus, female
17. *Hydrachna cruenta,* genital plates and epimera III, IV, nymph
18. *Hydrachna cruenta diminuata,* dorsal plate
19. *Hydrachna cruenta diminuata,* genital organ and right epimera III, IV, female
20. *Hydrachna crenulata,* left palpus
21. *Hydrachna rotunda,* lateral view
22. *Hydrachna rotunda,* genital organ and left epimera, female
23. *Hydrachna rotunda,* genital organ and left epimera III, IV, male

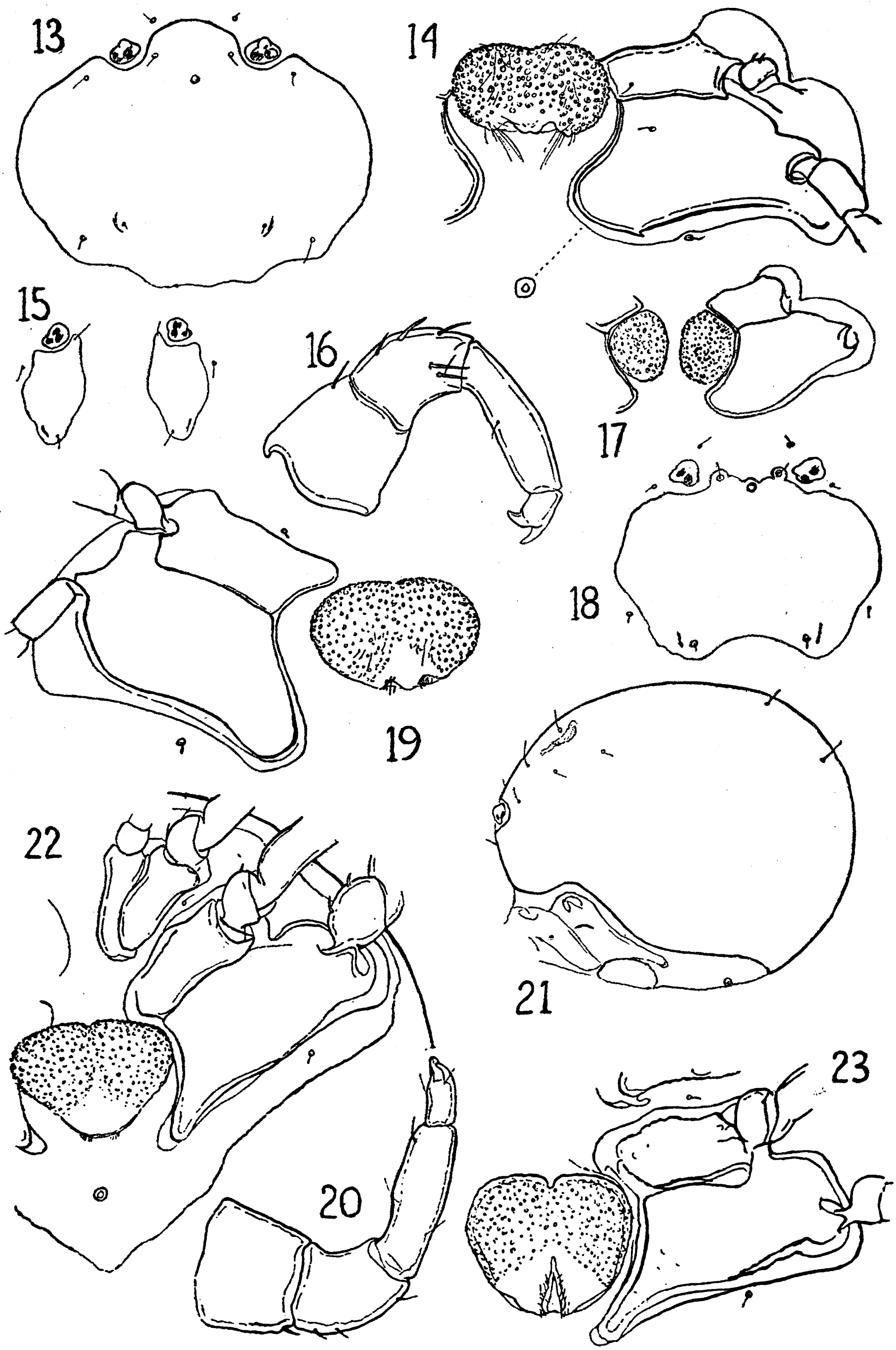

13
14
15
16
17
18
19
20
21
22
23

PLATE III

24. *Hydrachna crenulata*, genital organ and left epimera, male
25. *Hydrachna crenulata*, dorsal view
26. *Hydrachna rotunda*, left palpus, male
27. *Limnochares aquatica*, maxillary organ and palpus, lateral view
28. *Limnochares aquatica*, ocular plate
29. *Limnochares aquatica*, epimera III, IV and leg IV, left
30. *Limnochare americana*, ventral structures
31. *Limnochares americana*, ocular plate
32. *Limnochares americana*, leg IV, left
33. *Limnochares americana*, dorsal view
34. *Sperchonopsis verrucosa*, ventral view, male
35. *Sperchonopsis verrucosa*, right palpus
36. *Sperchonopsis verrucosa*, dorsal view

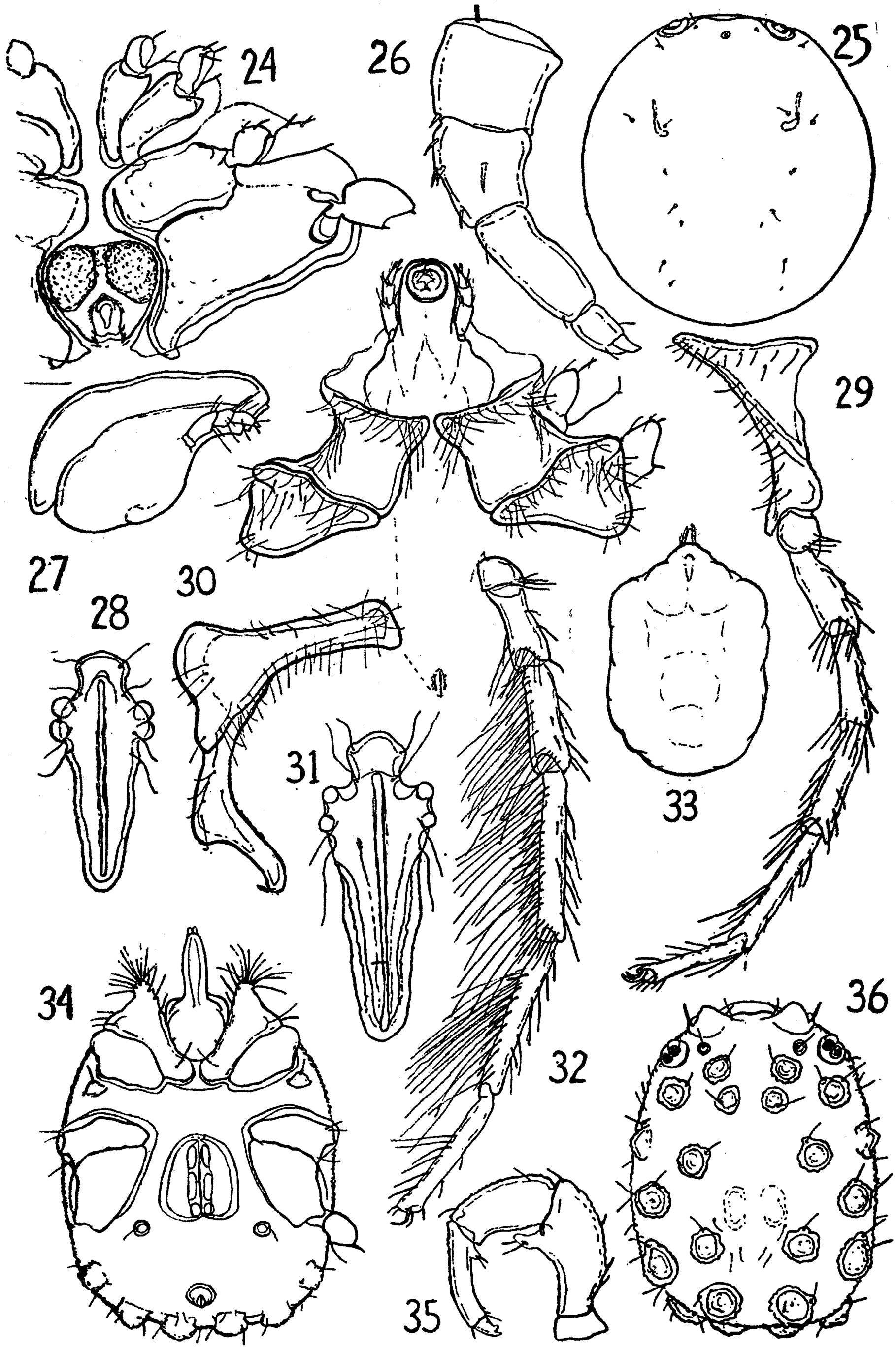

24
26
25
29
27
30
28
31
33
34
32
36
35

PLATE IV

37. *Eylais infundibulifera bakeri*, ocular plate
38. *Eylais infundibulifera bakeri*, left palpus
39. *Eylais desecta*, ocular plate, above
40. *Eylais desecta*, ocular plate, below
41. *Eylais desecta*, dorsal view
42. *Eylais gibberipons hirsutipalpis*, ocular plate
43. *Eylais gibberipons hirutipalpis*, palpus
44. *Eylais robustus*, ocular plate
45. *Eylais robustus*, ocular plate, irregular form
46. *Eylais robustus*, left palpus
47. *Eylais falcata*, ocular plate
48. *Eylais rimosa*, ocular plate

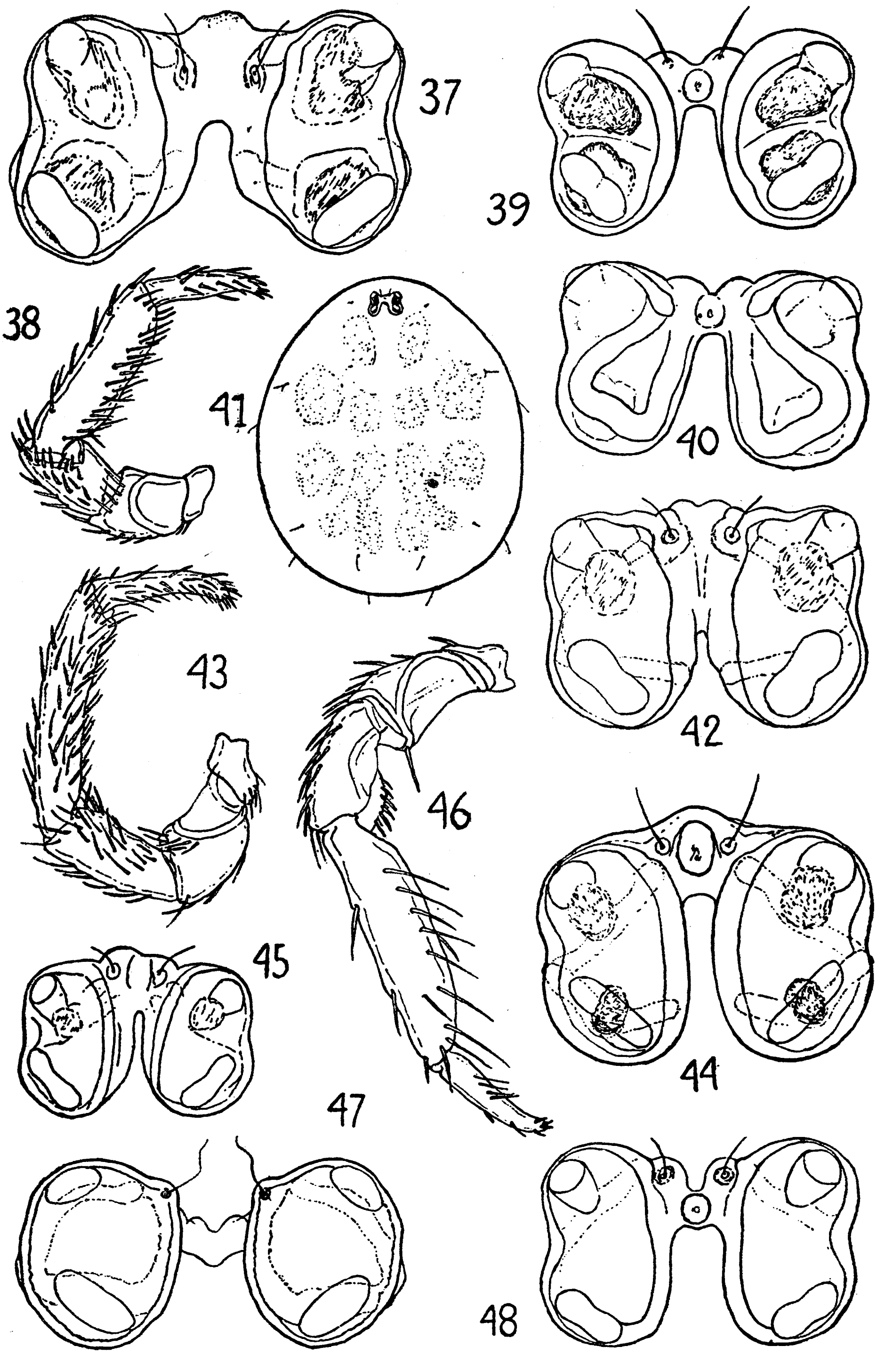
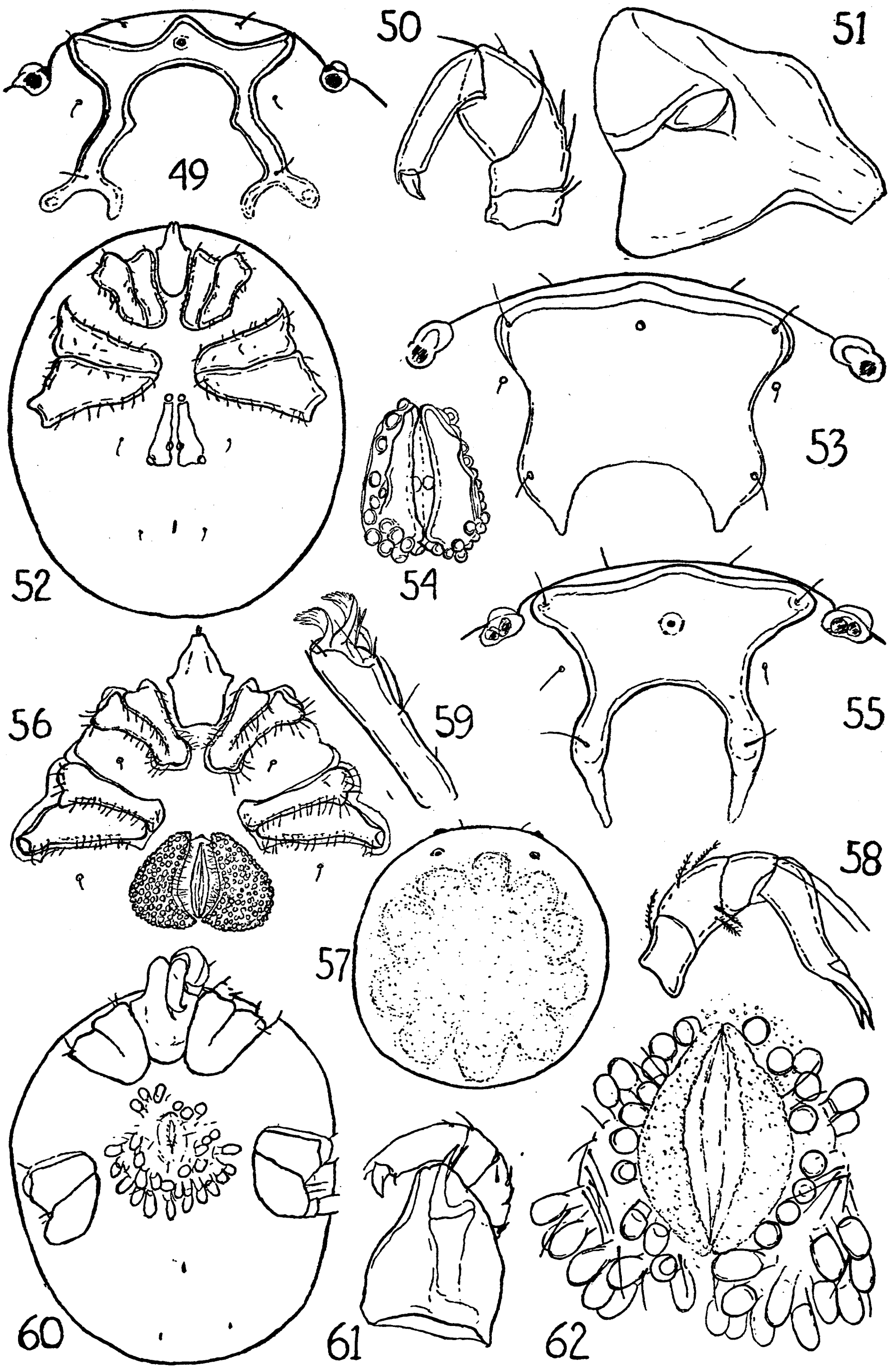

37
39
38
41
40
42
43
46
45
44
47
48

PLATE V

49. *Hydryphantes tenuabilis*, dorsal plate
50. *Hydryphantes tenuabilis*, palpus
51. *Hydryphantes tenuabilis*, rostrum, lateral view
52. *Hydryphantes ruber*, ventral view
53. *Hydryphantes ruber*, dorsal plate
54. *Hydryphantes multiporus*, genital organ
55. *Hydryphantes multiporus*, dorsal plate
56. *Diplodontus despiciens*, ventral plates
57. *Diplodontus despiciens*, dorsal view
58. *Diplodontus despiciens*, left palpus
59. *Calonyx ovalis*, leg IV, 6
60. *Calonyx ovalis*, ventral view, male
61. *Calonyx ovalis*, maxillary organ and palpus
62. *Calonyx ovalis*, genital organ, female


49
50
51
52
53
54
55
56
57
58
59
60
61
62

THE PHYSALOPTERA (NEMATODA) OF CARNIVORES

BANNER BILL MORGAN

Department of Veterinary Science, University of Wisconsin

The writer, in an attempt to identify some specimens of physalopterid nematodes collected from various carnivores, was unable to obtain complete descriptions of some forms because several species were inadequately described. With this situation a confusion exists in the literature as to which species are valid and which are synonyms. There appear to be nine valid species of *Physaloptera* recorded from carnivores. The purpose of this paper is to present briefly what is known of the various species, redescription of one species, a key to the species of *Physaloptera* found in carnivores, and a world host list.

While making this study, material was loaned by Dr. A. B. Erickson, University of Minnesota, Dr. E. A. Benbrook, Iowa State College, and Dr. H. W. Brown, University of North Carolina. Specimens collected by the writer were examined as well as supplementary material at the United States National Museum Helminthological Collection, Washington, D. C.

In previous publications, Morgan (1941, 1942), in a summary of North American Physalopterinae, reported that only five species of *Physaloptera* had been shown to occur in North American carnivores; namely, *P. felidis, P. maxillaris, P. preputialis, P. torquata,* and *P. rara.* Five additional species have been reported from carnivores from other parts of the world; *P. canis, P. anomala, P. terdentata, P. brevispiculum,* and *P. masoodi.* The most common habitat of *Physaloptera* is the stomach although they are occasionaly found in the small intestine. The *Physaloptera* have a wide range in the Order Carnivora, having been recorded from six Families; Felidae, Canidae, Procyonidae, Mustelidae, Hyaenidae, and Viverridae.

Physaloptera maxillaris Molin, 1860. Syn. *P. semilanceolata* Molin, 1860; *P. mephites* Solanet, 1909; *P. mydai* Baylis, 1926.

Molin (1860) based his original description on specimens taken from the stomach of a skunk (*Mephitis chinche*) from Brazil. Drasche (1883) substantiated *P. maxillaris* as a valid species. Linstow (1889) reported *P. maxillaris* from *Procyon cancrivora* (crab-eating raccoon) in Europe. Parona reported this parasite from *Mephitis suffocans* (bare-nosed skunk) from Argentina. Cameron (1936) identified *P. maxillaris* from the intestine of *Procyon cancrivora* (crab-eating raccoon) captured in Trinidad, British West Indies, on the basis of one female specimen.

Physaloptera maxillaris was probably recorded for the first time from North America by Ortlepp (1922) from *Mephitis mephitis* (Canadian skunk) shipped from Canada to England. Ortlepp (1922) also reexamined Molin's type material and gave a redescription of the parasite. Later, McClure (1930) reported *P. maxillaris* from a Canadian skunk which had died in the New York Zoological Gardens. In Mexico, Caballero and Peregrina (1938) reported this parasite from the stomach of a hooded skunk (*Mephitis m. macrura*). Stegeman (1939) recorded *P. maxillaris* from New York, in the stomach of *Mephitis m. nigra* (Eastern skunk). Stiles and Baker (1935) did not list *P. maxillaris* from North American hosts. The writer examined 147 skunks from Iowa, Illinois, and Wisconsin and found *P. maxillaris* in 64 per cent of them. This parasite is one of the most common in North America.

Physaloptera praeputialis Linstow, 1889. Syn. *Chlamydonema felineum* Hegt, 1910; *C. praeputialis* Travassos, 1917; *C. praeputiale* Yorke and Maplestone, 1926.

Linstow (1889) described *P. praeputialis* from a wildcat (*Felis catus*) from Brazil. His description was based on several females and one male specimen. Walton (1927) mentioned in his revision of the Leidy collections the finding of a single female specimen which was identified as *P. praeputialis*, from a non-recorded host. In the host list Walton (1927) assigned this specimen to the group "Mammal." This is probably the first record of *P. praeputialis* in North America. Later, Chitwood (1931) reported the occurrence of this parasite for the first time in the United States from *Urocyon* sp. (gray fox) from Virginia and *Lynx rufus* (lynx) Nevada. Caballero and Peregrina (1938) reported this parasite from Mexico in the stomach of a lynx (*Lynx rufus texensis*) and an ocelot (*Felis p. pardalis*).

Physaloptera praeputialis was found by the writer eleven times in 147 cats examined from Madison, Wisconsin and vicinity for an occurrence of 7.4 per cent. This parasite occurred only in mild infections with one exception. One cat harbored 59 mature worms. From nineteen cats examined from Ames, Iowa, seven were found infected. Two dogs examined from Madison, Wisconsin and a silver fox from Wisconsin were found infected with *P. praeputialis.*

Physaloptera torquata Leidy, 1886. Syn. *P. papillotruncata* of Canavan, 1931.

Leidy (1886) described this species from *Meles labridora* = *Taxidea taxus* (common badger). Walton (1927) redescribed the type material on the finding of male specimens. As the males of the type specimens were immature with poorly developed spicules, a further description was deemed necessary. Examination of some of Leidy's original material, dissection of the females revealed two uteri without a common trunk. The redescription of *P. torquata* in this paper (Table I) is based on material in the United States National Museum Helminthological Collection and specimens collected by the writer. Some of this material was collected by Ehlers (1931) from Montana badgers. Ehlers (1931) reported a complete history of the pathology and symptoms of heavy infections of this parasite in badgers.

Physaloptera rara Hall and Wigdor, 1918. Syn. *P. cerdocyona* Sprehn, 1932; *P. felidis* Ackert, 1936; *P. clausa* of Caballero and Peregrina, 1938; *P. turgida* of Leigh, 1940.

This parasite was described by Hall and Wigdor (1918) from a single immature specimen removed from the duodenum of a dog from Detroit, Michigan. The short esophagus described by Hall and Wigdor has not been found in any other species of the genus. To make the position more difficult, the type specimen of *P. rara* cannot be located.

The writer has examined over 200 specimens of *Physaloptera* from dogs, silver foxes, red foxes, gray foxes, wolves, and cats. Several specimens were taken from dogs from the type

Explanation of Plate

All figures except 10, 11, 12, 13, and 14; ventral view, male bursa of the various species of *Physaloptera* found in carnivores. Scale not uniform. Where scale appears, equals 1 mm.

Fig. 1. *P. rara* (Original).

Fig. 2. *P. maxillaris* (Original).

Fig. 3. *P. praeputialis* (Original).

Fig. 4. *P. torquata* (Original).

Fig. 5. *P. anomala* (After Ortlepp).

Fig. 6. *P. brevispiculum* (After Ortlepp, outer cuticle removed).

Fig. 7. *P. canis* (After Monnig, outer cuticle removed).

Fig. 8. *P. masoodi* (After Mirza, outer cuticle removed).

Fig. 9. *P. terdentata* (After Ortlepp).

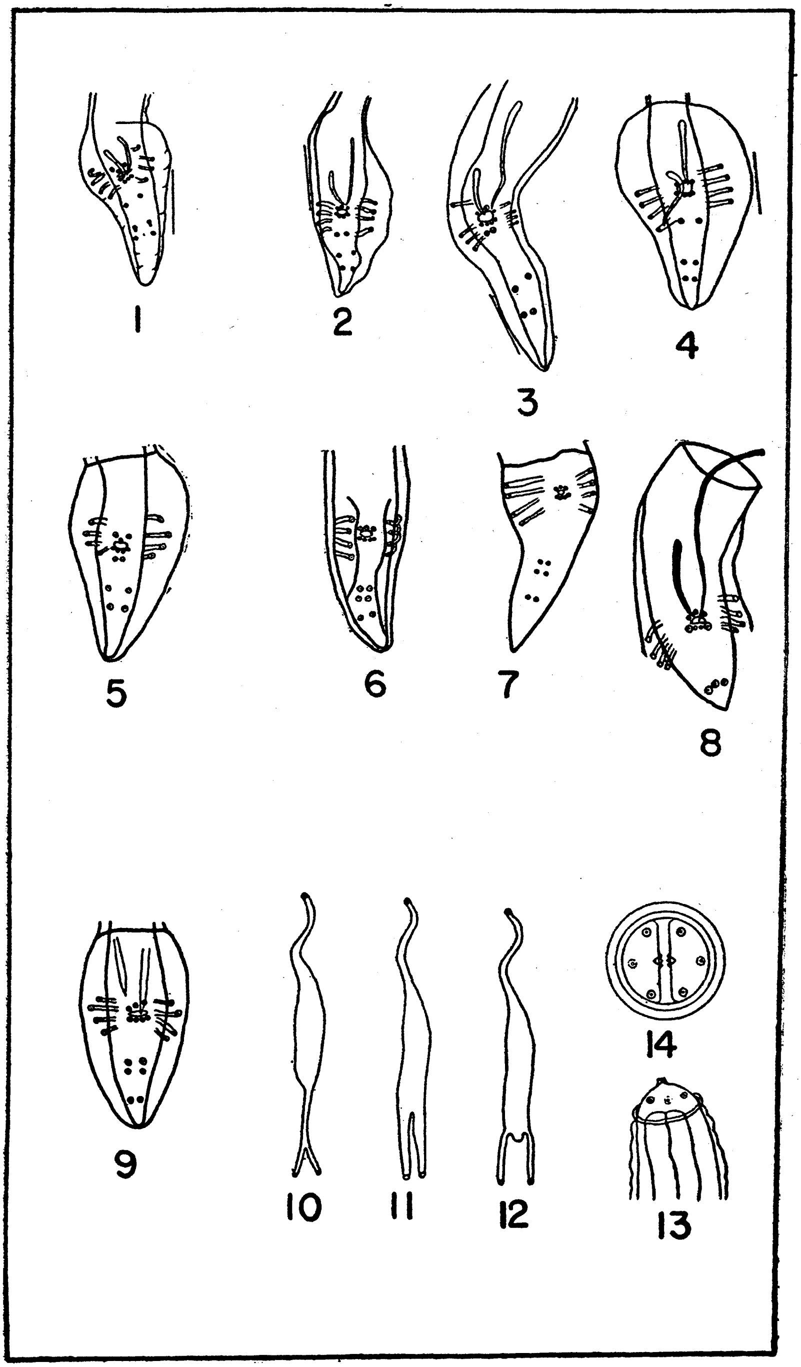
Fig. 10. 2-A type uteri (Diagrammatic).

Fig. 11. 2-B type uteri (Diagrammatic).

Fig. 12. 2-C type uteri (Diagrammatic).

Fig. 13. Anterior end, lateral view of *Physaloptera* (Diagrammatic).

Fig. 14. Anterior end, *en face* view of *Physaloptera* (Diagrammatic).


1
2
3
4
5
6
7
8
9
10
11
12
13
14

locality. All appeared to agree with the description of Ackert (1936) for *P. felidis*. However, the pair of small papillae described by Ackert (1936) appear to be phasmids. There is a great variation in the diameter of the phasmids when observed from a ventral view, which under certain conditions (over clearing) may be interpreted as small papillae.

Although *P. rara* was described from a single immature female and is possibly an abnormal specimen, examination of many specimens from the type host (dog) from the type locality (Detroit, Michigan) has convinced the writer that the parasite under consideration is the same species. Thus, *P. felidis* has been placed as a synonym of *P. rara*. In previous publications the writer attempted to separate *P. felidis* and *P. rara* but all identifications should now be regarded as *P. rara*.

Ackert (1936) described *P. felidis* = *P. rara* from local Kansas cats. Whitlock (1937) reported this parasite quite common in Kansas. Ackert (1941) examined 193 adult cats from the vicinity of Manhattan, Kansas, and 88 or 45.6 per cent were infected with this parasite. Olson *et al* (1937) reported *P. felidis* = *P. rara* from a coyote killed near Hubbard County, Minnesota. Immature specimens of *Physaloptera* from dogs have been recorded by Secord (1933) and Baker (1941).

Physaloptera pacitae Tubangui, 1925, from the domestic cat (*Felis domestica*) Philippine Islands; *P. papilloradiata* Linstow, 1889, from *Canis lupus* (wolf) Persia; *P. cesticillata* Sonsino, 1889; from *Canis cerdo* (Fennec fox) Egypt; and *P. elegantissima* Stossich, 1902, female specimens from *Ratelus capensis* (honey badger) Eritrea; have all been inadequately described. *Physaloptera gemina* Linstow, 1899, from the domestic cat and *P. vandenbrandeni* Gedoelst, 1924, from a wildcat (*Felis* sp.) from Belgian Congo; have been allocated to the genus *Abbreviata*.

PARASITE HOST LIST OF PHYSALOPTERA FOUND IN CARNIVORES

1. *Physaloptera rara*—CANIDAE. *Canis familaris* (domestic dog) Hall and Wigdor, 1918; Michigan. Morgan, 1941, 1942, Wisconsin, Michigan, Tennessee. *C. latrans* (coyote) Olson, Fenstermacher, and Pomeroy, 1937, Minnesota; Erickson, 1941, Minnesota; Morgan, 1941, 1942, Iowa, Mississippi. *C. nubilus* (timber wolf) Erickson, 1941, Minnesota; Morgan, 1941, 1942,

Nebraska, Kansas, North Dakota, South Dakota. *C. n. nebracensis* (prairie wolf) Morgan, 1941, 1942, Nebraska. *C. ochropus* (valley coyote) *Ibid,* California. *Urocyon c. cinereoargenteus* (Eastern gray fox) *Ibid,* Virginia, Eastern United States. *U. c. californicus* (California gray fox) *Ibid,* California. *U. c. floridanus* (Florida gray fox) *Ibid,* Arizona; Caballero and Peregrina, 1938, Mexico. *U. c. ocythaus* (Wisconsin gray fox) Erickson, 1941, Minnesota; Morgan, 1941, 1942, Wisconsin. *Vulpes fulva* (silver and eastern red fox) Morgan, 1941, 1942, Wisconsin, Minnesota. *V. regalis* (Northern plains red fox) *Ibid,* Iowa. *Cerdocyon azeaus* (wolf-like fox) Sprehn, 1932, Germany. PROCYONIDAE. *Procyon l. lotor* (Eastern raccoon) Morgan, 1941, 1942, Wisconsin, Iowa; Leigh, 1940, Illinois. FELIDAE. *Felis domestica* (domestic cat) Ackert, 1936, 1941, Kansas; Whitlock, 1937; Kansas; Morgan, this paper, Wisconsin. *Lynx rufus* (bobcat) Erickson, 1941, Minnesota.

2. *P. maxillaris*—MUSTELIDAE, PROCYONIDAE. A complete host list of this parasite has been recorded in a previous publication, (Morgan, 1943).

3. *P. praeputialis*—FELIDAE. *Felis catus* (wildcat) Linstow, 1889, Brazil. *F. domestica* (domestic cat) Hegt, 1910, Batavia; Gedoelst, 1911, Belgium; Bodkins and Cleare, 1916, British Guiana; Travassos, 1917, Brazil; Ortlepp, 1922, Federated Malay States, China, Ceylon, Dutch Guiana, British Guiana; Chandler, 1925, India; Faust, 1929, Chen, 1934, Tang, 1936, Andrews, 1937, all from China; Pinto, 1936, Brazil. Landa, 1934, Eastern Russia; Neuland, 1934, Southwest Russia; Volkenberg, 1939, Puerto Rico; Foster, 1939, Panama; Morgan, 1941, 1942, Wisconsin, Iowa; Benbrook, 1940, Iowa; Sandground, 1940, Indiana. *F. tigra* (Malay tiger) Harrison and Hall, 1909, London Zoo. *F. nebulosa* (clouded leopard) Ortlepp, 1922, India; Chandler, 1925, India. *F. pardus* (leopard) Ortlepp, 1922, Nigeria; Monnig, 1923, South Africa; Sandground, 1928, Tanganyika. *F. tigrinum* (tiger) Thwaite, 1927, Ceylon; Boulenger, 1923, Zanzibar. *F. caffra* (caffra cat) Monnig, 1923, South Africa. *F. p. pardalis* (ocelot) Caballero and Peregrina, 1938, Mexico; *F. bengalensis* (leopard cat), *F. viverina* (fisher cat) Travassos, 1917, Brazil; *F. cougar* (mountain lion) Morgan, 1941, 1942, West Virginia. *Lynx rufus texensis* (lynx or bobcat) Caballero and Peregrina, 1938, Mexico; *Lynx rufus* (bobcat) Chitwood,

1931, Nevada; Spurlock, 1940, California. *L. uninta* (mountain bobcat) Morgan, 1941, 1942, Oregon. *Lynx rufus baileyi* (Bailey bobcat), Crater, 1936, Arizona. *Lynx canadensis* (bobcat) Morgan, 1941, 1942, Canada. CANIDAE. *Canis familiaris* (domestic dog) Morgan, 1941, 1942, Wisconsin; Pinto and Almeida, 1935, Brazil; Stiles and Baker, 1935, location not given; Andrews, 1937, China. *C. mesomelas* (black-backed jackal) Monnig, 1923, South Africa. *Urocyon* sp. (gray fox) Chitwood, 1931, Virginia. *U. c. cinereoargentaus* (Eastern gray fox) Morgan, 1941, 1942, Iowa. *U. c. borealis* (Northern gray fox) New Hampshire, *Ibid.* *Vulpes fulva* (silver fox) Morgan, 1941, 1942, Wisconsin. VIVERRIDAE. *Genetta ludia* (genetta cat) Monnig, 1923, South Africa.

TABLE I. Comparative measurements of *P. torquata*

	Walton	Morgan
Length M F	8.3 mm 7.5-7.8 mm	20-23 mm 30-38 mm
Width M F	570μ 630μ	565-798μ 1.2-1.6 mm
Esoph M		3.4-4.1 mm 4.3-5.3 mm
Vulva	2.25 mm	5.5-10.1 mm
Eggs		51 × 33μ
L. spicule		604-854μ
R. spicule		532-804μ

4. *P. torquata*—MUSTELIDAE. *Taxidea t. taxus* (common badger) Leidy, 1886, Pennsylvania; Walton, 1927, Pennsylvania; Morgan, 1941, 1942, Wisconsin, Illinois; Canavan, 1931, Philadelphia Zoological Gardens. *T. t. neglecta* (Western badger) Ehlers, 1931, Montana; Hannum, 1939, Arizona; Morgan, 1942, California. PROCYONIDAE. *Procyon l. lotor* (Eastern raccoon) Morgan, 1942, Wisconsin, Iowa.

5. *P. anomala* Molin, 1860. FELIDAE. *Felis onca* (jaguar) Molin, 1860, Brazil. Ortlepp, 1924, Dutch Guiana.

6. *P. brevispiculum* Linstow, 1906. Syn. *P. malayensis* Ortlepp, 1922. *Chlamydonema fuelleborni* Mirza and Narain, 1934. FELIDAE. *Felis rubiginosa* (rusty-spotted cat) Linstow, 1906,

TABLE II. Comparative measurements of *P. maxillaris*

	Ortlepp	McClure	Caballero	Morgan
Length M F	23-32 mm 20-36 mm	19-25 mm 20-28 mm	25-30 mm 20-25 mm	20-26 mm 21-29 mm
Width M F	550-800μ 800μ-1.2 mm	550-900μ 839-953μ	647-770μ 1.0 mm	545-880μ 840-1.2 mm
Esoph M F				3.1-5.3 mm 4.3-6.1 mm
Vulva	Anterior	Anterior	4.3-9.1 mm	4.6-8.3 mm
Eggs	43 × 31μ		49 × 31μ	47 × 32μ
L. spic.	1.2 mm	973μ	612μ	840-990μ
R. spic.	560μ	735μ	437μ	550-615μ

Comparative measurement of *P. rara*

	Ackert	Morgan
Length M F	25-29 mm 27-44 mm	26-28 mm 30-41 mm
Width M F	710-803μ 958μ-1.1 mm	800μ 1.0 mm
Esoph M F	4.7-5.3 mm 6.6-7.8 mm	4.8-6.0 mm 7.0 mm
Vulva	3.2-5.8 mm	4.8 mm
Eggs	42-46 × 29-35μ	43 × 32μ
L. spic.	671-830μ	796μ
R. spic.	513-603μ	482μ

Comparative measurement of *P. praeputialis*

	Linstow	Ortlepp	Pinto	Korke	Morgan
Length M F	21 mm 30 mm	13-40 mm 15-48 mm	30-35 mm 40-55 mm	35-45 mm 38-45 mm	19-41 mm 22-58 mm
Width M F	1.5 mm 2.0 mm	700-1.3 mm 1.0-1.7 mm	1.0-1.5 mm 1.0-2.0 mm	1.2-1.8 mm 1.6 mm	800-1.3 mm 1.0-1.2 mm
Esoph M F				5.7 mm	4.0-6.2 mm 4.6-8.0 mm
Vulva	8.0 mm	Anterior	Anterior	15-20 mm	11.0-18 mm
Eggs	55 × 33μ	49 × 35μ	56 × 42μ	45 × 30μ	56 × 35μ
L. spic.		1.0-1.2 mm	1.18 mm	1.1 mm	1.2-1.4 mm
R. spic.		840-900μ	980μ	425-700μ	845-890μ

Ceylon. *F. chaus* (jungle cat), *F. tigris* (tiger), "Tiger Cat," Ortlepp, 1922, Federated Malay States, "Bush Cat" Nigera. *F. domestica* (domestic cat) Mirza and Narain, 1934, India. HYAENDAE. *Hyaena striata* (hyaena) Ortlepp, 1922, Nigeria.

7. *P. canis* Monnig, 1929. CANIDAE. *Canis familiaris* (domestic dog) Monnig, 1929, South Africa. FELIDAE. *Felis domestica* (domestic cat) Monnig, 1938, South Africa.

8. *P. masoodi* (Mirza, 1934). Syn. *Chlamydonema masoodi* Mirza, 1934. FELIDAE. *Felis chaus* (jungle cat) Mirza, 1934, India.

9. *P. terdentata* Molin, 1860. Syn. *P. digitata* Schneider, 1866. FELIDAE. *Felis concolor* (puma) Molin, 1860, Brazil. Schneider, 1866, Brazil. *F. tigrina* (tiger) Molin, 1860, Brazil. *F. pardus* (leopard) Shipley, 1905, Sudan.

KEY TO SPECIES OF *Physaloptera* FOUND IN CARNIVORES

1. Female with 2-A uteri 2
   Female with 2-B uteri 3
   Female with 2-C uteri 5
2. Male with 5 pairs of post anal papillae; 2 pair surrounding cloaca; 1 pair directly behind center pair of cloacal papillae; 2 pairs equidistant on tail; 3 pre-anal papillae .... *P. anomala* Molin, 1860
   Male with 5 pairs post anal papillae; 2 pairs surrounding cloaca; 3 pairs equidistant on tail; 3 pre-anal papillae .... *P. maxillaris* Molin, 1860
3. Male with 5 pairs post anal papillae; 2 pairs surrounding cloaca; 3 pairs equidistant on tail; 3 pre-anal papillae 4
4. Spicules slightly unequal; left spicule 604 to 931μ; right spicule 532 to 791μ; right spicule with definite twist .... *P. torquata* Leidy, 1886
   Spicules slightly unequal; slightly curved, slender; left spicule 740 to 924μ; right spicule 477 to 700μ .... *P. rara* Hall and Wigdor, 1918
5. Vulva in middle of body 6
6. Male with 5 pairs post anal papillae; 2 pairs surrounding cloaca; 3 pairs further down on tail; 3 pre-anal papillae .... *P. canis* Monnig, 1929
7. Vulva in anterior third of body 8
8. Male with 3 pairs post anal papillae; 1 unpaired papillae; 2 pairs surrounding cloaca; 3 papillae in transverse row near tip of tail; 3 pre-anal papillae .... *P. masoodi* (Mirza, 1934)
   Male with 5 pairs post anal papillae; 2 pairs surrounding cloaca; 1 pair directly behind center pair of cloacal papillae, 2 pairs equidistant on tail; 3 pre-anal papillae .... *P. praeputialis* Linstow, 1889
9. Male with 5 pairs post anal papillae; 2 pairs surrounding cloaca; 3 pairs further down on tail; 3 pre-anal papillae 10
10. Spicules long, unequal, slightly curved; left spicule 1.4-2.5 mm., right spicule 580-597μ .... *P. brevispiculum* Linstow, 1906
    Spicules short, equal, or subequal; left spicule 320μ right spicule 305μ .... *P. terdentata* Molin, 1860

LITERATURE CITED

Ackert, J.
1936. *Physaloptera felidis* n. sp. A nematode of the cat. Trans. Amer. Micro. Soc. 65: 250-254.

Ackert, J.
1941. The cat as a host of the nematode *Physaloptera felidis* Ackert.
1941. Rev. Med. Trop. y Parasitol. Bact. Clin. y Lab. 7: 7-8.

Andrews, N.
1937. Helminth parasites of dogs and cats in Shanghai, China. Jour. Helminth. 15: 145-152.

Baker, D.
1941. *Physaloptera* in New York state dogs. Cornell Vet. 31: 80-82.

Baylis, H.
1926. Some parasitic worms from Sarawak. Sarawak Mus. Jour. 3: 303-322.

Bodkins, G. and Cleare, L.
1916. Notes on some animal parasites in British Guiana. Bull. Ent. Res. 7: 179-190.

Boulenger, C.
1923. A collection of nematode parasites from Zanzibar. Parasitology. 15: 113-121.

Caballero, E. and Peregrina, D.
1938. Nematodos de los mamiferos de Mexico. Anales Inst. Biol. 9: 289-306.

Cameron, T.
1936. Studies on the endoparasitic fauna of Trinidad. III. Some parasites of Trinidad Carnivores. Can. Jour. Res. 14: 25-38.

Canavan, W.
1931. Nematode parasites of vertebrates in the Philadelphia Zoological gardens and vicinity. Parasitology. 23: 196-229.

Chandler, A.
1925. The helminths of cats in Calcutta, and the relation of cats to human helminthic infection. Indian Jour. Med. Res. 13: 213-228.

Chen, H.
1937. Some parasitic nematodes from mammals of South China. Parasitology. 29: 419-434.

Chitwood, B.
1931. Jour. Parasitol. 18: 53.

Crater, R.
1936. Jour. Mammal. 17: 170-171.

Drasche, R.
1883. Revision der in der nematoden. Verhandl. Zool. Bot. Gesell. Wien. 32: 117-218.

Ehlers, G.
1931. The anthelmintic treatment of infestations of the badger with Spirurids (*Physaloptera* sp.). Jour. Amer. Vet. Assoc. 31: 79-87.

Faust, E.
1929. The animal parasites of the dog and cat in China. Lingnan Sci. Jour. 8: 27-44.

Foster, A.
1939. Some helminthic parasites recovered from domesticated animals (excluding equines) in Panama. Proc. Helm. Soc. Wash. 6: 101-102.

Gedoelst, L.
1924. Notes on parasitologie Congolaise. Ann. Soc. Belg. Med. Trop. 4: 1-7.

Hall, M. Wigdor, M.
Physaloptera from the dog, with a note on the nematode parasites of the dog in North America. Jour. Amer. Vet. Med. Assoc. 6: 733-744.

Harrison, M. and Hall, I.
1909. Fatal enteritis in a tiger caused by *Physaloptera praeputialis*. Parasitology 2: 29-31.

Hegt, J.
1910. *Chlamydonema felineum*, Nov. Gen. Nov. Sp., eine neue parasitch lebende Nematode. Tijdsch. der Nederl. Dierk. Vereen. 12: 5-59.

Korke, V.
1928. Revision of type species of Linstow in India. Indian Jour. Med. Res. 16: 199-202.

Landa, D.
1934. Biological Abstracts. 8: 679.

Leidy, J.
1886. Notices of nematoid worms. Proc. Acad. Nat. Sci. Philadelphia. 38: 308-313.

Leigh, W.
1940. Preliminary studies on parasites of upland game birds and furbearing mammals in Illinois. Ill. Nat. Hist. Survey Bull. 21: 185-194.

Linstow, O.
1889. Helminthologisches. Arch. fur. Nat. 54: 235-246.
1899. Nematoden Aus der Berliner Zoologischen Sammlung. Mitt. Zool. Mus. 1: 5-28.

McClure, G.
1930. Nematode parasites of mammals. Zoologica. 15: 1-28.

Monnig, H.
1923. South African parasitic nematodes. Rept. Direct. Vet. Ed. Res. 9/10: 435-478.

Monnig, H.
1929. *Physaloptera canis*, n. sp., A new nematode parasite of the dog. Rept. Direct. Vet. Ser. Union. South Africa 15: 329-333.

Molin, R.
1860. Una monografia del genere *Physaloptera*. Sitzungsb Akd. d. Wissemsch. 39: 637-672.

Morgan, B. B.
1941. A summary of the Physalopterinae (Nematoda) of North America. Proc. Helm. Soc. Wash. 8: 28-30.
1941. Additional notes on North American Physalopterinae (Nematoda). *Ibid.*, 8: 63-64.

1942. The Physalopterinae (Nematoda) of North American vertebrates. Sum. Doctoral Diss. Univ. Wis. 6: 88-91.
1943. The Physalopterinae (Nematoda) of Aves. Trans. Amer. Micro. Soc. 62: 72-80.
1943. The *Physaloptera* (Nematoda) of Rodents. Wassmann Collector. 5: 99-107.
1943. The *Physaloptera* (Nematoda) of Reptiles. Le Nat. Can. 70: 179-185.
Mirza, M.
1934. *Chlamydonema masoodi* n. sp. Ann. Parasitol. 12: 367-370.
Mirza, M. and Narain, S.
1934. *Chlamydonema fuelleborni* n. sp. Current Sci. Bangalor. 2: 288.
Neuland, D.
1934. Biological Abstracts. 8: 971.
Olson, O., Fenstermacher, R., and Pomeroy, B.
1937. The coyote as a host to *Physaloptera felidis*. Cornell Vet. 27: 327.
Ortlepp, R.
1922. The nematode genus *Physaloptera* Rud. Proc. Zool. Soc. London. 999-1107.
Ortlepp, R.
1924. On a collection of helminths from Dutch Guiana. Jour. Helminthol. 2: 15-40.
Pinto, C.
1936. *Physaloptera* dos catos do Brasil. O. Campo. 7: 45.
Pinto, C. and Almeida, J.
1935. Sinopse dos helmintos dos animois domesticos do Brasil. O. Campo. 6: 60.
Sandground, J.
1928. Some new cestode and nematode parasites from Tanganyika territory. Proc. Boston Soc. Nat. Hist. 39: 131-150.
Schneider, A.
1866. Monographie der Nematoden. 1-357.
Secord, A.
1933. A study of nematodes found in dogs from Franklin County, Ohio. Ohio State Univ. Vet. Alum. Quart. 21: 9-19.
Shipley, A.
1905. Notes on a collection of parasites belonging to the Museum of University College, Dundee. Proc. Cambridge, Phil. Soc. 13: 95-102.
Solanet, E.
1909. Sobre una *Physaloptera* del *Mephites suffocans*. Rev. centro. Est. Agron. y. Vet. 90-92.
Sprehn, C.
1932. Uber einige von Dr. Eisentraut in Bolivien gesammelte Nematoden. Zool. Anz. 100: 273-294.
Stegeman, L.
1939. Some parasites and pathological conditions of the skunk (*Mephitis mephitis nigra*) in Central New York. Jour. Mammal. 20: 493-496.

Stiles, C. and Baker, C.
1935. Key catologue of parasites reported for Carnivora, with their possible public health importance. Nat. Inst. Health Bull. No. 163.

Stossich, M.
1889. Il Genere *Physaloptera* Rud. Bull. Soc. Adriat. Sci. Nat. Trieste. 2: 1-24.

Tang, C.
1936. A survey of helminth fauna of cats in Foochow. Peking Nat. Hist. Bull. 10: 223-231.

Thwaite, J.
1927. On a collection of nematodes from Ceylon. Ann. Trop. Med. Parasitol. 21: 225-244.

Travassos, L.
1917. Infermacoes sobre um interessante parasito dos gatos. Arch. Eseola Sup. Agric. Med. Vet. 1: 101-103.

Tubangui, M.
1925. Metazoan parasites of Philippine domesticated animals. Philippine Jour. Sci. 28: 11-35.

Walton, A.
1927. A revision of the nematodes of the Leidy collection. Proc. Acad. Nat. Sci. Philadelphia. 79: 49-163.

Whitlock, J.
1937. Endoparasitism of the cat. Vet. Med. 32: 514-520.

Yorke, W. and Maplestone, B.
1926. Nematode parasites of vertebrates. London.

WINTER OXYGEN CONTENT AND BIOCHEMICAL OXYGEN DEMAND IN A WISCONSIN ARTIFICIAL LAKE

CHARLES H. LEWIS AND NEIL E. STEVENS
University of Illinois

The oxygen content of lake and reservoir water under ice is important in the culture of at least two Wisconsin food crops, fish and cranberries. The direct relation between the oxygen content of water under ice and the death of fish by smothering has long been known. Recently it has become recognized that certain important and widespread cranberry troubles known as leafdrop, flower bud absorption, etc., may be caused or aggravated by a deficiency of oxygen in the water in which they are submerged. In extreme cases the vines may be killed outright.

In connection with a study of cranberry problems we have gathered the information on the winter oxygen content of water presented below. Much of the work here recorded was carried out in the laboratory of Wisconsin Conservation Department at Spooner, Wisconsin. For permission to use this laboratory, and for helpful suggestions, we are indebted to D. J. O'Donnell, biologist of the Wisconsin Conservation Department.

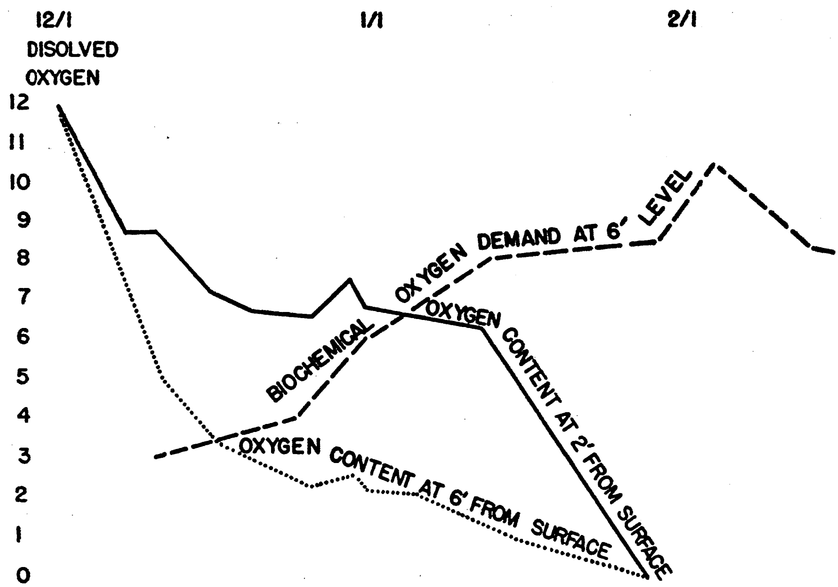
The reservoir studied is in Washburn County. It was made in 1912 by damming up Beaver Brook at which time it covered about forty acres. Because of reduced rainfall it was found necessary from 1930 to conserve water by pumping it back into the reservoir from the marsh, and in 1934 to supplement the flow of the brook by pumping it from a deep well. The area of the reservoir has been gradually increased by raising the dam, and is now approximately one hundred acres. All of this, except the bed of Beaver Brook itself, was originally covered with vegetation. There are numerous tree stumps still in the reservoir. The water in the reservoir is relatively hard, varying in pH from 7.6 to 8.2.

The present paper is based on about 300 separate determinations and gives a practically continuous record of the oxygen content and biochemical oxygen demand of the water from the time the reservoir first froze over in the fall until the ice melted in the spring. So far as we have been able to discover no similar data have been published.

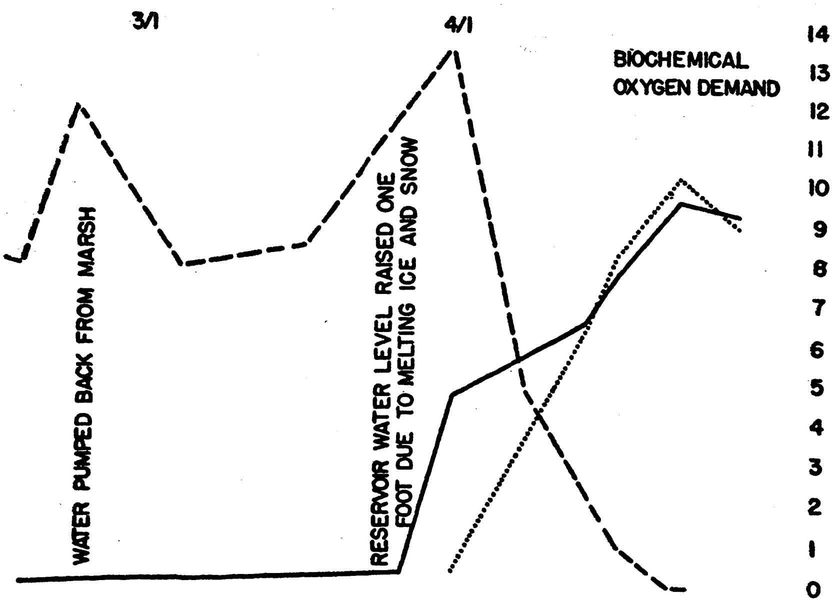
Oxygen Content

Determinations of the dissolved oxygen content were made by the modified Winkler method, following exactly the directions given by the Wisconsin Department of Health in the Wisconsin Sewage Works Operators' Short Course. The standardized solutions and many of the chemicals used were furnished by Dr. W. B. Griem, chemist of the Wisconsin Department of Agriculture. In all, several hundred determinations were made at a series of stations spaced at intervals over the reservoir. Although there are naturally some slight variations from place to place they do not appear to be constant or significant. Consequently the figures from only one representative station are given in the graphs.

Ice covered the reservoir November 26, 1942. Determinations were begun November 29 at which time the ice was five



inches thick and covered with less than an inch of snow. The ice increased in thickness up to twenty inches on about March 26, and was covered with snow most of the winter. The depths from which the samples were taken are measured in feet from the top of the ice. As is evident from the graph, throughout the month of December the oxygen content of the water declined fairly steadily from 10.5 to 7 parts per million at a depth of two feet and from 10 to 2.2 parts per million at a depth of six feet. A corresponding difference in the oxygen content at the different depths was observed at all stations. During January, 1943, there was a rapid decline in the oxygen at both levels and by February 27 it had reached a point so near zero that our determinations can no longer be considered significant. These conditions remained unchanged except for a slight but measurable rise about February 26 to 27 caused by pumping back large quantities of water used in flooding the marsh on February 24. Between March 25 and 31 the reservoir was raised one foot by melting ice and snow, and there was a marked rise in oxygen content which was still further increased by pumping on April 5, 6 and 7. It should be added that by the first of February it was evident that most of the fish were dead. The only fish to



survive the winter were the larger ones that were able to migrate to the springs.

Biochemical Oxygen Demand

The biochemical oxygen demand was determined by the methods outlined in the directions mentioned above. This is a somewhat simplified form of the directions given in "Standard Methods of Water Analyses. 1936." The biochemical oxygen demand of a water sample is expressed in terms of the difference of the amount of dissolved oxygen in a sample of thoroughly aerated distilled water, and a similar sample of aerated distilled water with which has been mixed a known quantity of the water to be tested, after both samples have been incubated at the same temperature for the same length of time. In the results here reported 50 cc. of the reservoir water was mixed with 200 cc. of aerated distilled water and incubated at 20° C. for five days. It is thus a measure of the extent and to some degree of the rate with which such reservoir water may be expected to exhaust the oxygen present in any water with which it may become mixed. In Wisconsin this measure is widely used in studies of sewage and mill wastes which enter rivers.

As is evident from the graphs, the biochemical oxygen demand of the water of the reservoir at Beaver Brook rose slightly during December when the oxygen content of the water was above 3 parts per million and from this point rose more rapidly until shortly after February 26 when a considerable supply of freshly aerated water was pumped back from the marsh. The effect of this added oxygen is clearly shown by the fact that the biochemical oxygen demand of the reservoir water was materially less on March 3 and March 16. By the end of the month the biochemical oxygen demand was equal to or greater than before the pumping. Between March 25 and 31, the reservoir rose a foot from melting ice and snow. This raised the oxygen content of the water at the two-foot level to 6.7. On April 2 the marsh was flooded, removing at least two-thirds of the water from the reservoir. Much of this water was pumped back and this, together with the rapid accumulation of melting ice and snow, filled the reservoir by April 7. At this time the oxygen content of the water was approximately 8 parts per million at all levels. It should be especially noted, however, that while the biochemical oxygen demand was much lower on April 7 than on March 31, before the water was aerated, it was by no means reduced to zero; in fact it was still measurable nine days later.

SIGNIFICANCE OF THESE OBSERVATIONS IN CRANBERRY CULTURE

In a recent paper, Bergman has summarized the available information regarding injury to cranberry vines due to deficient oxygen under the ice. His researches have established the fact that injury may occur whenever the oxygen content of the water drops below four parts per million for a sufficient length of time.

The observations here recorded indicate that the cranberry grower who has experienced trouble from smothering during the winter, when flooding his marsh, must consider not only the oxygen content of the water but its biochemical oxygen demand. It is comparatively easy, as shown in Table I, to aerate water by

TABLE I. Increase in oxygen content of water following splashing over gates.

Date	Flood Gate number	Oxygen content of reservoir water immediately above gates p.p.m.	Oxygen content of water after flowing over gates and splash boards p.p.m.
Jan. 6	2	5.3	9.1
8	2	3.7	7.8
18	3	2.0	6.0
Feb. 25	1	0.1	10.1
25	2	0.1	8.1
March 2	2	2.4	8.3
April 2	2	4.4	7.6
2	1	6.7	8.7
2	3	6.7	7.8

flowing through gates and over a series of splash boards. The biochemical oxygen demand of this same water may, however, be so high that the oxygen is quickly exhausted. This is strikingly illustrated by the observations made on a typical field at Beaver Brook and recorded in Table II.

In spite of the fact that water was continuously flowing into the marsh from the reservoir the oxygen content dropped in the

TABLE II. Decrease in oxygen content of water on a cranberry field.

Date	Oxygen Content p.p.m.	
Mar. 2	8.3	Water circulating
3	7.0	Water circulating
4	5.9	Water circulating
5	2.8	Water not circulating

second day to 5.9. Within twenty-four hours after the flow from the reservoir was stopped the oxygen content dropped to 2.8. Under these conditions there appears to be no safe course but continual sampling. As soon as the oxygen content nears the danger point it must be raised by the addition of freshly aerated water.

FURTHER OBSERVATIONS ON ALKALINE FLOODING WATER IN CRANBERRY GROWING

NEIL E. STEVENS

University of Illinois

Additional evidence (1) of the apparently injurious effect of alkaline flooding water in cranberry culture has been derived recently from three distinct sources.

First, and in some respects most significant, is the fact that two successive crops of cranberries have been produced on the only marsh now cultivated in the Berlin area. These crops were not large in comparison with the most productive Wisconsin marshes. They were, however, commercial crops far larger than any produced there for many years. The only changes in culture methods relate to the handling of the water. The water in the ditches was held at a lower level by pumping, when necessary, into the canal leading to the Fox River. During both growing seasons, river water was excluded from the marsh, also by pumping when necessary. Until September, 1943, the water used in flooding the marsh came entirely from the reservoir the level of which was raised nearly a foot in 1943. Under the conditions of precipitation obtaining in 1942 and 1943, the water in the reservoir came chiefly from rain and melted snow. The pH of the reservoir water during these two years was about 6.8. This figure is an average of the readings taken at five different stations twice during 1942 and several times in 1943.

The second piece of evidence relating to this general subject was the unexpected, and as yet unexplained, effect of adding sodium bicarbonate to the flooding water. Some 160 pounds of technical sodium bicarbonate were added to the reservoir water (pH about 5.3) used in flooding about an acre of cranberries on June 10, 1943. The cranberries were submerged for less than sixteen hours. There followed an extremely heavy vegetative growth whose abundance was lacking on adjacent sections flooded at the same time with untreated water. Whatever the explanation of this may be, the fact is significant in relation to the history of marshes with alkaline flooding water.

Finally, further study* of the history of cranberry culture in the Berlin area has brought out several very important points not wholly clear hitherto and indicates an even closer relation between the yield of cranberries in the Berlin area and the use of alkaline water than was suggested in the earlier paper. The famous crop of 1872 in this area was the high point in a series of good crops. The canal from Willow Creek at Auroraville to the Carey marsh was dug in 1873. This was the first use of alkaline water in large amounts in this region. The other canals, that connecting Willow Creek with the Walters' and nearby marshes and that connecting the Fox River with the Sacket Marsh, were not dug until more than ten years later. Because of the importance of these facts in relation to the general problems of the history and geography of cranberry culture in Wisconsin, such figures relating to the actual crops as appear in the Berlin *Courant* are given in Table I.

Curiously enough there appears no estimate of the 1872 crop for the Berlin area. There is, however, abundant collateral evidence that it was very large. The figures given for Carey (10,000) and Sacket** (8,000) are based on berries actually harvested and in at least one case this was before picking was finished, so they are too small rather than too large. Moreover, we have some figures on the number of pickers. The following note appeared in the Berlin *Courant*, September 26, 1872.

> "We understand that on Carey's marsh there have been an average of 1,500 pickers and on Sackett's 1,200. On Sacket's marsh there have been already 8,000 barrels picked. . . . Somewhere in the vicinity of $50,000 are paid for cranberry picking in this locality."

The following week the *Courant* also reported that pickers on Carey's marsh held a straw vote in the presidential campaign in which Greeley got 1,117, Grant 340. As a means of predicting the outcome of the election this is about as good as the *Literary*

* This involved reading all items relating to cranberries in the Berlin *Courant*, a nearly comcomplete file of which is available in the library of the Wisconsin State Historical Society. In this work considerable assistance was given by various members of the staff of the State Entomologist, particularly Mr. Noel F. Thompson. The Berlin *Evening Journal*, established in 1881, has also been a useful source of information.

** In the earlier paper the name Sacket is incorrectly spelled, and H. S. Sacket, whose own work was important is given credit for the pioneer work of his father, Edward.

TABLE I. Cranberry statistics from the Berlin, Wisconsin, area.
Reported Yield in Barrels

Year	Estimates for Berlin District	Individual Crops	Price per Barrel dollars
1865		Sacket 938	14-16
1869		Carey 2,000	
1870	10,000	Carey 3,500	11-12
1871	20,000*		10-12
1872		Carey 10,000 Sacket 8,000*	12
1874	30,000**	***	
1875		Mason, Paddock and Rounds 5,000	
1879	15,750	Carey 3,600 Sacket 7,600	7
1881	5,000-6,000		
1882	5,000	Carey 2,000	
1883	A very poor crop		
1884	3,000	Carey 1,000	

* A preliminary estimate with the comment "much larger than ever before"
** A preliminary estimate as picking started

No estimates are available for the crops of the Carey Marsh 1873-1878, but evidence that they were not too good is found in a report published in the Berlin *Evening Journal* August 7, 1885,

"James Carey says prospects on the Carey Marsh are better this year than at any time since 1872, the year of the big crop."

Digest poll of 1936, but it does prove that the Careys had almost 1,500 pickers.

The regular price for picking cranberries in the Berlin area in 1872 was 75 cents a bushel as indicated by the *Courant* of August 29. If the estimate that $50,000 was paid pickers that year is approximately correct, that would equal an estimated yield of 66,000 bushels or 22,000 barrels. Moreover, if Sacket with 1,200 pickers had harvested 8,000 barrels by September 26, then it is obvious that the Careys with a much larger crew may well have had more than the 10,000 barrels with which they have usually been credited.

The preliminary estimate of 30,000 for 1874 gains some support from the statement, published September 12, 1874, of a reporter who had recently visited the marshes, that Sacket's Marsh had over 800 pickers and Carey's 1,600. No doubt labor conditions would affect the number wanting to pick cranberries, but the large number of pickers would probably indicate a good crop of cranberries.

I do not wish to labor a point which may already be as fully established as it can be by any evidence not experimental, but it is apparent that the Carey Marsh became less productive following the introduction of alkaline water from Willow Creek in 1873. On the evidence of Daniels (2), writing from Auroraville in 1878, other marshes had been "more remunerative during the last two years." This and adjacent marshes became unprofitable and have long since been abandoned. The Sacket Marsh also seems to have been less productive following the use of alkaline water from the Fox River after 1885.

In all fairness it should be added that in the conclusions here drawn I find that I am putting in print a conviction long held by a number of the older residents of Berlin and Aurora. They firmly believe that the decline of cranberry growing in that area dates from and was caused by the introduction of water from Willow Creek and Fox River. Their courtesy and kindliness to an inquisitive stranger surely deserves this brief acknowledgement.

Literature Cited

1. Stevens, N. E., Rogers, L. M., and Bain, H. F.
   1940. Alkaline flooding water in cranberry growing. Trans. Wis. Acad. Sci., 32: 351-360.
2. Daniels, E. W.
   1878. Cranberries in Waushara County. Trans. Wis. State Hort. Soc. 8: 140-143.

A SURVEY OF THE WISCONSIN LIME INDUSTRY

KENNETH BERTRAND

The burning of lime is one of the oldest manufacturing industries in Wisconsin. As such, it spans the transition from a pioneer to a highly integrated industrial economy. It therefore provides an example of the effect on industry of technological change, variation in market demands, and depletion of cheap fuel supplies. Insofar as the Wisconsin lime industry has been unable to adjust itself to these changes, it has suffered serious decline. It is the purpose of this survey to explain the causes of this decline, which is clearly shown in Figures 1 and 2.

From 1904 to 1940 the amount of lime sold by producers in the nation as a whole increased 80 per cent, from 2,707,809 tons to 4,886,929 tons. In the same period Wisconsin producers suffered a decline of 65 per cent.[1] In 1940 the eleven producers in Wisconsin sold 65,632 tons of lime, in contrast to 244,903 tons sold by 25 operators in 1925. In this year the latest peak of production was reached, followed by the decline from which the industry has not been able to extricate itself. As shown in Figure 1, production was fairly uniform from 1904 until 1925 except for the temporary decline during and following the first World War. From 1907 to 1914 Wisconsin ranked third in the nation, following the major producers, Pennsylvania and Ohio, and until 1925 was rarely lower than fifth. By 1940 Wisconsin ranked thirteenth. In 1908 Wisconsin producers sold 8.5 per cent of all the lime sold in the nation; in 1940 they contributed only 1.3 per cent.

HISTORICAL DEVELOPMENT

The date of the construction of the first lime kiln in Wisconsin is not certain, but lime is known to have been burned in crude

[1] Unless otherwise indicated all statistics used in this paper are taken from the section on lime appearing annually from 1904 to 1923 in the *Mineral Resources of the United States*, U. S. Geol. Surv., Dept. of Interior. From 1924 to 1931 the figures are from *Mineral Resources of the United States*, Bur. of Mines, U. S. Dept. of Commerce. From 1932-33 to 1940 figures are from *Minerals Year Book*, Bur. of Mines, U. S. Dept. of Int. These figures show lime sold by producers and consumed by producers in the various states and are equivalnet to lime produced.

kilns constructed in the fields by the first settlers to obtain lime for mortar and whitewash.[2] In places where the soil was stony the rock to be burned was collected from the newly cleared fields. The number of commercial kilns increased to meet the growing demand for lime created by rapid development of the state from 1850 to 1880. Great quantities of otherwise unmarketable local cordwood provided an abundant supply of cheap fuel. Those kilns which were near enough to Lake Michigan to be able to ship by water were the first to expand beyond the local market.[3] Others began production for distant consumers as railroads extended their lines through southern and eastern Wisconsin. The industry developed rapidly on the stimulus provided by such rapidly growing cities as Milwaukee and Chicago, far removed from competition of eastern producers.[4]

It was early discovered that of all the available rocks in the state only the Niagara dolomite produced a lime free enough of impurities to satisfy the demands of the trade. Consequently, the commercial lime industry became more and more concentrated in the eastern part of the state, a shift well shown in the series of maps in Figures 3 to 6. Of the 51 plants operating in the state in 1911, 30 were burning Niagara dolomite. The others, except one plant working a thin, high-calcium formation of Ordovician limestone in LaFayette County, were producing only

---

[2] Albert G. Ellis describes the homes of the French settlers in Green Bay upon his arrival the morning of September 1, 1822, as ". . . uniformly whitewashed with lime": Ellis, Albert G., "Fifty-four Year's Recollections of Men and Events in Wisconsin," *Collections of the State Hist. Soc. of Wis.*, 7: 215, 1876.

[3] J. A. Horlick and Sons opened their plant at Racine in 1853. A second plant was constructed by William Beswick on the Root River one and one-fourth miles from the center of Racine in 1860. See Butterfield, C. W., *The History of Racine and Kenosha Counties, Wisconsin*, p. 469, Chicago, 1879.

A lime plant located at the base of the escarpment at Gardiner (now Little Sturgeon) for a period between 1854 and 1877 shipped out as much as a boatload of lime a week. See Holand, Hjalmar R., *History of Door County, Wisconsin*, pp. 429-433, Chicago, 1917.

The Druecker quarry north of Port Washington is another of the early kilns from which lime was shipped by lake.

[4] In a state survey published by the Western Historical Company in its *History of Washington and Ozaukee Counties, Wisconsin*, Chicago, 1881, it is stated (page 171) that 400,000 barrels of lime were produced annually at that time from the Niagara formation. Pellon Kilns at Pewaukee are credited with a production of 12,000 barrels weekly, which were shipped to Chicago, Grand Haven and Des Moines.

In 1887 Wisconsin's production was estimated at 1,000,000 barrels of lime (200 pounds per barrel), while the national production was estimated to be 46,750,000 barrels (*Mineral Resources of the United States*, U. S. Geol. Surv., 1887, p. 533). In 1888 the state's production had risen to 2,060,000 barrels, of a national total of 49,087,000. (*Mineral Resources of the United States*, U. S. Geol. Surv., 1888, p. 554). If this last figure is a fairly accurate estimate of Wisconsin's for local use.[5] In 1940 the eleven producers were located in the eastern part of the state. All but one, the Green Bay plant of the Western Lime and Cement Company, which was importing limestone from Michigan, were burning Niagara dolomite.

RECENT TRENDS

Two significant trends in the national lime industry are reflected in the Wisconsin industry. The first is the gradual absorption of the industry by big companies with capital sufficient to meet the varied and increasing demands of the market. The second is the decrease in the number of plants with an accompanying increased output per plant. The number of plants in operation in Wisconsin declined from 48 in 1906 to eleven in 1932. Production, however, remained fairly uniform, as shown in Figure 1, until 1925. This was largely due to the fact that the first kilns to be abandoned were the small local producers.

Paralleling the national trend, as small producers suspended operation, an increasing percentage of the Wisconsin lime industry passed into the control of a big company. By 1924 ten of the 25 operating plants were owned by the Western Lime and

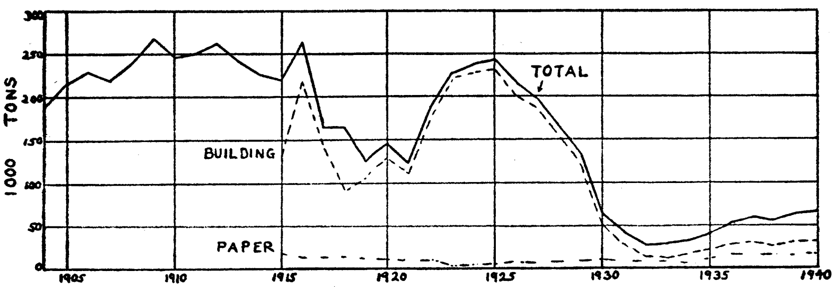


FIGURE 1. The graph shows the number of tons of lime sold annually from 1904 to 1940 by Wisconsin producers. The solid line indicates the total amount of lime sold while the two broken lines show the amount sold for the specific purposes indicated. Note that as the total production declined a smaller percentage has been sold for building purposes.

---

production, more lime was produced in 1888 than has been produced in the state in any year since annual reports were first published in 1904.

[5] *Mineral Resources of the United States*, U. S. Geol. Surv., 1911, Pt. 2, p. 806.

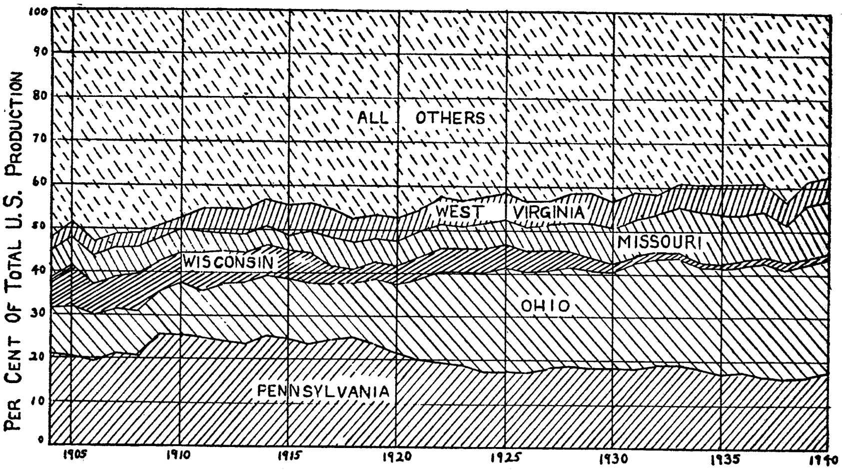


Figure 2. The graph shows the percentage of the entire national production of lime contributed by the leading states and Wisconsin. The widths of the shaded areas represent the percentages of the respective areas.

Cement Company. Two plants were owned by the Standard Lime and Stone Company and the Valders Lime and Stone Company. The other eleven plants were owned by individual operators.[6] Of the 18 operating plants in 1929, the Western Lime and Cement Company owned eight. Two were operated by the Standard Lime and Stone Company, and eight producers operated single plants.[7] In 1939 the Western Lime and Cement Company operated seven plants, the Standard Lime and Stone Company two, and individual owners the other three.

Lime Plants

Of the plants now operating all but the Green Bay plant are located at points where a rail line passes near a rock outcrop or at points where the overburden of glacial till is relatively thin. Five of the plants are located at the base of the Niagara escarpment; six are located on the dip slope of the cuesta.

The Rockwell Lime Company north of Manitowoc is the only plant in which lime is burned in pot kilns. All others operate shaft kilns. The more modern rotary kiln has never been used to burn lime in the state, very likely because this type is least

[6] *Mineral Resources of the United States*, U. S. Geol. Surv., 1924, Pt. 2, pp. 220-221.
[7] *Mineral Resources of the United States*, U. S. Geol. Surv., 1929, Pt. 2, pp. 297-298.

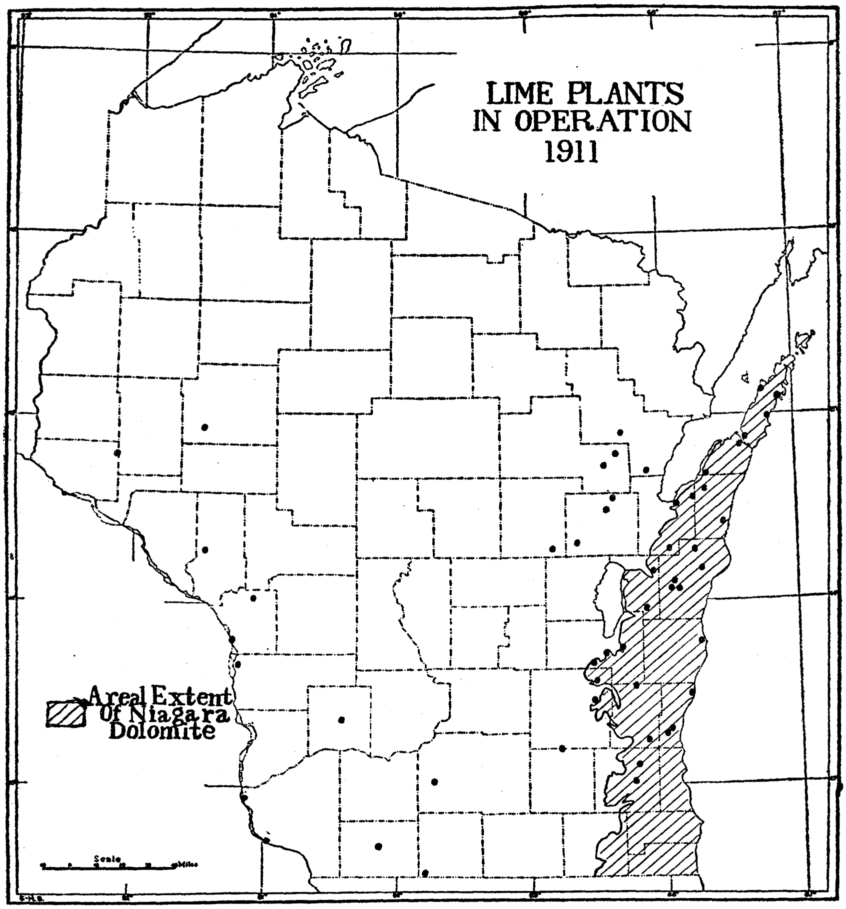


FIGURE 3. After U. S. Geological Survey, *Mineral Resources of the United States*, Pt. 2, 1911, Plate V.

efficient in the use of fuel,[8] an important item of cost in the Wisconsin industry. Pot kilns are vertical shafts which may be operated continuously but are usually fired by batches. This type is charged with alternating layers of limestone and fuel, which must be strong enough to support the load in the kiln. Largely due to loss of heat in the cooling period between batches, this

[8] Moyer, Forest T., "Lime-fuel Ratios of Commercial Lime Plants in 1939," U. S. Bur. of Mines, *Information Circular 7174*, pp. 6-7, 1941.

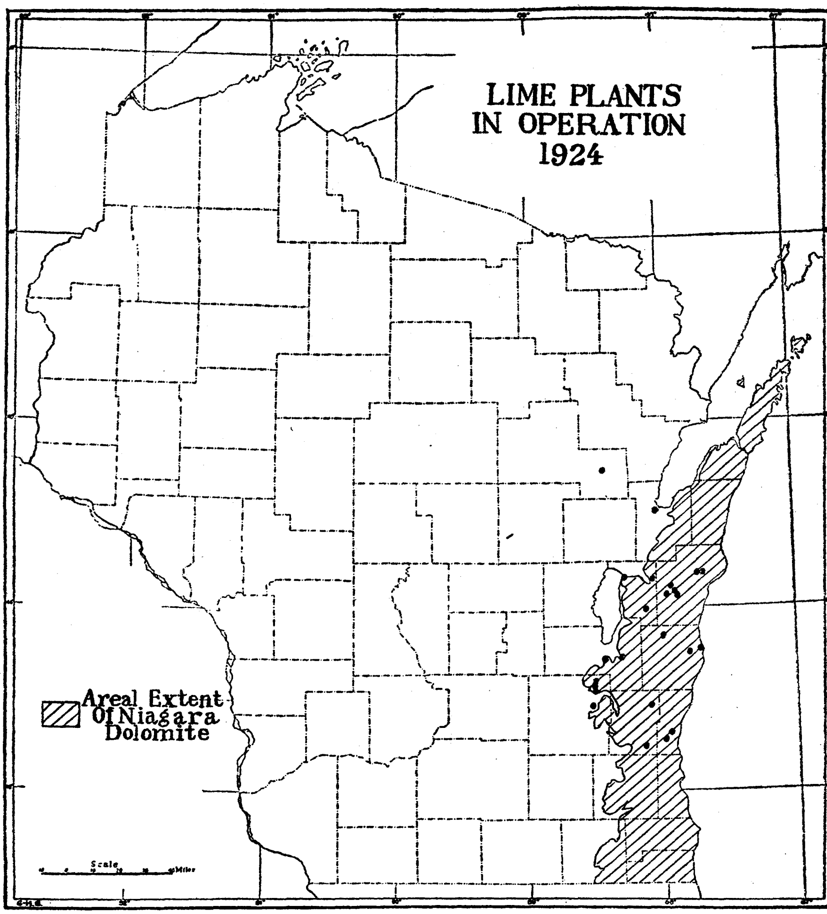


FIGURE 4. Material from U. S. Bureau of Mines, *Mineral Resources of the United States*, Pt. 2, 1924, pp. 220-221.

type is rated less efficient in the use of wood fuel than the shaft kilns.[9]

Shaft kilns are generally short, wide, vertical stacks lined with refractory material enclosed by either a steel or stone casing.[10] Stone is fed into the kiln at the top by means of a tramway and dump cars, and the lime is drawn off at the bottom.

[9] Moyer, Forest T., *op. cit.*, page 8.

[10] For a description of this and other types of kilns see Bowles, Oliver, and Banks, D. M., "Lime," U. S. Bur. of Mines, *Information Circular, No. 6884R*, pp. 39-41, 1941.

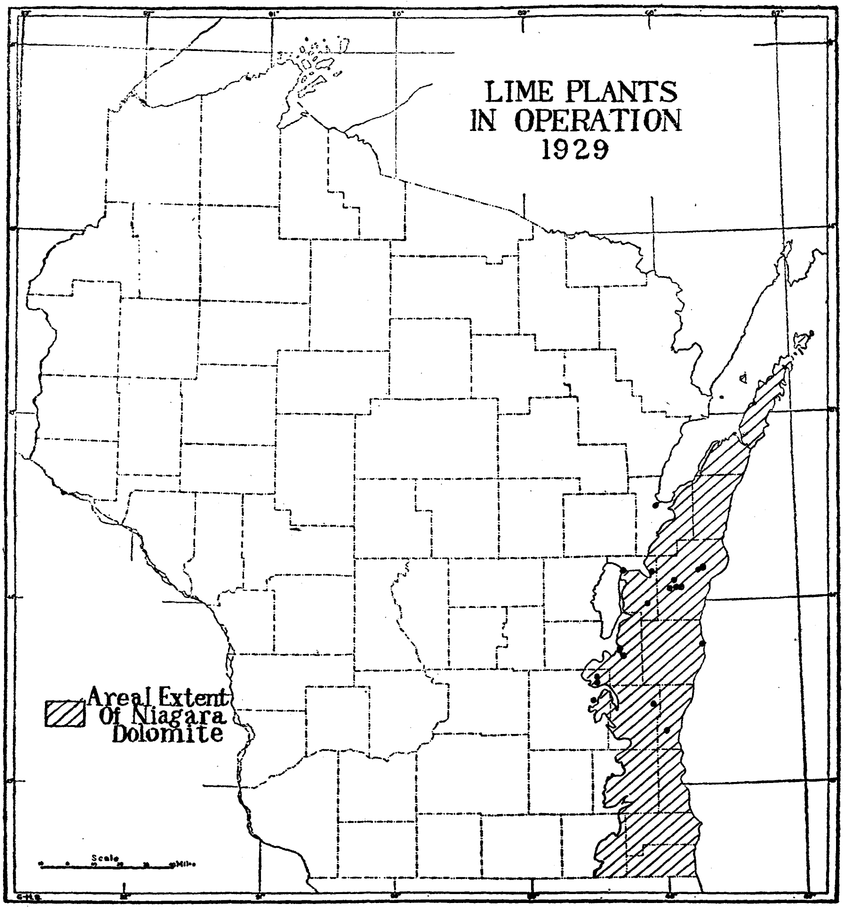


FIGURE 5. Material from U. S. Bureau of Mines, *Mineral Resources of the United States*, Pt. 2, 1929, pp. 297-298.

The rock is preheated by escaping gases in the upper part of the stack. As it slides down into the calcining chamber, it is converted to lime by hot gases and flame eminating from two or more fire boxes located in openings in the sides near the bottom of the kiln. The lime is withdrawn at four-hour intervals from the cooling chamber at the bottom of the kiln. Shaft kilns are operated continuously, halting only for occasional repairs.

The capacity and the number of kilns per plant vary widely. The Eden and Brillion plants of the Western Lime and Cement

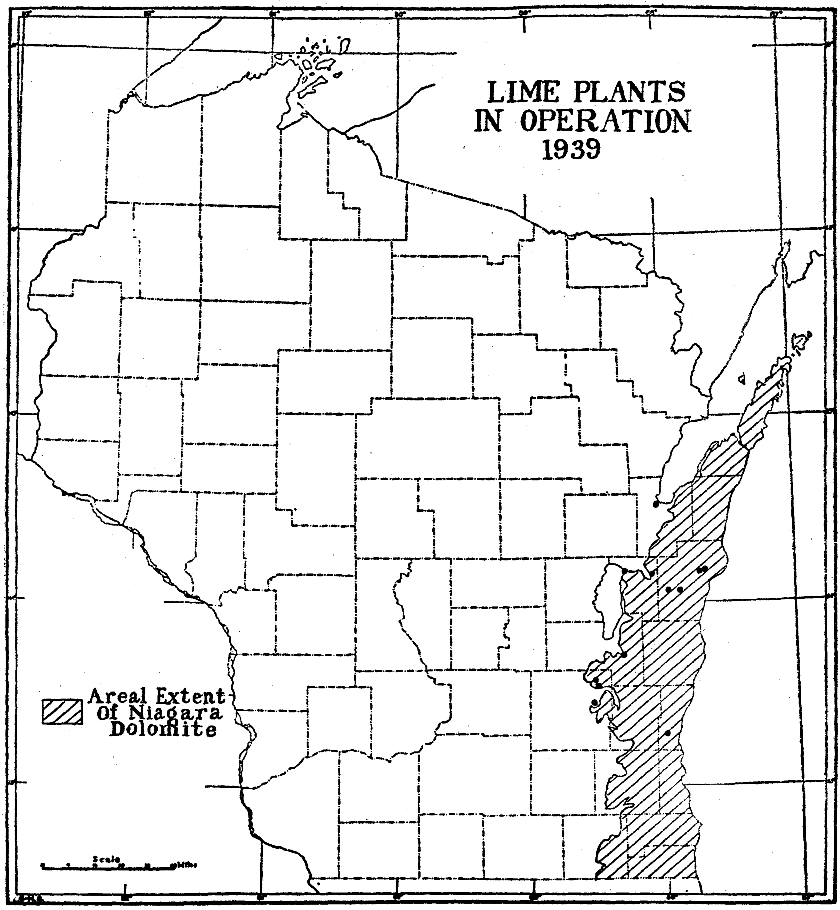


FIGURE 6. Information obtained from the office of the Wisconsin Geological and Natural History Survey.

Company each have ten kilns, while the plants of the Mayville White Lime Works and of John F. Groth and Son at Cedarburg have but three kilns. Most of the plants in the state, whether operating or not, have either four or five kilns. Production varies from six to sixteen tons per kiln per day, the average being about ten tons.[11] Six plants were producing both lump lime and hydrated lime in 1940. Wood is used as fuel by all plants but

[11] For details of individual plants as of 1924 and 1929 see the following: *Mineral Resources of the United States*, 1924, U S. Geol. Surv., pt. 2, pp. 220-221; *Mineral Resources of the United States*, 1929, U. S. Geol. Surv., pt. 2, pp. 297-298.

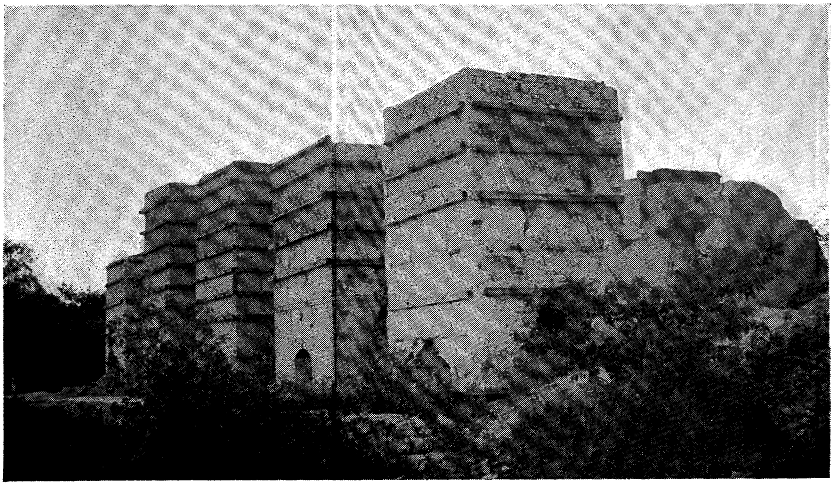


PLATE 1. A symbol of declining industry, this abandoned lime plant is located just south of Grafton in southern Ozaukee County. It is one of several to be found in eastern and southeastern Wisconsin.

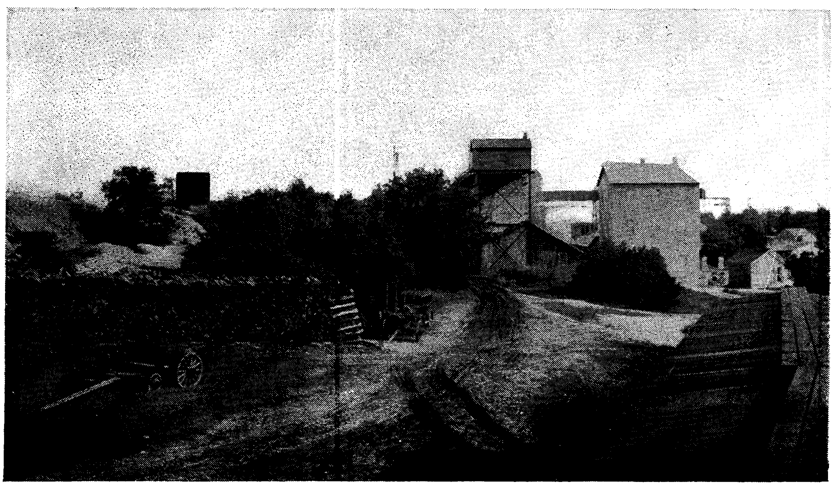


PLATE 2. This view of the Brillion plant of the Western Lime and Cement Company shows the northernmost of the ten kilns. Immediately to the right is the hydrating plant where the lump lime is crushed and the underburned and overburned lime is removed. The lime is then slaked mechanically with just enough water added to complete the process without producing a sticky or pasty product. The quarry is located on the left beyond the waste pile. Note the pile of cordwood.

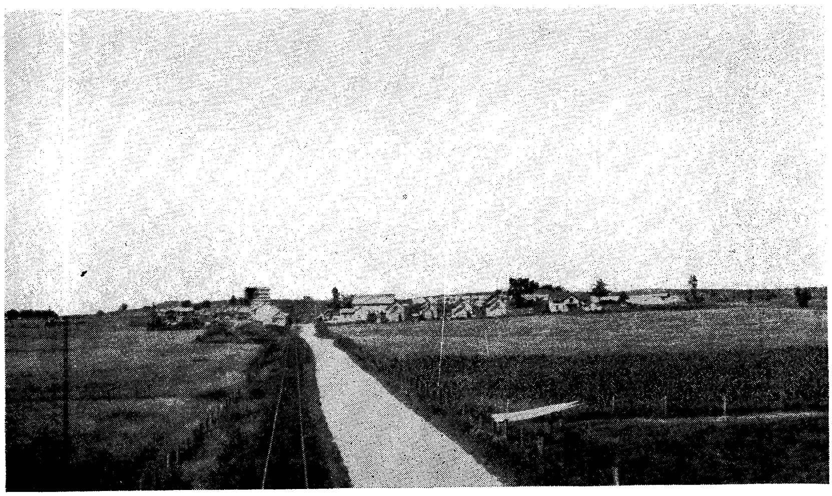


PLATE 3. This view of the quarries northwest of Valders shows the end of the lime kilns immediately left of the road and the cluster of company houses surrounding the plant.

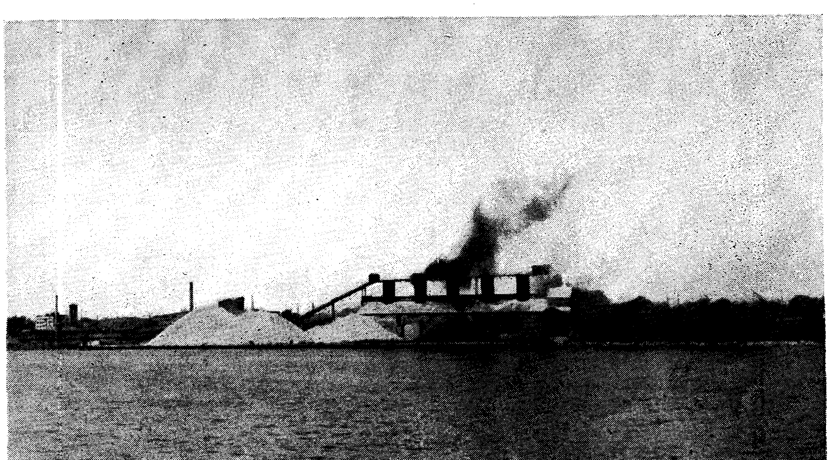


PLATE 4. The Green Bay plant of the Western Lime and Cement Company located on the west bank of the Fox River. The piles of limestone shown on the dock are shipped from Rock Port, Michigan. The coal comes from West Virginia. Lacking an unloading bridge, the plant can receive cargo only from self-unloading boats which are equipped with a giant boom with an endless conveyor.

the Green Bay plant, which burns bituminous coal. Operations vary according to the seasons, with little activity during the winter. The number of men employed fluctuates accordingly, the number of workers engaged by the industry at any one time never being very large. The 1940 census reported an annual average of 169 wage earners employed by the lime industry in Wisconsin in 1939. As few as 137 were employed in January, and the number rose only to 182 in July. From six to eighteen men are employed at each plant with about half of the crew working in the quarry.

The average lime plant consists of a battery of three or more kilns, the lower portions of which are enclosed in a long shed. A narrow guage tramway leads from the quarry to the runway across the tops of the smoking stacks. In addition to the kilns, each establishment consists of sheds, a warehouse, and in some instances a hydrating plant. Piles of cordwood occupy the surrounding yard. The edge of the quarry is generally strewn with piles of overburden and waste materials from the quarry and the kilns. Much of it is overgrown with brush and tall weeds. In each case a railroad spur extends to the plant. In most instances company houses occupied by workers have been built adjacent to the plants.

CHANGING MARKET DEMANDS

Changes in the market demand and in the consumption of lime throughout the nation are shown in Figure 7. Most signifi-

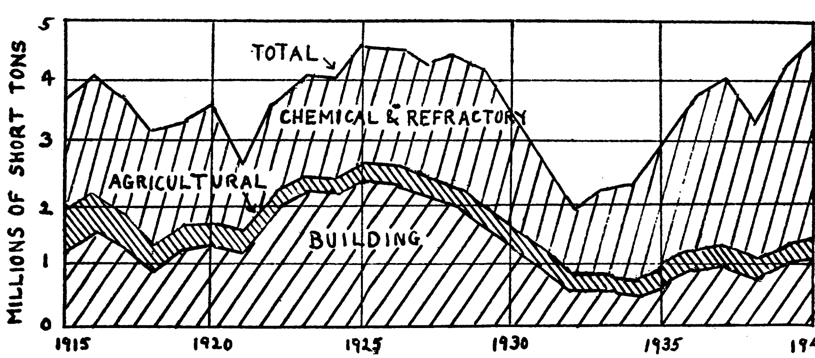


FIGURE 7. The graph shows the total amount of lime sold by prodocers in the the nation and the amounts sold to various types of consumers from 1915 to 1940. Taken from the U. S. Bureau of Mines, *Minerals Year Book, Review of 1940*, p. 1214.

cant for the Wisconsin industry is the marked decline in the amount of lime sold for construction purposes, a use for which the Wisconsin product is eminently suited. For the nation as a whole, less lime has been sold annually for building purposes since 1930 than was sold in any year beginning in 1906 with the exception of 1918. As shown in Figure 1 the decline in the amount of building lime sold by Wisconsin producers is even more severe than for the nation as a whole. No one factor explains this decrease in the demand for building lime. To a certain extent the decline is a reflection of the economic collapse of 1929 and the depression which followed. Moreover, data gathered by Hatmaker shows that the Chicago area, Wisconsin's chief market, suffered more than other districts in the nation in terms of a general decline in building since 1929.[12] Following the gradual demise of the lumber industry several Wisconsin cities remained in a state of economic stagnation for several years until substitute industries developed. This was counteracted throughout the state as a whole, however, by the abnormal building boom that followed cessation of building during the first World War.

It is noteworthy that the building activity encouraged by government grants and loans in the late thirties had relatively little effect on the demand for lime. This perhaps reflects the competition that has been given lime in recent years by gypsum in the preparation of plaster, which in turn competes with a variety of wall boards. In general construction, too, lime has had to compete with cement. Cut stone and mortar have been replaced by concrete in the construction of foundations, piers, abutments, and retaining walls. Lime, however, is finding an increased use in waterproofing concrete.

The Niagara dolomite burned for lime in Wisconsin produces a fine quality, high-magnesium lime, which is excellent for construction purposes but which has only limited uses as chemical and industrial lime. Tests conducted by the United States Bureau of Standards and by the University of Wisconsin Engineering Experiment Station show that mortars produced with high-magnesium lime have greater strength than those produced

---

[12] Hatmaker, Paul, "Trade Trends in the Lime Industry," U. S. Bur. of Mines, *Report of Investigations, No. 3227,* Figs. 7 and 9, and p. 7, 1934.

with a high-calcium lime.[13] Other factors in preparing the mortar, however, are more important than the type of lime used in determining the strength, and either type of lime produces a sufficiently strong mortar for ordinary building purposes. High-magnesium lime generally slakes more slowly and at a lower temperature than high-calcium lime and therefore yields less mortar. The mortar, however, is more plastic, and has a greater sand carrying capacity. This higher plasticity makes it especially well adapted for finishing plaster.[14]

Lime has long been used in the chemical and manufacturing industries. As early as 1911 a list of 47 different industrial uses of lime was published by the United States Geological Survey.[15] Both the number of uses and the quantity of lime required have greatly increased in recent years. Lime is widely used as a chemical reagent, and enters directly into the manufacture of many products. In the same period that the sale of building lime has declined the amount of lime sold annually to chemical industries has risen from slightly over 100,000 tons to approximately 1,000,000 tons. Lime sold to the paper industry has risen in amount from 152,681 tons in 1907 to 566,818 tons in 1940.

There is a great variation in the kind of lime required in each of the various industrial and chemical uses.[16] Some demand hydrated lime, while others require quicklime. For some processes either high-calcium or high-magnesium lime are equally satisfactory; others specifically require one or the other. In general, the use of high-magnesium lime in industry is rather limited. It is used as a hardening agent in the manufacture of soft rubber goods, in the production of some types of glass, and in tanning certain types of leather. On the other hand, high-calcium lime must be used for water purification and in the manufacture of alkalis, bleaches, and calcium carbide. Dolomitic

---

[13] Emley, W. E., and Young, S. E., "Strength of Lime Mortar," *Proc. Am. Soc. Test. Mat.*, 14, Pt. 2: 339-358, 1914.

Baker, George J., "Wisconsin Magnesium Lime Mortars," *Univ. of Wis. Eng. Expr. Sta., Bulletin*, Series No. 75, 39 pages, 1933.

[14] Hatmaker, Paul, "Utilization of Dolomite and High-Magnesium Limestone," U. S. Bur. of Mines, *Information Circular No. 6524*, p. 7, 1931.

[15] *Mineral Resources of the United States*, U. S. Geol. Surv., 1911, Pt. 2, p. 650.

[16] Steidtmann, Edward, "Limestones and Marls of Wisconsin," *Wis. Geol. and Nat. Hist. Surv., Bull.* 66: 103-118, 1924. Hatmaker, Paul, "Utilization of Dolomite and High-Magnesium Limestone," *op. cit.*, pp. 9-13, 1931. Bowles, Oliver, and Banks, D. M., *op. cit.*, pp. 17-25. Bowles, Oliver, and Jensen, Mabel S., "Limestone and Dolomite in the Chemical and Processing Industries," U. S. Bur. of Mines, *Information Circular, 7169*, pp. 6-15, 1941.

lime is undesirable in the tanning of most leather, in the refining of sugar, in the manufacture of either sand-lime or refractory brick, in the production of paint and varnish, as a hardening agent for hard rubber goods, and in the cyanide process for the recovery of gold and silver. High-calcium lime is required as a flux in the basic open-hearth process of steel conversion and in the manufacture of glycerin, soap, and lubricating greases.

The paper industry consumes large quantities of lime, and since Wisconsin has long ranked high in the manufacture of paper,[17] it would appear that the lime industry possesses an important nearby market.

High-magnesium lime is required by the industry for the preparation of a very fine-grained pigment for coating paper. Unfortunately, however, in only one of the processes by which pulp is digested is a high-magnesium lime preferred. As a consequence, lime sold to the paper industry by Wisconsin producers has never since exceeded the 16,997 tons in 1915, the first year that reports for specific industries by states were published. In the sulfite process wood chips are digested under high pressure and temperature in a liquor made of sulfur dioxide and lime. In this case a dolomitic lime is preferred, for it is claimed that a magnesium-bisulfite liquor is more soluble, more stable, and produces a softer and whiter pulp than calcium bisulfite. In both the soda process and the sulfate process of pulp production a lime containing less than two per cent magnesia is used as causticizing agent in recovering the caustic soda and the sodium sulfate respectively from the wash in which the pulp has been digested.[18] In the Jennsen tower system, however, a high-calcium limestone rather than lime is used. Methods are steadily being improved by which lime can be recovered and used again thus cutting down the total demand for lime by the paper industry.

In answer to the demand for high-calcium lime the Western Lime and Cement Company in 1923 constructed a plant consisting of five shaft kilns on the west bank of the Fox River in Green Bay. From the beginning of operation a high-calcium limestone

---

[17] Ranked third after Washington and Maine in both tons of pulp produced and cords of pulpwood consumed in 1939. *Census of Manufactures*, 1939, 16th Census of the United States.

[18] Bowles, Oliver, and Banks, D. M., *op. cit.*, pp. 19-20.

has been shipped by boat from eastern Michigan.[19] At the present, bituminous coal from West Virginia is also shipped by water. The plant has a capacity of 30 tons of lime daily, but in 1940 was operating only at 60 per cent capacity. At least 50 per cent of the output which is high-calcium lime is sold as chemical lime with a higher percentage in winter when operations are cut. About 25 per cent of the output in spring is sold as agricultural lime.

That the Wisconsin industry is failing to meet the demands even within the state is revealed by statistics for recent years which show that the consumption of lime in Wisconsin has exceeded production each year since 1930. In that period production has ranked from 44 to 66 per cent of consumption, being over 60 per cent for five years and under 50 per cent for two. Due to the fact that Wisconsin has continued to ship high quality lime to other states the actual proportion of Wisconsin-produced lime consumed within the state is even smaller. The deficit between Wisconsin lime consumed in the state and total consumption is made up by shipments from other states. These imports have since 1930 been nearly equal to and in some cases have exceeded Wisconsin production.

From the foregoing discussion it is apparent that the Wisconsin lime industry is greatly restricted in a market demanding high-calcium lime while it produces mainly high-magnesium lime. This fact in itself, however, is not the sole reason for the decline of the industry, for the greatest share of the lime produced in Ohio, the leading producer, is dolomitic lime. Moreover, the Ohio production has steadily increased and now totals 25 per cent of the nation's output.

Annual statistics from 1915 to 1932 show that as in Wisconsin, over 50 per cent of the Ohio production was sold to the construction industry. Since then the proportion of the lime sold for building purposes in both states has dropped below half of the total. In general, however, a greater proportion of the Ohio production has always been sold for non-building uses than has been true for Wisconsin. It is significant that even in the amount of lime sold to the paper industry, Ohio exceeds Wiscon-

[19] For a discussion of the Michigan limestone industry see Morrison, Paul C., "Michigan Limestone Industry," *Econ. Geog.*, 18: 258-274, 1942.

sin by a considerable tonnage in spite of the fact that it is unimportant in paper production. The superior status of the Ohio lime industry, concentrated in the northwestern part of the state, can be explained in part by its more central location within the great northeastern industrial quadrant of the nation, thereby having an advantage in transportation costs. However, as has been shown, the Wisconsin industry is no longer meeting the demand for lime within the state itself, where transportation costs would be in its favor. An important advantage in favor of Ohio is the cost of fuel.

FUEL

With few exceptions, where producer gas and coal were experimented with, wood has been the main fuel used by the Wisconsin lime industry, and at present all but the Green Bay plant still use wood. Formerly this fuel was cheap and locally abundant. At present it is largely shipped in by rail from the cutover region of the Upper Lakes. Wisconsin producers claim that it costs about 75 cents more to produce a ton of lime with wood than with coal, but that if high-magnesium lime is to be used by the paper industry it must be burned with wood. This is perhaps due to the fact that lime can be burned more steadily and at a lower temperature with wood than with coal. The minimum temperature of the decomposition of dolomite is lowered by the steam released as one of the gases of combustion in the burning of wood. As a result of this lower temperature the impurities are less active, thus making a purer lime, an important factor in the paper industry.

The depletion of the former abundant supply of cordwood is an important factor in the ability of the Wisconsin lime producers to compete with producers in other regions, particularly Ohio, Pennsylvania, West Virginia, and Missouri, all of which lie within, or relatively near, coal fields. Since the average price of a ton of lime ranges between six and eight dollars, it is obvious that a slight difference in the comparative cost of fuel used to produce that lime will greatly affect the ability of the producer to compete on the national market. Comparison with Ohio is perhaps justified, since it too produces mainly high-magnesium lime. All other major producing states specialize in high-calcium lime. Compared to fuel costs in Ohio, the additional freight involved in shipping coal from West Virginia, Pennsylvania, or Ohio to Wisconsin lime kilns is of consequence. That it is done at all is due to the cheap water transportation available to the Green Bay plant. But in this one instance high-calcium limestone is also imported. Furthermore, Green Bay is located in one of the major paper-making regions of the state. Few localities in the state can boast this combination of advantageous factors. Fuel costs vary with individual plants making a general comparative figure difficult to obtain. It would appear, however, that fuel costs per ton of lime are between 60 and 75 cents greater in Wisconsin than in Ohio. This reflects particularly the increasing difficulty in obtaining adequate and inexpensive supplies of cordwood in Wisconsin.

CONCLUSION

Within the past fifteen years the Wisconsin lime industry has experienced a remarkable decline, resulting from a combination of factors, three of which appear to be most important. First, the industry is suffering from a decline in the demand for construction lime, a use for which the Wisconsin product is best suited. Secondly, the industry is unable to meet the demand for lime by chemical and manufacturing industries because Wisconsin's high-magnesium lime is not well suited for that purpose. Thirdly, Wisconsin producers are at a competitive disadvantage due to the comparatively high cost of fuel as the supply of cordwood has become depleted. Hope for the future lies mainly in cheap labor, in supplying nearby markets, and in new technological developments. Perhaps of greatest interest for the Wisconsin industry are recent experiments in obtaining practically complete hydration of the magnesia in dolomitic limes when hydration is conducted under pressure.

STUDIES OF SILURIAN FOSSILS IN THE THOMAS A. GREENE COLLECTION AT MILWAUKEE-DOWNER COLLEGE

KATHERINE F. GREACEN AND JOHN R. BALL

The Thomas A. Greene Memorial Museum was established at Milwaukee-Downer College in 1913, the gift of the heirs of the collector. The mineral collection has been catalogued, but the fossil collection is so extensive that it has never been completely studied nor catalogued.

Thomas A. Greene was born in Providence, Rhode Island, in 1827. While still in grade school, he became interested in the study of geology and botany, and began collecting Rhode Island minerals, thus forming the nucleus of the present extensive geological collection. At the age of sixteen, young Greene went to work in a drugstore. Deciding to make this his life work, four years later he set out for the west, seeking a new home and his fortune. He arrived in Milwaukee July 4, 1848. Finding a drugstore for sale in Milwaukee, he bought it, and sent for his friend Henry H. Button. The firm of Greene and Button later gave up the retail drug business, and became a prosperous wholesale house.

The pressure of a growing business concern did not leave Greene much time for his hobbies; but the fact that he made his buying and selling trips in the summer, leaving winter travel to his partner Button, indicates that he may have made side trips to study geology and botany, as he did on his trip west at the age of twenty. By 1857, apparently the business was successful enough to permit Greene to go back to his mineral collection, and to enlarge and improve it, chiefly by purchases from dealers.

When his health failed in 1878, and his physician advised him to give up work for a while and spend as much time as possible outdoors, Greene turned, naturally, to examining the rocks in the vicinity of Milwaukee. These did not yield many minerals, but they were full of fossil forms.

It was not long before his interest was centered wholeheartedly on the collection of these fossils, and Greene, a perfectionist, set himself the task of building up as complete and perfect a fossil collection as he could. The circumstances were peculiarly favorable for such a purpose—Greene had the time to visit quarries, examine and study specimens, make exchanges and carry on an extensive correspondence. He had plenty of money to spend on fossils—he outbid the Public Museum on certain occasions, and made a practice of paying quarrymen in advance, to reserve the best specimens for himself; and it was a time when many new quarries were being opened. Through the 1880's and early 1890's, when he was collecting most actively, quarries were being worked which are no longer available, and Greene was able to obtain excellent specimens from the upper horizons as well as from the lower ones.

As Greene stressed in his letters concerning exchanges, the emphasis was on quality, not quantity. The quantity rose, however, to an estimated total of 65,000 to 75,000 specimens. The Silurian and Devonian fossils are by far the most abundant, since they are the ones which occur in and around Milwaukee. Greene determined to make his Silurian collection as complete as possible, and so, after scouring the quarries of Wisconsin and Illinois, he visited the famous locality at Waldron, Indiana, and also acquired some specimens from Niagara County, New York and Hardeman County, Texas. As the Silurian and Devonian collections grew, Greene began to collect fossils from all the other geological periods, acquiring some by personal field trips, but completing the collection chiefly by purchase and exchange.

Greene loved nothing better than to get to the quarries himself, and his correspondence shows that he frequently made such trips, usually writing to the quarrymen in advance, so that they would have an array of their finds ready for him to inspect. He was a busy man, however, and so he had to rely more and more on exchanges and purchases for his new specimens, rather than on collecting trips. He was very particular and meticulous in all his dealings. In general, he seems to have preferred to purchase material, rather than to obtain it by exchange. When he did make an exchange, he sent only the best material, and demanded similar quality in the specimens sent to him. After unsatisfactory dealings with certain men, he refused to examine any more of their material, complaining that it would be a waste of time. Their boxes were returned, unopened.

Because of his interest in the fossils, Greene trained himself to be a thoroughly competent paleontologist. He read a great deal, and studied his acquisitions carefully, labeling many of them quite completely. Others, however, were left unclassified. Greene did not hesitate to call on the leading paleontologists of the day when he was at a loss to identify his specimens, nor when he found something unusual. The labels contain notations by James Hall, Charles Wachsmuth and Robert P. Whitfield. Greene's notes indicate that from time to time these men suggested that probably he had new species in his collection. These suggestions have been noted in the present study, but there has not been time as yet to verify or disagree with them. In some cases, new species of brachiopods actually were described by James Hall. Some of these were named after Greene, an honor which pleased him highly.

Except for a preliminary study of the type specimens in the collection, the present work has been confined to Niagaran fossils from Illinois—almost entirely from Cook County. They are from quarries at Bridgeport, Cheltenham, Cicero, Hawthorne, Lyons and Stony Island. Practically all of these localities now are inaccessible to collectors. The collections include, altogether, more than 7,400 specimens which have been examined and listed by the authors. Many of the identifications are tentative, however, and more thorough work is necessary before the classification can be considered final. It is highly probable that there are new species in the material that has been studied, but final judgment is withheld. The greatest number of new species probably will be described from the Crinoidea; others will be from the Cystoidea; and probably a few Mollusca, Brachiopoda and Anthozoa. It is fortunate that the probable new species are represented by a large number of specimens in most cases, and it is hoped that the same forms may be found in other collections.

Aside from the finding of new species, the work has been very interesting because of the wide variety of species represented, and the excellence of the material. Some forms are extremely abundant; others are labeled "rare" and are represented by relatively few specimens. In some cases, where certain species never before described from Cook County have been found, new evidence of the faunal population of Silurian seaways may be inferred.

The compilation of species has not been completed, but an idea can be given of the generic range in the Niagaran rocks of Cook County. Porifera are relatively scarce, and are represented by two or three genera—*Ischadites, Receptaculites,* and an undetermined "rare" form. Corals are much more abundant, and are represented by at least 16 genera. Both solitary and colonial forms are present. Bryozoa are chiefly of the fenestellid group, but there are a few others. Brachiopods are present in great abundance, with at least 29 genera, representing both the Inarticulata and the Articulata. There are good representations of internal spiralia, as well as the more common features. The Echinoderma are also extremely well represented. There are at least 5 cystoid genera, 1 or more blastoids, and 20 or more genera of crinoids, representing a large number of species. Mollusca are represented by large and small Pelecypoda, Gastropoda and Cephalopoda, involving at least 9, 18, and 13 genera respectively. The Arthropoda are represented by about 15 genera of trilobites, of which *Bumastus* is the most abundant.

Further studies probably will reveal additional genera. There is no doubt that the number of species is large, and the abundance of specimens permits comparisons which may yield interesting results.

GENERA REPRESENTED IN NIAGARAN MATERIAL FROM COOK COUNTY, ILLINOIS

(*List is tentative and incomplete.*)

Sponges
- Receptaculites
- Ischadites
- Cerionites

Corals
- Zaphrentis
- Amplexus
- Streptelasma
- Diphyphyllum
- Omphyma
- Chonophyllum
- Strombodes-
  - Arachnophyllum
- Cystiphyllum
- Cystiphorolites
- Heliolites
- Favosites
- Alveolites
  - Cladopora-
    - Coenites
- Syringopora
- Halysites

Stromatopora

Cystoids
- Holocystites
- Caryocrinites
- Hallicystis
- Coelocystis
- Gomphocystites

Blastoid
- Troosticrinus

Crinoids
- Dimerocrinus
- Cyphocrinus
- Gazacrinus
- Lampterocrinus
- Siphonocrinus
- Archaeocrinus
- Lyriocrinus
- Melocrinus
- Macrostylocrinus
- Eucalyptocrinus
- Calliocrinus
- Periechocrinus
- Platycrinus
- Lecanocrinus
- Icthyocrinus
- Stephanocrinus
- Crotalocrinus
- Cyathocrinus

Bryozoans
- Ceramopora
- Fenestella
- Undetermined

Brachiopods
- Monomorella
- Trimerella
- Orthis
- Leptaena
- Stropheodonta
- Strophonella
- Schuchertella
- Triplecia

Parastrophia
Anastrophia
Conchidium
Stricklandinia
Pentamerus
Clorinda
Gypidula
Sieberella
Rhynchotreta
Uncinulus
Wilsonia
Camarotoechia
Rhynchotrema
Magellania
(Waldheimia)
Atrypa
Spirifer
Cyrtia
Homoeospira
Whitfieldia
Nucleospira
Meristina

Pelecypods
Cleidophorus
Edmondia
Cypricardites (?)
Pterinea
Ambonychia
Amphicoelia
Conocardium
Modiolopsis
Cypricardinia

Gastropods
Sinuites (?)
Tremanotus
Pleurotomaria
Phanerotrema
Murchisonia
Straparolus
Euomphalus
Raphistoma
Euomphalopterus
Trochonema
Cyclonema
Strophostylus
Holopea
Loxonema
Subulites
Cyrtospira
Platyceras
Diaphorostoma

Cephalopods
Orthoceras
Dawsonoceras
Protokionoceras
Kionoceras
Lituites ??
Gyroceras
Trochoceras
Actinoceras
Cyrtorizoceras
Cyrtoceras
Protophragmoceras
Gomphoceras
Phragmoceras

Trilobites
Illaenus
Illaenoides
Scutellum
Goldius
Lichas
Metapolichas
Arctinurus
Dicranopeltis
Ceratocephala
Encrinurus
Calymene
Cheirurus
Sphaerexochus
Dalmanites

BORON DEFICIENCY IN BEETS AS CORRELATED WITH YIELDS AND AVAILABLE BORON[1]

K. C. Berger and E. Truog

Department of Soils, University of Wisconsin

Introduction

Boron is now known to be one of the 15 essential nutrient elements required by higher plants. Although Wittstein and Apoiger (10) in 1857 found boron in the ash of the seed of *Maesa picta,* it was not until 1915 that Mazé (6) demonstrated that boron is essential for the normal growth of the corn plant. In 1910 Agulhon (1) obtained increased yields of wheat, oats, and turnips by the use of boron in nutrient solutions, but he did not establish the essentiality of boron for the normal growth of the plants. In 1923, Warrington (9) showed that boron is essential to legumes and that its absence causes distinct deficiency symptoms.

Brandenburg (5) in 1931 discovered that the application of boron prevents heart rot of sugar beets, and in 1938 Raleigh and Raymond (7) found that fertilization with boron would control internal breakdown of table beets. Also, in 1938, Walker, Jolivette, and McLean (8) published their findings which showed that boron is essential for the normal growth of table beets, and that a lack of the element causes deficiency symptoms which they called black spot instead of internal breakdown or rot.

The amounts of boron normally present in various plants expressed in parts per million of the dry tissue are as follows: barley, wheat, and corn, three to 10 parts; spinach, celery, and peas 10 to 20 parts; carrot and red clover 20 to 30 parts; and cabbage, alfalfa, turnips, tomato, sugar beet and table beet 30 to 50 parts. Plants containing the higher amounts of boron also require greater amounts of available boron for normal growth.

The boron content of soils varies considerably even though the amounts normally present in soils of the humid temperate

[1] This work was given financial aid by the American Potash Institute, Inc., and publication is approved by the Director of the Wisconsin Agricultural Experiment Station.

regions are relatively low. Sands usually contain from two to 10 parts per million of total boron and loams 15 to 40. Ordinarily, about five per cent of the total boron present is available; thus, sands and soils low in organic matter and also calcareous soils usually contain from 0.1 to 0.7 part per million of available boron, while slightly acid soils, high in organic matter, usually contain from 0.7 to 4.5 parts per million.

Methods involving the quinalizarian reaction for the determination of total boron in soils and plants, and available boron in soils have been developed and described by the writers (2), (3), (4). Treatments of soils with boiling water was found to be the most satisfactory procedure for the extraction of available boron, and hence, this means was adopted. The results obtained for available boron with this method were correlated with the boron deficiency symptoms found in table beets and a good correlation was obtained (3).

Visual deficiency symptoms are usually found only when the deficiency becomes rather extreme, and thus slight deficiencies go unnoticed, although yields may be appreciably lowered. In order to obtain additional information regarding boron deficiency symptoms in beets as correlated with yields and the available boron content of soils, further investigations were conducted. A brief discussion of these and the results obtained follow.

EXPERIMENTAL

During a four-year period, field fertilizer experiments were conducted with beets in eastern Wisconsin on three soil types. Each of these experiments involved numerous plots variously treated with the common fertilizers, and in addition some of the plots also received borax. Only data obtained from a set of plots which received a 3–12–12 fertilizer alone, and another set which received borax in addition are presented here (Table I).

The data given in Table I for the available boron content of the soils represent the average of results obtained by analyzing a sample of soil from each plot before treatment. The plots on each soil type were found to be very uniform as regards the available boron content of the soil, the greatest variation being $\pm$ 0.15 part per million of boron.

The data given for yields represent an average of four randomized replicated plots; each plot was four rows wide and 70

TABLE I. Yield and boron deficiency symptoms of beets grown on various soil types with and without boron fertilization.

Kind of Beets	Year	Soil Type	Available boron in soil	Acre Yields (1)		Increase due to boron fertilization	Black Spot or Heart Rot		Boron Fertilization (2)	
				without boron fertilization	with boron fertilization		without boron	with boron	pounds per acre	method of application
			p.p.m.	tons	tons	%	%	%		
Table beets	1940	Miami silt loam	0.50	8.33	9.60	15.3	none	none	40	broadcast
Sugar beets	1940	Superior clay loam	0.80	16.85	18.58	10.3	none	none	25	broadcast
Table beets	1941	Miami silt loam	0.80	12.49	15.51	24.2	30.0	3.0	20	side seed
Sugar beets	1941	Superior clay loam	0.70	18.69	20.68	10.6	none	none	25	broadcast
Sugar beets	1941	Carrington silt loam	1.00	18.84	18.60	—1.3 (3)	none	none	25	broadcast
Table beets	1942	Miami silt loam	0.75	5.70	7.70	35.1	none	none	50	broadcast
Sugar beets	1942	Carrington silt loam	1.10	13.10	14.20	8.4 (3)	none	none	25	broadcast
Table beets	1943	Miami silt loam	0.90	5.97	7.80	30.7	none	none	20	side seed
Sugar beets	1943	Miami silt loam	0.95	13.32	13.00	—2.5 (3)	none	none	25	broadcast

(1) Average of 4 randomized replications.
(2) In addition, all plots received 200 pounds of 3-12-12 fertilizer per acre at the side of the seed.
(3) Not a significant change in yield at the 5-per cent level in accordance with the analysis of variance method.

feet long. For obtaining yields, the inner two rows, 60 feet long, were harvested. Boron deficiency symptoms were noted by visual observation of the tops throughout the growing season, and by examination of the roots at harvest.

Discussion

When soil tests for available boron were correlated with boron deficiency symptoms in table beets in a previous investigation (3), it was found that when the soil contained about 0.75 part per million of available boron the boron deficiency symptoms were reduced to a negligible degree. However, in the case of most nutrient elements, even before deficiency symptoms appear, the yield is lowered by a slight deficiency of one of these elements. The results given in Table I show that this holds true for boron in the case of beets. The results also show that sugar beets require at least about one part per million of available boron in soils rather than 0.75 part as previously stated. Table beets probably require slightly more.

The response to applications of borax is greatly influenced by the moisture conditions during the growing season; in 1940, a wet growing season, the increase in yield of table beets was only 15 per cent when borax was applied to a soil having 0.5 part per million of available boron, while in 1943, a dry growing season, the increase in yield was about 31 per cent when borax was applied to a soil having 0.9 part per million of available boron.

The level of available nutrients other than boron is also a factor in determining the amount of available boron needed by the crop. In 1941, on a highly fertile Miami silt loam having 0.8 part per million of available boron, a 24-per cent increase in yield was obtained by the application of borax, and 30 per cent of the beets where borax was not applied had visual boron deficiency symptoms. The yield was greater than in 1940 on this same type of soil, and a greater response to borax was obtained because of larger plant growth due to higher fertility, and consequently a larger demand for boron.

Summary

Since boron deficiency symptoms in beets appear only when the deficiency becomes quite serious and after yields are markedly reduced, such symptoms do not always serve as a satisfactory means of telling when fertilization with boron is needed.

Determination of available boron in soils, involving extraction with hot water, appears to be a much more satisfactory means of doing this. Results from field tests indicate that sugar beets require at least about 1.0 part per million of available boron, and table beets slightly more. Common field crops probably require less than one-half these amounts.

Literature Cited

(1) Agulhon, H.
1910. Emploi du bore comme engrais catalytique. Compt. rend., 150: 288-291.

(2) Berger, K. C., and Truog, E.
1939. Boron determination in soils and plants using the quinalizarin reaction. Ind. Eng. Chem., Anal. Ed., 11: 540-545.

(3) Berger, K. C., and Truog, E.
1940. Boron deficiencies as revealed by plant and soil tests. J. Amer. Soc. Agron., 32: 297-301.

(4) Berger, K. C., and Truog, E.
1944. Boron tests and determinations for soils and plants. Soil Sci., 57: 25-36.

(5) Brandenburg, E.
1931. Die Herz-und Trockenfäule der Rüben als Bormangel-Erscheinung. Phytopath. Zeits., 3:499-517.

(6) Mazé, P.
1915. Determination des éléments minéraux rares nécessaires au developpement du maïs. Compt. Rend. Sci., 160: 211-214.

(7) Raleigh, G. J., and Raymond, C. B.
1938. A preliminary note on the control of internal breakdown in table beets by the use of boron. Proc. Amer. Soc. Hort. Sci., 35: 526-529.

(8) Walker, J. C., Jolivette, J. P., and McLean, J. G.
1938. Internal black spot of canning beets and its control. Canning Age, Dec. 1938.

(9) Warrington, K.
1923. The effect of boric acid and borax on the broad bean and certain other plants. Ann. Bot. (London), 37: 629-672.

(10) Wittstein, A., and Apoiger, F.
1857. Entdeckung der Borsäure im Pflanzenreiche. Ann. Chemie Pharm. (Liebig), 103: 362-364.

THE ACIDITY OF HONEY*

H. A. SCHUETTE AND FRANK J. SCHUBERT
Department of Chemistry, University of Wisconsin

"Honey is nothing else but a Composition of an infinite Number of Flowers, which the Bees suck and receive into their Stomachs, Carry into their Hive, and afterwards disgorge into small square Holes made of Wax, and prepared by them before, wherein they keep Honey for their own Nourishment." This two-century-old definition (Lemery-1745) has been superseded by its modern, official one: the nectar and saccharine exudation of plants gathered, modified and stored in the comb by the honeybee. This modification of nectar and saccharine exudation results in the production of an unrefined, concentrated syrup of invert sugar having a flavor which is characteristic of its floral source.

Among the minor components of honey there are a considerable number of mineral constituents, esters and other volatile compounds, organic acids, proteins, amino acids and substances closely related to them, plant pigments, seven members of the B vitamin complex, ascorbic acid and dextrins. Very largely responsible for the differences in the taste characteristics of the different floral types of honey are the first three of this group.

Several reports on the nature and the identity of the acids in honey have been made by those who have studied this problem, the most convincing evidence yet presented being that of Nelson and Mottern (1931) whose investigations covered 15 honeys of different floral types. Formic acid was found in all of them but in amounts so small as hardly to justify the assumption of the importance which had hitherto been given it. The largest amount of this acid, or .024 per cent, was found in tulip honey. The acetic acid content, in the group studied, reached its highest concentration, or .046 per cent, in sage honey. Succinic acid was identified in sourwood, cotton blossom and tulip honeys, and in all of them citric and malic acids. Because the latter are widely

* Published here by permission of *Industrial and Engineering Chemistry.*

distributed in fruits and other plant materials, their presence in honey is to be expected. Heiduschka (1911) found oxalic acid in several honeys, an observation which is not necessarily unique in view of the known occurrence of calcium oxalate in the vegetable kingdom.

Normal, natural honey has an acid reaction, a condition to which its volatile acids and the acid salts of its non-volatile ones are contributive. The actual quantity of these acidic constituents, or titratable acidity, has been determined by various investigators and has been found to be of the order of magnitude of 4 cc. of *N* alkali solution per 100 g. of honey. Fermentations of the acetic or lactic acid types and similar agencies cause an appreciable increase in its natural acidity. Unripe honeys frequently show lower values.

The intensity or degree of this acidity is, however, another matter; it is expressed as hydrogen ion concentration in terms of the so-called pH scale. Contributive to this degree of acidity is not only the total amount and nature of the acids present but also, among others, the mineral constituents.

Published information on the hydrogen ion concentration of honey is not extensive. With one known exception it is of foreign origin. The reports of Fiehe and Kordatzki (1928) who surmised that the hydrogen ion concentration of a honey is an index of either a natural or a synthetic past, of Elser (1929), of Stitz and Szonntag (1932) and of Canneri and Salani (1935) reveal a variation in the pH of this food between 3.29 and 4.87. The few values reported by Bridges and Mattice (1938) for the American-grown product lies within these limits.

Quite apart from the value of conducting a fact-finding survey as to the pH of domestic honeys in comparison with those grown in Europe, or of securing data for use as a helpful tool in gathering proof of alleged honey adulterations—this is apparently no longer a serious problem in this country—lies a very practical interest in the application of these data to industrial problems. The situation in question is one now confronting manufacturers of confectionery who share with the housewife the obligation of conserving the nation's sugar supplies. At least one instance is known in which factory batches of confectionery, wherein honey had been substituted wholly or in part for sucrose, failed the laboratory formula because it had been assumed, apparently, that the pH of this natural sweet is a constant factor.

EXPERIMENTAL

Available for this survey was a group of 48 samples which on other occasions had been used in this laboratory in a series of studies on the chemistry of honey. Among them were representatives of the whole gamut of the color classification used in the merchandizing of honey (Sechrist—1925), from the so-called water-white to dark. Geographically, they represent a wide distribution. With few exceptions, and these were bottled blends for the retail trade, they had been obtained from the growers themselves in Arkansas, California, Colorado, Florida, Georgia, Illinois, Minnesota, New York, Ohio, South Carolina, Texas, Virginia, West Virginia, Wisconsin, Hawaiian Islands, Panama and West Indies. Included herein were honeys whose known predominant floral sources were, respectively, alfalfa, algarroba, blue curls, buckwheat, several varieties of clover, cotton blossom, gallberry, holly blossom, horsemint, mesquite, orange blossom, pepper bush, white sage, sourwood, spike weed, tamarisk, thistle, titi, tupelo, tulip poplar and wild flowers.

Approximately one third of this lot had been received in the comb. The extracted variety included 14 honeys packaged in glass jars and 17 in tinned containers. Seven chunk comb honeys are included in the latter group. Their contact with tin could not have been long. The comb honeys were strained through cheesecloth and all samples were stored in glass while awaiting analysis.

Earlier investigators in this field had used the colorimetric method with a series of indicators for determining the hydrogen ion concentration of honey. This method, however, cannot be recommended for general use, and probably not in this instance, because of the errors introduced by proteins, salts, the color of the material under examination, oxidation-reduction systems and the temperature coefficient. Others reported having used an electrometric technique.

With the introduction of the portable pH meter, its electrode assembly and other appurtenances in compact form, these measurements can now be readily made. Two of the standard commercial forms, the Beckman and the Coleman, were used in this investigation.

Ash determinations were made in platinum dishes at temperatures well below the volatilizing temperatures of the inorganic constituents of honey.

RESULTS

All data have been more or less arbitrarily grouped into two divisions (Tables I and II), light and dark, as typifying in a qualitative sense the most obvious color-differences. This separation is consistent with the present merchandizing practice inasmuch as a statement of floral source is not a condition involved in the lawful, interstate sale of honey. By this scheme of division, the light-honey group includes those whose predominating floral sources are alfalfa, algarroba, several species of clover, orange blossom and white sage, respectively. Similarly, the members of the dark-honey group had their origins in buckwheat, holly blossom, Mexican clover, pepper bush, sourwood, spike weed, tamarisk, thistle and titi (buckwheat tree). These data have been grouped (Table III) also to show the relationship

TABLE I. Hydrogen ion concentration of light honeys.

Predominant floral source	Origin	Color grade		Ash pct.	pH
		Pfund scale	Description		
Clover	Wisconsin	0.15	water-white	0.040	3.47
Algarroba	Hawaii	0.30	" "	.054	3.39
Sweet clover	Wisconsin	0.60	" "	.059	3.39
White sage	California	0.70	" "	.062	3.78
Sweet clover	Wisconsin	1.00	" "	.056	3.46
Clover	Ohio	1.30	" "	.075	3.45
Orange blossom	California	1.50	" "	.067	3.44
Alfalfa	Colorado	1.80	white	.059	3.43
White clover	Wisconsin	1.80	"	.053	3.76
White clover	New York	2.00	"	.105	3.78
Clover	West Virginia	2.40	"	.059	3.21
Mesquite	California	2.70	"	.098	3.78
Gallberry	Georgia	2.90	"	.099	4.19
Unknown	Wisconsin	3.40	"	.097	3.69
Unknown	Illinois	3.90	extra light amber	.061	3.64
Blue curls	California	4.00	" " "	.164	3.29
Wild flowers	Virginia	4.00	" " "	.064	3.62
White sage	California	4.30	" " "	.100	3.67
Tupelo	Florida	4.50	" " "	.074	3.79
Horsemint	Texas	4.70	" " "	.229	3.53

TABLE II. Hydrogen ion concentration of dark honeys.

Predominant floral source	Origin	Color grade		Ash pct.	pH
		Pfund scale	Description		
Buckwheat	Minnesota	4.90	light amber	0.036	3.55
Unknown	Panama	5.00	" "	.089	3.72
Tupelo	Florida	5.00	" "	.094	3.83
Unknown	Illinois	5.30	" "	.115	3.56
Thistle	California	5.50	" "	.086	3.20
Cotton blossom	Texas	5.70	" "	.068	3.61
Sage, buckwheat	California	5.80	" "	.132	3.92
Unknown	Illinois	5.80	" "	.082	3.45
Unknown	Illinois	5.80	" "	.063	3.77
Holly blossom	Arkansas	6.00	" "	.167	4.28
Alfalfa	California	6.40	" "	.105	3.42
Cotton blossom	Georgia	6.60	" "	.119	3.16
Alfalfa	California	6.60	" "	.201	3.57
Tupelo	Georgia	6.70	" "	.172	4.24
Sourwood	South Carolina	7.70	" "	.506	4.33
Mexican clover	Georgia	7.80	" "	.248	3.46
Alfalfa, clover	California	8.00	" "	.146	3.44
Titi	Georgia	8.10	" "	.307	4.52
Pepper bush	Georgia	8.20	" "	.220	3.72
Tamarisk	California	8.70	amber	.144	3.40
Buckwheat	New York	8.70	"	.133	3.34
Spike weed	California	9.00	"	.244	3.90
Unknown	Georgia	10.50	"	.311	3.90
Unknown	West Indies	10.60	"	.283	3.84
Buckwheat	Wisconsin	11.30	"	.077	3.78
Tulip poplar	South Carolina	11.90	dark	.526	4.37
Unknown	Wisconsin	12.00	"	.081	3.72
Buckwheat	Wisconsin	12.50	"	.214	3.44

which was revealed here between the color grade of the honeys and their respective hydrogen ion concentrations.

SUMMARY

The pH of all samples studied lay between 3.16 and 4.52, values which are of the order of magnitude of those reported by European workers, or 3.29 and 4.87. Geographical origins apparently exert little influence on this value. If the pH values herein reported be converted into their corresponding hydrogen ion concentrations—they then become mathematical expressions—an average of 3.59 results. This average for the whole group

TABLE III. Color grade of honey in relation to its hydrogen ion concentration.

Classification	Samples	Ash *pct.*	pH *Ave.**
Light			
water-white	7	0.06	3.52
white	7	.08	3.69
extra light amber	6	.12	3.59
Dark			
light amber	19	0.16	3.72
amber	6	.20	3.69
dark	3	.27	3.84

* For purposes of comparison, these values have been treated as if they were actual numbers when in fact they are logarithmic. However, for practical purposes no serious error has been committed in this instance in reporting an arithmetic mean because of the fact that the pH values here lie within a narrow range.

is in good agreement with that reported by Bridges and Mattice (1938), or 3.8, who contrasted their value with that of maple syrup, or 5.5, and a popular brand of so-called corn syrup, or 4.5.

Although the data herein presented have not been segregated according to type of honey examined, it may be stated that the comb honeys had a lower pH (3.52) than extracted honeys packaged in glass or in tin containers. The extracted honeys which had been received in glass containers had practically the same pH as those packaged in tinned containers, the average pH values for the extracted honeys being 3.62 and 3.61, respectively.

The per cent of ash was found to vary over a wide range; in general an increase in ash accompanied an increase in pH and an increase in color.

LITERATURE CITED

Bridges, M. A., and M. R. Mattice.
1938. Over two thousand estimations of the pH of representative foods. Am. J. Dig. Dis. Nutrit., 6:440-449.

Canneri, G., and R. Salani
1935. The composition of Italian honeys (*trans. title*). Ann. chim. applicata, 25:397-406; Chem. Zentr., 1936 I:2850.

Elser, E.
1929. Die Grundlagen der Chemischen Honigforschung. XII. Die Methodik der chemischen Untersuchung des Honigs. Landw. Jahrb. Schweiz, 43:471-499.

Fiehe, J., and W. Kordatzki,
1928. Ueber der Säuregrad (die Wasserstoffkonzentration) von Honig und Kunsthonig. Ztschr. Untersuch. Lebensm., 55:59-63.

Heiduschka, A.
1911. Ueber die Säuren im Honig. Pharm. Zentralhalle, 52:1051-1053.

Lemery, L.
1745. A Treatise of all Sorts of Foods, both Animal and Vegetable: also of Drinkables. London. 3 ed. p. 263.

Nelson, F. K., and H. H. Mottern
1931. Some organic acids in honey. Ind. Eng. Chem., 23:335-336.

Sechrist, E. L.
1925. The color grading of honey. U. S. Dept. Agr. Circ. 364, 5.

Stitz, J., and J. Szonntag,
Der Wasserstoffionenkonzentration des Honigs. Ztschr. Untersuch. Lebensm., 63:215-218.

GASOGENS

C. V. SWEET

Chief, Division of Industrial Investigations
Forest Products Laboratory, Forest Service*
U. S. Department of Agriculture

The gasification of wood or charcoal in generators, commonly called gasogens, attached to trucks, busses, passenger cars, tractors, and motor boats for use in lieu of gasoline has been developed vigorously during recent years in several foreign countries. It is applicable for use with internal combustion engines other than diesels. Probably the most active development since the start of the war has taken place in Sweden and in Germany. In countries where the gasoline supply has seemed to be adequate, the interest in substitute fuels, especially non-liquid fuels, has been relatively small. Of 74,567 motor vehicles registered as operating in Sweden in 1942, over 90 per cent were operated by means of gasogens. Some reported figures as to use of gasogens in other countries are as follows:

Germany	350,000	Brazil	22,000
France	110,000	Denmark	20,000
Russia	100,000	Switzerland	15,000
Australia	45,000	Belgium	15,000
Italy	25,000	India	10,000

A few experimental units have been operated in Canada and the United States.

Thus the term "gasogen" is more familiar to audiences in many foreign countries than in the United States. Under normal conditions, wide-spread commercial adoption of gasogens, or producer-gas units, is certainly not to be expected. Under certain conditions such that large quantities of gasoline are used for long steady hauls, especially in wooded or farm woodland areas, it is not impossible that sufficient saving in fuel costs can be realized to compensate for the disadvantages that lie in a non-liquid fuel. Use on Wisconsin farm tractors seems quite remote at present due to interference with the vision of the operator

* Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

and interference with maneuverability. Wisconsin's portable sawmills may come to use them; so may some other similar users of gasoline.

The Forest Products Laboratory undertook a limited amount of active work on the subject of gasogens in 1943 after following, by remote control for several years, the developments in European countries. The Laboratory undertook active work because Chinese supply officials in Washington were anxious to have built and tested a unit of the best possible design prior to the placement of an order with some American manufacturing concern for production and shipment for use in China. The Laboratory was able to secure the services and the designs of an American engineer who had been engaged in the gasogen field in France and who managed to leave France just after Hitler arrived there. The experimental unit built for the Chinese and tested in the Madison-Baraboo hills area was of a type designed for the burning of charcoal. Comparable tests are now under way with a type of British design intended for use with raw wood, such as sawdust. Its inventor is temporarily on the staff of the Forest Products Laboratory. The charcoal unit was sufficiently satisfactory to the Chinese officials so that a sizable contract was let under Lend-Lease for manufacture and shipment to China. The sawdust unit will be ready for testing in the near future.

Different fuels, such as nut shells, coke, anthracite coal, wood or charcoal, can be used in properly designed gasogens. Of these, charcoal is generally considered the best fuel, for it is relatively free of resins, tars, oils, and of acid-forming substances, such as sulfur, which would be injurious to the unit and to the engine. The danger of tar or acetic acid formation, which is present in using wood, is absent when good charcoal is used. A charcoal gasogen unit will also weigh less than a wood unit. For these reasons charcoal gasogens are in more common use in foreign countries even though wood is a cheaper fuel.

It has previously been held that if raw wood is used, the pieces should be of fairly uniform size, about that of a man's fist, and dried to a fairly uniform moisture content of 10 to 20 per cent. The design now being prepared for test is intended to permit the use of green sawdust.

The remainder of this paper will relate only to charcoal because it is too soon to say anything about the sawdust unit.

Equipment and Principles Applicable to Charcoal Gas Generators

A gasogen unit is made of three main parts: the gas producer, the cleaning and cooling equipment, and the mixing device.

The gas producer is generally in the form of a vertical cylinder, and consists of a gas-tight fuel hopper to feed the fuel by gravity into the fire zone.

The gas is formed in the producer by incomplete combustion of the fuel. The rate of combustion is controlled by the suction of the engine. Air is delivered at one zone in the fuel bed where the glowing carbon combines readily with the available oxygen in the air to form carbon dioxide with the evolution of much heat. The fuel through which the carbon dioxide passes must be sufficiently hot so that the glowing carbon reduces the carbon dioxide to carbon monoxide. Some of the water vapor present reacts with the glowing fuel to form hydrogen and carbon monoxide, and volatile tars and resins are converted by the same means to methane and carbon monoxide. It is all these gases which, upon the proper addition of air, become the combustible mixture.

The gas leaving the producer passes through the cleaning and cooling equipment before it enters the engine. When the gas leaves the producer it carries with it particles of charcoal dust, soot, ash, and tarry substances; all must be removed in the filters.

The gas must be cooled to as low a temperature as possible before entering the engine so that its maximum density is realized. In some cases, the surfaces of the filters and the interconnecting pipes are sufficient to give good cooling; in others, special coolers are provided. The mixing device provides the proper proportions of gas and air to form a combustible mixture before it enters the engine.

The space and weight requirements of the producer are such that the pay load is reduced by about 10 per cent.

Operation

After the producer is filled with charcoal fuel, the fuel door is clamped down and the fuel ignited. A draft is created through the charcoal, either with a hand-operated blower or with the suction of the engine started on gasoline. When starting with gasoline, the change-over valve is partly opened so that the engine draws air through the fuel. This valve is gradually opened wider, cutting down the suction through the carburetor and increasing the suction through the gasogen until the engine is running completely on producer gas. From a cold producer to full power using charcoal, the following figures are quoted by various authorities: low, 3.5 minutes; high, 14 minutes; average, 10 minutes. This depends upon the season of the year, type of gasogen, and quality of the charcoal.

A truck driver must be trained to operate a gasogen properly; this can, however, be accomplished in a very short time. He must remember that gas must be manufactured before it can be used in the engine, and therefore, the engine should be operated to favor the fire zone. It is necessary to keep the speed of the engine up and not let it drag on heavy pulls. For this reason, and also due to reduction in power, it will be necessary to shift gears more frequently.

Although the gas produced contains carbon monoxide, which is highly poisonous, no unusual precautions must be taken while the gasogen unit is on the road. While the engine is running, there is little chance of gas escaping due to the suction from the engine. When the engine stops, a slight pressure is created, and the gas will leak out of the air inlet and through the mixing device. An absolutely essential precaution is that the unit should not be placed in a closed space immediately after stopping the engine.

In gasogen operation additional time is required for starting and refueling. With charcoal the driver will have to stop to refuel about three times as often as he formerly refueled with gasoline. Besides this, five per cent of the operator's time will be spent in cleaning filters and the generator.

Comparison of Power Developed by Gasoline and Producer Gas

About 13 pounds of charcoal is the equivalent of one gallon of gasoline. The gas produced by a gasogen using charcoal with good operation will have a heating value of about 140 B.t.u. per cubic foot. Air must be mixed with the gas before it can be burned in the engine, and the heat value of this mixture is about

68 B.t.u. per cubic foot. The heat value of combustible gasoline vapor mixture is usually quoted as about 94 B.t.u. per cubic foot which means that an engine operating on gasoline will develop between 30 and 40 per cent more power than when running on charcoal gas. The resistance of the flow of gases through the fuel bed, piping, and filters is greater than the resistance through the carburetor. These two factors mean that about 50 per cent as much power can be expected when operating on charcoal gas as when operating with gasoline. Therefore, unless the truck is overpowered, either an increase in running time or a reduction in the load will result.

On gasogens equipped with valves for readily changing from gasoline to producer gas it is possible to step up the power by operating partly on gasoline. If necessary, gasoline alone can be used on extremely hard pulls.

To overcome the resistance to gas flow through the fuel bed, piping, and filters, the charcoal gasogen unit built at the Forest Products Laboratory is equipped with a supercharger driven by a belt from the fan shaft.

General Results of Road Tests with Gasogen-Equipped Truck

The results of the road tests by the Forest Products Laboratory on measured and charted routes in the Madison and Baraboo hills area with a two-ton load and holding to a maximum speed limit of 35 miles per hour are in general as follows:

	Charcoal run	*Gasoline run*
Average miles per hour actual running time	23.8	32.7
Per cent of time not in high due to hills	23.0	3.8
Number of hills necessary to drop to first	7	None
Number of hills necessary to drop to second	14	1
Number of hills necessary to drop to third	9	5
Number of hills not made in high	30	6

Later, with a unit of the same type modified in certain respects and installed on another truck and tested in a less hilly area near Kalamazoo, Michigan, the following results were obtained, still operating on the 35-mile-per-hour speed limit for both gasoline and charcoal gas:

	Charcoal	*Gasoline*
Average miles per hour actual running time	30.5	32.1
Number of hills necessary to drop to fourth gear	2	None
Number of hills in high gear where speed dropped below 25 miles per hour	12	1

On long steep hills the gasogen-operated truck has to drop one gear lower than when gasoline is used.

It must be borne in mind that the manufacture of a gasogen takes several hundred pounds of steel and a few pounds of metal alloys which tend to throttle its use in times of metal shortage.

No close figures are available as to the probable cost of the equipment installed on a truck. Even if manufactured in quantity, however, the cost would probably be from \$350 to \$450. Thus only with vehicles which require a large annual consumption of gasoline can the cost of the equipment be written off by savings in fuel cost in this country. Where gasoline is not available at the usual prices and with usual ease, the case for gasogens is better.

PROFESSOR BEATTY'S INTERPRETATION OF SHAKESPEARE

JULIA GRACE WALES
University of Wisconsin

There is something unique about spoken commentary—commentary called out by the reading of a great piece of literature with a class present. It is too living a thing to get into a book; colloquial paraphrase, contemporary application, rhetorical question—these escape the record. Especially was this true of Professor Beatty's course in *Shakespearean Drama* (English 37). The play never subserved the lecture; the lecture was there for the play. Those of us privileged to sit in on the course looked forward to each hour as truly an hour with Shakespeare.

Hence it is hard to illustrate the process in brief space. In order to give the commentary, one would have to give the play; they ran antiphonally.

Some parts of what I have attributed to him may have been quotations, for I have depended on my own hastily taken notes, which let many things slip. He was full of the poets and other creative writers. Many a point depended on one's recognizing a context. He kept us aware of the stream of English poetry, bringing in sidelights from Chaucer, Spenser, Milton, Coleridge, Wordsworth, Keats, Tennyson, Browning, Kipling, Housman, Bridges. He *used* English poetry—used it for what it is *for*, to know it by heart. His knowledge was "easy as an old shoe."

He was deeply read in the older critics, but gave heed to the new ones too, sometimes differing sharply, sometimes accepting with enthusiasm, but always centering interest in the immediate problem—the illumination of the play itself. He would review the current controversies and pose their questions. But he was never caught by dogmatism. His own imagination kept its freedom. He loved whatever gave the reader freedom and breathing space. He hated theories that measured by rule, or applied touchstones alien to the matter in hand. Common sense and imagination were his guides, and everyday speech—without technicalities—his medium. Much of his teaching was in questions that you had to think about. He put the factors before you, but left you to think them out, told you to read and keep your mind open.

Despite insistence on freedom of approach, however, he never minimized difficulties or the need of hard work. "You ought to have your clothes torn going through Hamlet, because you are going through a thicket. You can't ride through in a limousine. Observe. Learn to see straight. Know the play; know the notes; *know* it."

The sense of place in the plays came to us augmented by the lecturer's own sense of England; and he had it from both personal tradition and frequent brief residence abroad. His was the England which exists in the imagination of the scholar-traveller who knows her history, her novels, her poetry. It is a place out of time, not coinciding with the fact of the past nor actual in the present, but permanently real and indestructible. He knew the "worm-eaten holds of ragged stone" where once lived these wailing women and terrified children and tired old dying kings. And he knew the English countryside too, in all seasons and weathers.

Throughout his teaching of Shakespeare Professor Beatty stressed the poetry most of all. He insisted that Shakespeare "was a born poet who learned to be a dramatist." He would say, "See how he keeps the action cooling its heels while he gives us quite unnecessarily beautiful poetry. . . . He doesn't trouble to save his poetry for his good people; he is lavish with it."

And by the poetry of the plays he meant more than the great lyrical passages, though he stressed these; more also than the flashing single lines, which he always caught when many readers would be carried past them by the momentum of the drama. It was the poetry of the whole play that he chiefly meant, of the world of the plays—something that he never defined, but that he assuredly conveyed to us.

So it was that he gave us Shakespeare—rescued from schoolroom tasks, from any tyranny of scientific history, exact scholarship, theoretical criticism (though he made these good servants), rescued from a changing and perilous world;—Shakespeare, and with him a timeless England, English flowers, English horses, English ships, and robust English laughter from Chaucer down.

He had a keen interest in how the plays had been acted; not as mere matter of history, but to shed light on the living problems of the characters and how their lines should be read. He called up the shades of great actors he had seen. Professor Beatty could have been an actor himself. I should have liked to see his Richard III, his Falstaff, his Prospero.

Perhaps one reason he liked to work with Richard III, was that this play called in so much imaginative material from its background: history, legend with its prejudice, the literary and theatrical tradition, and the type of the villain—"the villain who *was* a villain and stuck it out." He made us feel the richness of this realm—but not in terms of scientific work-a-day history and examinations. No; it was the history of childish picture books come alive again, when those bearded, armored kings were apt to be either "good" or satisfyingly diabolical.

"There is something fine and hearty about Richard III." We were made to feel the gusto with which Richard manipulated his puppets, knocking them about like ninepins, twirling them like tops, playing cat and mouse, sending a bishop "trotting" off for strawberries—"A bishop as subservient as this!"—stopping a funeral procession with "a dramatic challenge to the supernatural (wounds bleed in the presence of a murderer)"; answering Elizabeth's horrified *What thou?* with an "imperturbable" *Even so; what think you of it, Madam?* . . . "Milton must have learned much about Satan from Richard III."

It was the diabolical humor of Richard that he stressed chiefly, until the last act, and there the strangely lyrical element that makes him human. Of the contrasting camps, Richmond's and Richard's, "Shakespeare is more interested in the tragic scene. *Stir with the lark tomorrow, gentle Norfolk.* . . . Famous line, beautiful line. *Saddle White Surrey*—that particular horse. . . . The Ghost of Buckingham says to Richmond: *And Richard falls in height of all his pride.* King Richard starts out of his dream. *Give me another horse: bind up my wounds.* See the connection: he dreams that his horse has been killed under him. . . . In the last scene the dream comes true. *His horse is slain, and all on foot he fights/Seeking for Richmond in the throat of death./ Rescue, fair lord, or else the day is lost.* Enter King Richard: *A horse! a horse! my kingdom for a horse!*"

He never tired of teaching the great trilogy of *Henry IV-V*, "the epic of the Lancastrian house." He loved the spaciousness and freedom of these plays, their very historical inconsistency, which gave them timelessness. Less dark and far away than Richard III, though actually about an earlier time, glamorous, full of brilliancy, it was in their zest of life that he liked to present them. "Note that this period is mediaeval; but the plays are not mediaeval; they are Elizabethan." He went over the "old jolly, turbulent play"—*The Famous Victories*—to show in detail what the raw material was like and what Shakespeare did with it. Bringing in the work of several modern scholars, he traced the growth of the Falstaff group, how Shakespeare enlarges the surroundings of the Tavern. . . . "An unparalleled set of comic characters—a prodigality of creation unique even in Shakespeare . . . such variety!" He adapted Dryden: "Here is God's plenty."

So he made the action escape the bounds of the theatre: the depth of night on the highway, the tethered horses; the lantern in the innyard and the sharp air of dawn—"Ostlers, a class of men all by themselves"; Glendower calling up spirits—the supernatural always led to rich digression; Hotspur on his horse—"Shakespeare, the country boy; he had as much Greek as the average Ph.D.; but horses, he knew about horses"; the wakeful king in the palace, thinking of the happier lowly folk of his kingdom, the sailor on the giddy mast—how often the lecturer stopped over the sea passages, bidding us hear them with the ears of a maritime people; the lighted tavern full of noise, Pistol at the door—Shall we let him in? "Too bad Pistol wasn't in Part I"; *I see no reason why thou shouldst be so superfluous to demand the time of day. . . . Play out the play. I have much to say in the behalf of that Falstaff.*

"If you don't appreciate Falstaff, you are too young. . . . No use trying to make Falstaff respectable; no use trying to forget any of him. . . . Whatever contrasting things you say of him, he is both and neither; he remains unclassified. You can't capture him. He exists in the free world of Shakespeare's imagination—airy nothing—two hundred and seventy-five pounds. Here is prodigality of creation. . . . He really died in *Henry V*—a scene unparalleled in all literature—just exactly as he ought to have died. . . . You should never rationalize him more than Shakespeare has rationalized him. . . . Falstaff is elemental; he's cosmic. His lies are cosmic lies—a world we have no conception of. The Lord surveyed his work and found it good. It does not say, found it comprehensible. To create does not mean to understand. Creation does not work from a system or formula. Get some savor of the welter of life that is in Shakespeare; the welter of life itself. Chaucer knew this world. It is the only world we have. This is not to say this world is an anarchy. For with creation goes a certain order; but not until you have *it all*. Hence you can't *make a formula*. Our world was made out of chaos; there is some chaos still. . . .

"You must allow humor to be in any situation in life. There is a time to laugh, and that is always, especially when you are most solemn. This is English. The critic will have Shakespeare saying some ultimate thing that excludes the humor. Beware of those who are consciously summing up the wisdom of life. Shakespeare's characters are hard to come at if you lack humor. . . . Don't oversimplify. Note the departure from drama to poetic commentary."

He reviewed Sidney's *Apology for Poetry*. "Sidney has no conception whatever of romantic comedy; he bases his ideas on what *has* been done . . . Do you want your dramas to get down to business? Or do you want all this unnecessary poetry? . . . Don't leave it at a phrase, or a partial judgment. High comedy is difficult. These are not stories just going to an end. They have length, breadth, thickness. Each person matters for himself. A gay mood—a complex whole: plastic, plastic. . . .

"Ben Jonson wrote reasonable plays, banished this nonsense. Ben Jonson would have the best of the argument. This of Shakespeare's is not a reasonable world; it is a world of make-believe. These ingredients were expected, but he liked them too. The dressing up is part of Shakespeare's look at the world. He knew the fairies at first hand; they were part and parcel of his mentality. Don't try to explain him on Ben-Jonsonian grounds. Ben Jonson abandoned the native tradition and took a new rationalistic road. Shakespeare took the old road, used the old stuff. . . .

"Beware of the people who believe that literature must have a mission. . . . What a ridiculous world this is! You realistic young folk are apt to be hard on these people. They are innocent and naïve. . . . I'll give you Malvolio—but he is *not* the play. . . .

The action is thin, I grant you. These comedies are difficult of appreciation because they are impalpable. Consider them in terms of the Forest of Arden; don't try to make them live in our world. . . . Wait till you're grown up, until your sense of humor develops."

He often began the course with the uproarious *Comedy of Errors*: the riot at the first performance (recalling a campus parallel), when "the Temple people didn't think they had good enough seats, and left in disorder"; the Elizabethan world showing through the foreign disguise: *Enter the Hangman*—"with his axe on his shoulder; people were given to going to executions." Book in hand, he demanded the kind of attentive reading that gets each irony, each repeated motif, each refrain and theme song. "Now the fun begins. Which Dromio is it? The effect of this play is cumulative; gets funnier. . . . It's a joke either way, if you're right in your guess, or wrong." He would point up little comicalities with his zestful chuckle. "Antipholus of Syracuse is always about to leave town—but never does. . . . Why is it that the world finds such nonsense so wise? Why is there such a thing as comedy?" And then the lyrical element, so strangely interwoven—he gave time to that.

He would touch off a character in a phrase. On the Duke and Valentine in *The Two Gentlemen of Verona*: "The wily greybeard listening to the wisdom of youth. . . . The scene acts as immensely humorous—the young whipper-snapper instructing the elderly man of the world. . . . Valentine is good at writing testimonials. . . . Cardboard outlaws. . . . Valentine has passed the proficiency test in language. . . . The ever-ready Eglamour entirely and disinterestedly devoted to helping ladies in distress. . . . Note the poetry breaking in: *The uncertain glory of an April day.*"

He made himself a link with the past, when it came to the sources of *A Midsummer Night's Dream*, and was full of fireside tales from books and life—the stuff of the fancy that went to the making of the play. Afterwards if you wanted to look up learned footnotes on these things, you found that their content had been delightfully served up; the cupboard was bare. But it was only the imaginatively edible that he gave us. "Don't worry about anything that Shakespeare didn't worry about. Never mind how big the fairies were. A fairy is just as big as a fairy. . . .

"I don't know at what point Shakespeare began to get the idea of the play *A Midsummer Night's Dream.* Maybe the play began when he was a boy visiting his grandmother. . . . If the fairies were going to be seen by anybody, it would be the mechanicals. The reason we don't realize this at once is that with us the fairies are derived from books and not from life. Most of the people who saw the play had seen some fairies. Shed your disbelief. The fairies are as real as the Ghost. Oberon and Titania are bookish fairies; Puck steps in from life. English fairies have attached themselves to the train of Oberon. . . . The wedding is three days off. Now how put in the time? . . . Shakespeare knew Chaucer quite well. A lucky thing he did. I wish he'd known him better. *The Knight's Tale* is one of the greatest narrative poems in English literature. . . . Bottom is a mon-actor [he may have invented the term]. . . . The quality of folk belief is that it is prosaic and poetic—at one and the same time. . . . There is many a house still in Ireland—and in England too—where the fairies lived; so you have to do a more purely aesthetic thing than Shakespeare's audiences did. Shakespeare himself knew the fairies. I'm sure he was nervous on some kind of nights. He's here reviving the memories of his childhood. Also he read. This is partly book knowledge; but not primarily. He did not read up for this play. Vivid pictures of low life here—equal to Hogarth. . . . What keeps the fairies alive? They *are* alive. Do you believe in the Universe? I never should have thought of it. You'd better entertain it. . . . There were ways to find out if a baby was a changeling. That's why they hastened to church and got it christened—so that it couldn't be taken. . . . A wedding is a time you'd better have the fairies on your side." And much more lore of the same kind. *Wild geese that the creeping fowler eye,/ Or russet-pated choughs, many in sort,/ Rising and cawing at the gun's report*—Observation of a country-bred man. . . . An important part of the play at the end—too often neglected. Very important to placate the fairies so that they bless the wedding; should be given time with dances. . . . If you get too dramatic you are going to miss three quarters of Shakespeare. . . . May dew gathered by the fairies. . . . Bathe the face with it; it gives beauty. . . . Leave flowers on the window sill for the fairies to touch. . . . The greatest criticism of *A Midsummer Night's Dream* is Puck's at the end: *If we* *shadows have offended,/ Think but this, and all is mended,/ That you have but slumber'd here,/ While these visions did appear./ And this weak and idle theme,/ No more yielding but a dream,/ Gentles, do not reprehend.* Shakespeare disappears if you try to analyze it. Yet it needs annotation. Of imagination all compact. Needlessly beautiful." He said of the *little western flower* passage, dismissing controversy, "This is good enough to mean just itself. Hold it as poetry—don't pass it on until you must. . . . What is the meaning of the play? Does it mean anything? Is it a symbol? a metaphor? The less said about that the better. It is difficult to prove that Shakespeare ever wrote a play symbolical of anything. Poets pay the penalty for being poets in this way; they have a habit of taking a simple fact and using such vivid and intense language about it that people think it must have meant something else—can't believe that the simple situation in itself could have had all that content. . . . *I know a bank where the wild thyme blows.* Just a memory of Stratford —nothing more."

Of *Much Ado About Nothing* Professor Beatty said: "A curious play: stuff not plausible; stuff highly plausible. The clever people are fooled; the fools solve the problem. . . . Shakespeare's men and women are in a vacuum as far as any realistic background is concerned." He was excellent on Dogberry and the Watch. *Let us go sit upon the church bench till two and then all to bed*—"A very sleepy scene." The friar's plan: "An elaboration of the plot that never was needed. It is not really this that works the solution. . . . Shakespeare works by scenes, by acts. The reason he does is that he works by creation. Dogberry and Verges were pulling Shakespeare's coattails asking to be taken into something."

He said of *Twelfth Night*: "Observe the subtlety and certainty of the phrasing and the quality of the poetry. Here the lyric secret is recaptured as in *Romeo and Juliet,* and transferred into the realm of comedy—a world in which poetry is the natural thing. . . . Sir Andrew is the most consummate idiot in all Shakespeare. . . . A fine jolly play; a lot of nonsense; also seriousness—human rather than social. Contrast Ben Jonson and his social criticism, satire, and social conscience; a corrector of society, bound to be more realistic, he pictures the age more clearly than Shakespeare. . . . [But] do not make the mistake of thinking that Shakespeare represents the literature of escape. He takes life out into the Forest of Arden. Not only can he create people in the world but he can first create the world. Don't patronize Shakespeare because of your admiration of Ben Jonson, or *vice versa*. . . . Feste is not young; he dates back to Olivia's father. . . . The cathedrals were schools of voice training. Feste sings *Come Away Death.* This is the quality of the clown. There is a tragic note in his songs and sayings. . . . We must not simplify Shakespeare and misinterpret the clown. Feste's deeper note is sounded whenever he appears. . . . Why does Shakespeare have so many shipwrecks? Why, because of London; the ships of the world were in its harbors. Shakespeare knew ships well, though never at sea; he lived in a cosmopolitan world. . . . Sebastian is a gorgeous character; healthy; no phobias; zest of life; brother of delightful Viola. He acts like six-foot-two-inches." And at the end of the Clown's song about *The rain it raineth every day,* he made final comment: "Surface jollity but a constant dipping down into something deeper."

In discussing *The Winter's Tale* Professor Beatty gave most of the time to the fourth act. "*The sweet of the year*—Some of this garden stuff must have gone over the heads of the theatre; it would be understood at Stratford." In looking for the sources of beauty in the plays, he was always very loyal to Shakespeare's home town. "The idea that art itself is nature doesn't convince Perdita. You must know the garden lore to get the beauty and pathos of the scene." And he would expound it.

The Tempest opened vistas into the kind of background he gloried in—the sea, the voyages. And in this play, more than anywhere else, he was tempted to read in symbolism; but he resisted valiantly.

"Written by a man that knows about ships for an audience that knew also about storms. The seaman orders the aristocrats about, supreme on the ship, contemptuous of the landlubbers—the prime minister, important at home. . . . All a kindly parody of witchcraft; all harmless. Shakespeare takes the dark witchcraft and opposes a contrasting magic, a benevolent. Beware of reading in too much symbolism. . . . The play is carried on in a more open atmosphere than any romance; salty; as in Hakluyt and such books. . . . Gonzalo is a kind of glorified Polonius; the wise man. Shakespeare has read the wise books. . . . *Dark back-*

ward and abysm of time—not historical time, but the time of consciousness. . . . Why shouldn't the poet know more about the human mind than professors of psychology? . . . *My library* . . . *volumes that I prize above my dukedom.* Shakespeare often speaks of the quiet life. . . . Fairies were good as long as you mastered them. . . . Mankind is beset on every hand by malevolent powers. You have to master them or they master you. A realistic world; not one of pleasant fancy. . . . [Of the drunken scene] This is the way civilization reached Caliban; but—that way madness lies; that is turning the play into a moral lesson; terrible irony here. . . . When Shakespeare creates, the character steps out of the frame of the story. Compare what Goethe said, that Hamlet has a life outside the play. Shakespeare must have seen the Prince of Denmark before he found a place to put him. You see Miranda in several dimensions. . . . *We are such stuff as dreams are made on.* Like the stage curtain. . . . *Bear with my weakness; my old brain is troubled.* You are young; I do not ask you to enter into my thoughts. . . . It is not unusual to find artists returning to the primary things. Shakespeare never got far from them. In all this you have wonderful poetry. What is it that Prospero knows? Magic? Yes; he puts that by. What is the central story? The whole play is just to bring Ferdinand to the Island, where Miranda is. . . . This story is surrounded by all sorts of strange things. . . . It has the quality of setting the critics to work as if it were an allegory. . . . The girl falls in love. This is more wonderful than the esoteric. Why make this fetch and carry for other departments of life? . . . Spenser's mind had to work with general notions; Shakespeare thinks in the concrete. Did he in the end become more dependent on general ideas? I don't believe it. . . . A boy lying in the grass—means *a boy lying in the grass.* The prosaic person is not satisfied with the single figure—has to mean *youth.* But the artist meant the boy. Goethe means Faust. The prosaic person will not believe that the poet attaches the ultimate value to the thing *itself*—not to the abstraction." However, he did go as far as this: "Just entertain in your mind penumbral shadows. For Shakespeare is here contemplative. . . . Yet these do lend themselves to symbolism; but resist the temptation to reduce them to set terms. . . . Prospero in the background knows what is going on better than the young people do. . . . Comedy comes from depths as deep as tragedy comes from." He quoted a colleague, Professor W. E. Leonard: "If you go to the deeps where there is light, you are doing as great a thing as going to the deeps where there is darkness."

Professor Beatty repeatedly insisted on the importance of going back to the poets who have interpreted Shakespeare: . . . "Consider Coleridge, Goethe, etc. who treat creation as creation. . . . *Hamlet* is not about what the prose people think it's about. When Goethe is talking about *Hamlet,* he is not talking about the same thing as the prose people are. . . . It is often from foolishness—from the vagrant stuff—that poetry is made. . . . Most students will rise to poetry if you catch 'em young. . . .

"Shakespeare's plays are practically all made out of books—out of his reading. . . . He read in a random way—supplementary to his business of making a living; read here and there, this and that and t'other; and out came the poetry. . . . The books start it, but Imogen comes out of nowhere. Plant seed and the marvel is what comes out. He has both worlds of comedy and tragedy. My advice: read both Shakespearean comedy and Shakespearean tragedy when you are not inhibited by practical considerations, when you can follow up an idea to its logical conclusions. Read Shakespeare, and the world will take care of itself. What is the matter with the world is that it has forgotten its Shakespeare. If people would behave as if it were a Shakespearean world—and die so too—what a world it would be! I hope that in twenty-five years you'll believe that. . . . Don't forget the Forest of Arden, where there are *no clocks*."

In dealing with the tragedies, too, he mediated between scholarship and the ordinary reader, taking up learning into the activity of the imagination. The old barbaric story of the Danish prince, the wanderings of Othello, pre-historic legend, fairy tale of the family of Cinderella, witchcraft, astrology, apparitions, the dark lore of madness, every kind of homely folk lore—he let us see these in successive transmutations that we might feel what the poet's alchemy finally made of them—not poetry alone, not tragedy alone, but the essence of tragic poetry.

The story of the star-crossed lovers seemed strangely real in "the two hours' traffic" of Professor Beatty's lecture room. "The story has a long, long history—architypal. . . . Three young men who troop together—Romeo, Benvolio, Mercutio. Street scenes.

. . . Costume party. They come as pilgrims. . . . When Shakespeare's characters come alive, they *do* come alive. Why did Mercutio come alive? I don't know. . . . This is a young man's play. . . . *More light . . . turn the tables up.* My party: have a good time. Romeo comes out from behind a pillar. You hear his voice. He speaks to a serving man, who is busy. . . . The lyric refrain—the torches. You hear the poetry. . . . Tyb the cat is on the watch. Romeo reappears in your attention. . . . Now the sonnets—the pilgrim motif. . . . Ellen Terry acted Juliet's nurse so well that it wasn't acting; she *was* the nurse. *What's he that follows there that would not dance?* Ellen Terry goes to find out. This is a very important moment. It must get time-value and clear, telling emphasis. Terrible effect of *Romeo and a Montague.* . . . They say Shakespeare has double time—two clocks. At the observatory they have star time." And so on through the scenes until the tragedy came home in pity and beauty. "Shakespeare invented little, but he invented all."

"*Hamlet* is no play for Hamlet to be in. . . . There is something wrong with Hamlet; call it perturbation. Shakespeare knows about men whose minds are perturbed. . . . *Seems, Madam!* a match to powder; an explosion. . . . The King is a very capable man, a murderer, and a gentleman. . . . An attempt has been made to make the Ghost subjective so that Hamlet speaks the Ghost speech. This is nonsense!" He liked J. Dover Wilson's note on *russet* in Horatio's speech about the dawn. "I would add the shepherds," he said, having a fancy for linking it with the imagery of the preceding speech and the shepherds on the hills under the benignant stars in the season when *the bird of dawning singeth all night long.* . . . "Wonderful dialogue. Shakespeare gives not only the image but the lyrical image—loaded up with poetry." On Polonius, *admit no messengers, receive no tokens*: "Ophelia obeys—against all her own feelings; hence her insanity later. Simple—perfectly simple and clear—simple as insanity. All the ultimate horrors are in this play." Of the play scene: "Hamlet is still punishing Ophelia for being in the plot. . . . Probably Shakespeare did much re-arranging in *Hamlet*; maybe he experimented; maybe second thoughts aren't always the best. . . . There is some criticism written with a view to squaring *Hamlet* with Aristotle. Can't be done. Aristotle did not know *Hamlet.* If he had, he (Aristotle) would have been a better and wiser man. There *is* such an animal; *Hamlet* exists. . . . Aristotle says the character is second to the plot. As far as *Hamlet* is concerned, don't you believe it. Hamlet the person is central. There is a proverb: *Hamlet with Hamlet left out equals nothing.* Hamlet is his own Iago; Hamlet is his own Lady Macbeth. Follow Hamlet himself. Don't invent things that aren't there. As to what Shakespeare doesn't say, never mind. . . . You are a guilty creature sitting at a play. That's what you have to be to get this—not a rationalistic professor talking about it." On *Hamlet* he went back and drew deeply on the criticism of Goethe and Coleridge, feeling, as he often said, that as poets they perceive the problem more profoundly than most critics. But he said of each, "His solution is less important than his presentation of the difficulty. . . . The problem is in the contradiction between the circumstances of *Hamlet* and the character. Shakespeare had many more characters looking for plays than he had plays . . . . The irreconcilable things *are* the play. The world is not out of joint except as Hamlet comes into it. . . . The problem is one of keeping within the play. Can we assume that literature and life are one? Or are they only parallel? Do they ever touch, necessarily? . . . This is the most popular play in any language. Why? What are the bases of the aesthetic experience? Beware of Polonius who has a complete theory of the whole. . . .

"The Turk nearly overwhelmed Europe. Shakespeare must have had this in his imagination—Othello the great general against the Turks. A magnificently capable mind; a long ancestry behind him." On III:ii:—"Othello the normal, capable, busy man. . . . Desdemona: *I saw Othello's visage in his mind.* And he was neither black nor white; he was Othello. . . . *But still the house affairs would draw her thence,/ Which ever as she could with haste dispatch,/ She'd come again and with a greedy ear/ Devour up my discourse.* An English domestic scene; middle class; the lady of the house busy with her housekeeping. More like Stratford than Italy. . . . Amazing how precise a notion we have of Desdemona and how little she says. . . . Othello is charged with using magic—a serious charge in those days. . . . *She loved me for the dangers I had passed,/ And I loved her that she did pity them.* Profound psychology. . . . *Thy escape would teach me tyranny.* Shakespeare is not sentimental; parents can be hard as granite. . . . Othello is one of the great masters of language in Shakespeare (perhaps Falstaff is the greatest). . . . If Iago had not had so many fools to work on, he could not have succeeded. . . . In real life it is amazing what some people will do for a slight thing. What makes Iago convincing? Iago. The explosive charge is in Iago, not in the external occasion". . . . III:iii:—"Perhaps the greatest scene in all Shakespeare. The power here lies in concentration. . . . *Good name in man and woman, dear by lord,/ Is the immediate jewel of their souls.* No other dramatist would put such a speech in the mouth of such a man. . . . *If thou dost slander her and torture me/ Never pray more.* Note the organic movement away from the iambic. . . . *Like to the Pontic Sea.* In the whole passage note the verse movement. . . . Irony piled on irony. The great evidence of her love is used as evidence against her." . . . Of IV:ii:—"Emilia keeps her level and Desdemona keeps hers. . . . The Greek rule that deaths must be off the stage is a good rule. . . . Nowhere is Othello so great as in his last speech. Shakespeare envisages his tragedy as a surprising thing, inexplicable. Shakespeare gives it the atmosphere of the prodigious. . . . Remember it is poetry; don't try to make it realistic. . . . Shakespeare gave this story wings." He quoted W. MacNeile Dixon on tragedy: "It presents the worst, and excites in us the best. . . . Its conclusions are not contained within its premises. . . . A kingdom inaccessible to fortune."

Of the plays Professor Beatty dealt with, I find my notes on *Macbeth* the least adequate and my sense of his teaching of the play the most vivid and strong. He was like Prospero with his book; old tomes of magic, here he was, with them on his desk, holding them up for us to see: King James' *Daemonologie*, Reginald Scot's *Discovery of Witchcraft*, the *Malleus Maleficarum*.

He refused to let us test the action of the play by mundane reality. It must carry its own world order with it: the palpable power of evil; the man like ourselves caught in its mesh, dictated to against his will. He left Macbeth, it seemed to me, hard to understand before he acts, but terrifyingly comprehensible after he acts.

"Personally, I would rather sacrifice a motive than the witches. If you refine the psychology, you will refine the witches away. . . . *If you can look into the seeds of time/ And say which* *grain will grow and which will not/*—A witch literally did that. . . . They had power—whether you believed in them or not—power over the innocent. All this is perfectly sound witchcraft. They are agents of the devil. . . . They appealed to curiosity about the future. . . . You can't understand the play unless you believe in witches. . . . Macbeth is really a poet embroiled with the powers of darkness. . . . *The earth hath bubbles, as the water has,/ And these are of them. Whither are they vanished?/ Into the air, and what seemed corporal melted/ As breath into the wind. . . . Were such things here as we do speak about,/ Or have we eaten of the insane root/ That takes the reason prisoner?* This scene must have slow tempo. . . . *Nothing in his life/ Became him like the leaving it; he died/ As one that hath been studied in his death/ To throw away the dearest thing he ow'd/ As 'twere a careless trifle.* Even so Shakespeare throws away these bits of poetry. . . . The task of the witches is to destroy the innocent. They dwell in waste places. Sometimes they have strange limitations of power. . . . The thing has the impelling force of a duty. *If it were done when 'tis done/ Then 'twere well it were done quickly.* If dead men would ever stay dead. Contrast *What's done is done. . . . . What's done cannot be undone. . . . At the south entry.* It was Hell's gate that the knocking was at. . . . Banquo's Ghost is a material ghost. The murdered man kept his word. . . . Name a ghost and he will appear. You must 'suspend your disbelief' 'willingly'. There was no such difficulty in the Globe theatre. . . . *How goes the night, boy? The moon is down.* Night . . . night. . . . *Methought I heard a voice cry 'Sleep no more',/ Macbeth doth murder sleep.* . . . Sleep . . . sleep. . . . *After life's fitful fever he sleeps well.*"

He read all the greatest passages, with their lyrical repetitions, letting them produce their own cumulative effect, the longing for the wholesome, the holy terror of the evil thing.

"Shakespeare is the only one who made a tragedy of the *Lear* story. . . . He did not follow any one version. There are fundamental changes from all the versions we know. . . . Spenser and the rest became part of a consciousness that could produce tragedy. . . . You know from the beginning that he is going to make it tragic. . . . Cordelia says one hundred lines, but see how we get to know her from what others say of her. . . . The cocksureness of Cordelia, her certainty that she is doing right—

that is unattractive. . . . France's speech, one of the finest in the play. How could Shakespeare be so wasteful as to let France, this wonderful character, disappear? . . . How important is he going to make Edmund? A vigorous man; might easily usurp the interest; appeals from convention to nature. At war with the powers that brand him as base. Edmund is in the sub-plot; note how his power goes into the main plot. . . . Even in Shakespeare's day an eclipse was a terrible thing; people were afraid. . . . The play stops to let the fool talk. And what a fool it is! The fool almost always talks poetry even when he talks least sense. . . . Observe how the mad imagery of Edgar is transformed into the mad imagery of Lear. . . . *Fathom and a half.* Seafaring folk understand; taking soundings on the rocks; shallow sea; danger. . . . See how this profoundly moving scene touches the common. . . . *Didst thou give all to thy two daughters/ And art thou come to this?* Nothing like this anywhere else, even in Shakespeare. *Couldst thou save nothing? Didst thou give them all?* This scene is stark humanity—and most of them crazy! . . . *Hark! do you hear the sea?* Compare Xenophon: 'The Sea! The Sea! . . . Gentleman: . . . *Sir/ Your most dear daughter/* Lear: *No rescue? What! a prisoner? I am even/ The natural fool of fortune. Use me well;/ You shall have ransome. Let me have surgeons;/ I am cut to the brains.* What 'daughter' means to him! . . . IV:vii:—Not incongruous now. Sheer beauty. . . . V:iii:—Dreadful things on the heel of each other all through this play. . . . *Re-enter Lear with Cordelia in his arms.* One of the most deeply affecting entrances in all Shakespeare. Unexpected . . . *Is this the promised end?* No answer. Nothing to be said. . . . Shakespeare makes wonderful use of the fact that Cordelia dies first. . . . My final feeling is that it is not solved. To my mind the insoluble incongruity *is the play*. . . . You ought to practice holding these plays in solution. . . . Shakespeare's tragedy is not reward and punishment. 'Who can control his fate?' . . . We are still mentally buying things that we can't afford. Literature is for the bitter hour [alluding to Housman whom he had just quoted] . . . Tragedy—the essence of it—is in the thing you can't explain. There couldn't be any if life could be conducted according to recipe—treatises on morals . . . based on the idea that you can beat the game if you know enough. . . . Some people think nothing is moral that does not give them fur coats and steam-heated apartments. . . . In tragedy the game is played on a familiar board according to rules that nobody knows. . . . In Shakespeare good and evil have nothing to do with any other end. Why did these men follow Lear? What about devotion in this play? Why such devotion? No answer. It is acceptance that Shakespeare calls for—not explanation or understanding."

He said the following in a lecture on *King Lear* which he gave after his retirement, substituting for a colleague: "Don't forget the scenes at Dover—and the sea. . . . *We are not the first/ Who, with best meaning, have incurred the worst.* Remember that this is in the play. The wonderful thing about when you're down: Nothing can happen to you; you know the worst. The wonderful thing about the English: because they have a sense of humor, they know the worst can happen." I recorded the date: April 10, 1940. This was, I think, the last time he lectured on Shakespeare.

RACIAL CLASSIFICATIONS OF THE SEVENTEENTH AND EIGHTEENTH CENTURIES

J. S. SLOTKIN

University of Wisconsin

The explorations of the 15th, 16th, and 17th centuries brought Europeans in contact with many new peoples, and finally scholars became interested in the problem of finding order in the bewildering variety of peoples with whom they were confronted. This led to attempts at more or less exhaustive classifications of the races of mankind.

It will be seen from the material given that the early classifications did not differ essentially from those of the present day, either in regard to methodology or criteria. The greatest improvement has been in the refinement of the criteria used as the basis for classification, both qualitative and quantitative.

Bernier

The first classification of the races of man known to the writer was made by Francois Bernier (1620-1688), a French traveller.

> "Although in the exterior form of their body, and especially in their faces, men are almost all different one from the other, according to the different districts of the earth which they inhabit, . . . still I have remarked that there are four or five species or races of men in particular whose difference is so remarkable that it may be properly made use of as the foundation for a new division of the earth.
>
> "I comprehend under the first species . . . all Europe, except a part of Muscovy. To this may be added a small part of [North] Africa . . . and also a good part of [Western and Southern] Asia. . . . For although the Egyptians, for instance, and the [East] Indians are very black, or rather copper-coloured, that colour is only an accident in them, and comes because they are constantly exposed to the sun; and for those individuals who take care of themselves, and who are not obliged to expose themselves so often as the lower class, are not darker than many Spaniards. It is true that most Indians have something very

different from us in the shape of their face, and in their colour which often comes very near to yellow; but that does not seem enough to make them a species apart, or else it would be necessary to make one of the Spaniards, another of the Germans, and so on with several other nations of Europe.

"Under the second species I put the whole of Africa, except the coasts I have spoken of. What induces me to make a different species of the Africans, are, 1. Their thick lips and squab noses, there being very few among them who have aquiline noses or lips of moderate thickness. 2. The blackness which is peculiar to them, and which is not caused by the sun, as many think; for if a black African pair be transported to a cold country, their children are just as black, and so are all their descendants until they come to marry with white women. The cause must be sought for in the peculiar texture of their bodies, or in the seed, or in the blood—which last are, however, of the same colour as everywhere else. 3. Their skin, which is oily, smooth, and polished, excepting the places which are burnt with the sun. 4. The three or four hairs of beard. 5. Their hair, which is not properly hair, but rather a species of wool, which comes near to hairs of some of our dogs; and, finally, their teeth whiter than the finest ivory, their tongue and all the interior of their mouth and their lips as red as coral.

"The third species comprehends [the rest of Asia].... The people of all those countries are truly white; but they have broad shoulders, a flat face, a small squab nose, little pig's-eyes long and deep set, and three hairs of beard.

"The Lapps make the fourth species. They are little stunted creatures with thick legs, large shoulders; short neck, and a face elongated immensely; very ugly and partaking much of the bear....

"As to the Americans, they are in truth most of them olive-coloured, and have their faces modelled in a different way from ours. Still I do not find the difference sufficiently great to make of them a peculiar species different from ours. Besides, as in our Europe, the stature, turn of the face, the colour and the hair are generally very different, as we have said, so it is the same in other parts of the world; as for example, the blacks of the Cape of Good Hope seem to be of a different species to those from the rest of Africa. They are small, thin, dry, ugly, quick in running" (1).

Then, as might be expected from a Frenchman, he proceeds to consider the relative beauty of the women of each of these races (2).

Bradley

The pre-Linnaean systematist, Richard Bradley (1666-1732), also had a classification of human races.

> "I proceed to take notice of the several Kinds of Men, whose Difference is remarkable.
>
> "We find five Sorts of Men; the *White Men*, which are *Europeans*, that have *Beards*; and a sort of *White Men* in *America* (as I am told) that only differ from us in having no *Beards*. The third sort are the *Malatoes*, which have their Skins almost of a *Copper* Colour, *small Eyes*, and *strait black Hair*. The fourth Kind are the *Blacks*, which have *strait black Hair*: And the fifth are the *Blacks of Guiney*, whose *Hair is curl'd*, like the *Wool* of a *Sheep*, which difference is enough to shew us their Distinction; for, as to their Knowledge, I suppose there would not be any great Difference, if it was possible they could be all born of the same Parents, and have the same Education, they would vary no more in Understanding than Children of the same house" (3).

Linnaeus

Carl von Linné (1707-1778) included the races of man in his taxonomic system. In the first edition (Leyden, 1735) of the *Systema Naturae* he divided Homo into four varieties:

"*Europaeus albesc.*
Americanus rubesc.
Asiaticus fuscus.
Africanus nigr."

The last revision, that of the tenth edition (Stockholm, 1758-59) was more elaborate.

"1. *Homo* know thyself

Sapiens	1.	H. Diurnus; varying by culture and place.
Ferus		on all fours, mute, hairy.
Americanus		reddish, choleric, erect. *Hair* black, straight, thick; *Nostrils* wide; *face* harsh, *Beard* scanty. *Obstinate*, merry, free. *Paints* himself with fine red lines. lines *Regulated* by customs.
Europaeus (4)		white, sanguine, muscular. *Hair* flowing, long. Eyes blue. *Gentle*, acute, inventive. *Covered* with close vestments.

Governed by laws.

Asiaticus sallow, melancholy, stiff.
Hair black. *Eyes* dark.
Severe, haughty, avaricious.
Covered with loose garments.
Ruled by opinions.

Afer black, phlegmatic, relaxed.
Hair black, frizzled. *Skin* silky, *Nose* flat. *Lips* tumid.
Women without shame. Mammae lactate profusely.
Crafty, indolent, negligent.
Anoints himself with grease.
Governed by caprice.
Monstrosus. . .
Troglodytes

2. H. nocturnus
Homo sylvestris Orang Outang" (5).

Blumenbach

Johann Friedrich Blumenbach (1752-1840) undertook an examination of the races of man. In the first edition (1770) of *De generis humani varietata nativa* he classified man into four races.

> ". . . although there seems to be so great a difference between widely separate nations, that you might easily take the inhabitants of the Cape of Good Hope, the Greenlanders, and the Circassians for so many different species of man, yet when the matter is thoroughly considered, you see that all do so run into one another, and that one variety of mankind does so sensibly pass into the other, that you cannot mark out the limits between them (6). . . . The first and most important to us (which is also the primitive one) is that of Europe, Asia this side of the Ganges, and all the country situated to the north of the Amur, together with that part of North America, which is nearest both in position and character of the inhabitants. Though the men of these countries seem to differ very much amongst each other in form and colour, still when they are looked at as a whole they seem to agree in many things with ourselves. The second includes that part of Asia beyond the Ganges, and below the river Amur, which looks towards the south, together with the islands, and the greater part of those countries which are called Australia. Men of dark colour, snub noses, with winking eyelids drawn outwards at the corners, scanty, and stiff hair. Africa makes up the third. There remains

finally, for the fourth, the rest of America, except so much of the North as was included in the first variety" (7).

In the second edition (1781) he revised his classification by dividing man into five races, to which he adhered in all subsequent works.

"Formerly in the first edition of this work I divided all mankind into four varieties; but after I had more accurately investigated the different nations of Eastern Asia and America, and, so to speak, looked at them more closely, I was compelled to give up that division, and to place in its stead the following five varieties, as more consonant to nature.

"The first of these and the largest [the Caucasian (8)], which is also the primeval one, embraces the whole of Europe, including the Lapps, whom I cannot in any way separate from the rest of the Europeans, when their appearance and their language bear such a testimony to their Finnish origin; and that western part of Asia . . .; also northern Africa, and lastly, in America, the Greenlanders and the Esquimaux; for I see in these people a wonderful difference from other inhabitants of America; and, unless I am altogether deceived, I think they must be derived from these Finns. All these nations regarded as a whole are white in colour, and, if compared with the rest, beautiful in form.

"The second variety [the Mongolian, (9)] comprises the rest of Asia. . . . The inhabitants of this country are distinguished by being of brownish colour, more or less verging to the olive, straight face, narrow eyelids, and scanty hair. . . .

"The third variety [the Ethiopian, (10)] comprises what remains of Africa, besides that northern part which I have already mentioned. Black men, muscular, with prominent upper jaws, swelling lips, turned up nose, very black curly hair.

"The fourth [the American, (11)] comprises the rest of America, whose inhabitants are distinguished by their copper colour, their thin habit of body, and scanty hair.

"Finally, the new southern world makes up the fifth [the Malayan (12)] . . .; the men throughout being of a very deep brown colour, with broad nose, and thick hair" (13).

"Each of these five principal races contains besides one or more nations which are distinguished by their more or less striking structure from the rest of those of the same division. Thus the Hindoos might be separated as particular sub-varieties from the Caucasian; the Chinese and Japanese from the Mongolian; the Hottentots from the Ethiopian; so also the North American Indians from those in the southern half of the new world; and the black Papuans in New Holland, &c. from the brown Otaheitans and other islanders of the Pacific Ocean" (14).

Goldsmith

In a hack work by Oliver Goldsmith (1728-1774) six races are given.

"If we look round the world, there seems to be not above six distinct varieties in the human species, each of which is strongly marked, and speaks the kind seldom to have mixed with any other" (15).

"I have taken four of these varieties from Linnaeus; those of the Laplanders and Tartars from Mr. Buffon" (16).

"The first distinct race of men is found round the polar regions. The Laplanders, the Esquimaux Indians, the Samoeid Tartars, the inhabitants of Nova Zembla, the Borandians, the Greenlanders, and the natives of Kamtschatka, may be considered as one peculiar race of people. . . .

"The second great variety in the human species seems to be that of the Tartar race. . . .

"To this race of men, also, we must refer the Chinese and the Japanese. . . .

"Another, which makes the third variety in the human species, is that of the southern Asiatics. . . . The nations that inhabit the peninsula of India seem to be the principal stock. . . .

"The fourth striking variety in the human species, is to be found among the negroes of Africa. . . .

"The inhabitants of America makes a fifth race. . . .

"The sixth and last variety of the human species, is that of the Europeans and the nations bordering on them" (17).

". . . hair . . . colour differs in different tribes and races of people. The Americans, and the Asiatics, have their hair black, thick, straight, and shining. The inhabitants of the torrid climates of Africa have it black, short, and woolly. The people of Scandinavia have it red, long, and curled; and those of our own and neighboring countries, are found with hair of various colours" (18).

"The under jaw in a Chinese face falls greatly more backward than with us" (19).

Camper

According to Petrus Camper (1722-1789),

TABLE. Camper's comparative ratios of face breadth.

	Vertex-Gnathion: Eurion-Eurion	Eurion-Eurion: Zygion-Zygion
Orang	19½: 14	14: 14
Negro	27: 20	20: 18
Calmuck	32: 20	20: 24
European	29: 23	23: 20

From: P. Camper, *Works on the Connexion Between The Science of Anatomy and the Arts of Drawing, Painting, Statuary, &c.*, Tr. T. Cogan (London, 1821, New Ed.), 1.5.

"People are distinguished according to the grand divisions of the continents, into Europeans, Africans, Asiatics, and Americans" (20).

"Having contemplated the inhabitants of various nations with great attention, I conceived that a striking difference was occasioned . . . by the position of the inferior maxilla, . . . the breadth of the face, and the quadrangular form of this maxilla" (21).

The first observation led him to the discovery of the facial angle. For comparative purposes in its investigation, he developed the plane which served him as a standard for the measurement of skulls (22).

"[Camper's plane:] An horizontal line has been drawn through the lower part of the nose . . . and the orifice of the ear . . .; and the . . . skulls were arranged with care on the line . . .; attention being also paid to the direction of the *jugale*, or cheekbone" (23).

"[Summary on the facial angle:] The two extremities . . . of the facial lines are from 70 to 100 degrees, from the negro to the Grecian antique; make it under 70, and you describe an ourang or an ape; lessen it still more, and you have the head of a dog" (24).

On the breadth of the face, he gives comparative ratios which appear in the table at the end of this article.

Ferguson

Adam Ferguson (1723-1816) made this classification:

"Mankind may be referred to six different races.

"The *European*, the *Samoeide*, the *Tartar*, the *Hindoo*, the *Negro*, and the *American*" (25).

REFERENCES

1. "Nouvelle division de la terre, par les differentes especes ou races d'hommes qui l'habitent," *Journal des Sçavans*, 12 (1684), (pp. 148-55) pp. 148-51; Tr. T. Bendyshe, London, 1863-64.
2. *Ibid.*, pp. 151-55.
3. *A Philosophical Account of the Works of Nature* (London, 1721), p. 169.
4. He classified man in Sweden as follows:

"*Classis I*
Quadrupedia
I. ANTHROPOMORPHA
Homo

THE MEN inhabiting Sweden are

a. GOTHS, of tall stature, hair white and straight, the iris of the eye ashen blue.
b. FINNS, muscular body, hair long and yellow, the iris of the eye dark.
c. LAPPS, small thin body, hair black, straight, short, the iris of the eye blackish.
d. VARIATIONS and mixtures of a. and b. and the others who have immigrated into Sweden, in the way that may be seen over all Europe." *Fauna Suecica* (Leyden, 1746), p. 1.

"The young women in Finland have much more swelling bosoms than those of Lapland." *Iter Lapponicum* [1732], p. 181; in *Skrifter*, ed. Kungliga Svenska Vetenskapsakademien (Upsala, 1905—), V; tr. C. Troilus, rev. J. E. Smith, London, 1811.

5. Pp. 20-32.
6. *Vide De Generis Humani Varietate Native*, (Gottingen, 1795, 3rd ed), 4.80; *Handbuch der Naturgeschichte* [1779] (Göttingen, 12th ed.), pp. 55-76.
7. (Göttingen, 1776, Reprint of 1st Ed.), pp. 40-42, tr. T. Bendyshe, London, 1865.
8. *Vide Abbildungen naturhistorischer Gegenstände* (Göttingen, 1797-1810), 3, 51.
9. *Vide ibid.*, 1.
10. *Vide ibid.*, 5.
11. *Vide ibid.*, 2.
12. *Vide ibid.*, 4.
13. *DGHVN* (1781, 2nd ed.); in *Anthropological Treatises*, tr. T. Bendyshe (London, 1865), pp. 109-10 n.; vide *DGHVN* (3rd ed.), 4. 80-89; *HN*, pp. 56-57; *Beyträge zur Naturgeschichte* (1790-1811) (Göttingen, 1806-11; I, 2nd ed.), 1. 12.
14. *BN*, 1. 12.
15. *A History of the Earth and Animated Nature* [1774] (London, 1853), 2. 1. 11 (I, p. 232a); *Vide idem* (I, pp. 237a-238b).
16. *Ibid.*, 2. 1. 11 (I, p. 232 n.).
17. *Ibid.*, 2. 1. 11 (I, pp. 232a-236b).
18. *Ibid.*, 2. 1. 5 (I, p. 202b).

19. *Ibid.*, 2. 1. 5 (I, p. 203a).
20. *Works on the Connexion Between the Science of Anatomy and the Arts of Drawing, Painting, Statuary, &c.* [1791] tr. T. Cogan (London, 1821, new ed.), 1.1 (p. 14).
21. *Ibid.*, intr. (p. 8).
22. *Vide ibid.*, plates 1-3.
23. *Ibid.*, 1. 3 (p. 33).
24. *Ibid.*, 1. 3 (p. 42); *vide ibid.*, intr; 1. 3-4.
25. *Institutes of Moral Philosophy* (Basle, 1800, New Ed.), 1. 1. 4 (after Buffon).

LIST OF PUBLICATIONS DEALING WITH WISCONSIN LIMNOLOGY 1871-1945

CHANCEY JUDAY* AND ARTHUR D. HASLER
Department of Zoology, University of Wisconsin

The publications included in this list deal mainly with the biology, geology, physics and chemistry of Wisconsin lakes; to this list have been added the earlier papers of E. A. Birge and C. Juday, as well as some publications by them based on observations of lakes situated in other states and countries.

The great majority of these books and papers has come from the Limnological Laboratory of the Wisconsin Geological and Natural History Survey, and from the department of Zoology, University of Wisconsin. Other departments of the University which contributed richly are: Botany, Agricultural Bacteriology, Chemistry, Physics, and Geology. A considerable number are the result of investigations carried on in cooperation with the U. S. Bureau of Fisheries, now a division of the Fish and Wildlife Service, the Wisconsin Conservation Department, the University of Michigan, the University of Illinois, the University of Minnesota, and the Works Progress Administration. Assistance in preparing some of the material for publication has also been received from the National Youth Administration. Much financial assistance for some of the projects has been received from the Brittingham Trust Fund and from the Wisconsin Alumni Research Foundation.

BIBLIOGRAPHY

Allgeier, R. J., Hafford, B. C. and Juday, C. 1941. Oxidation-reduction potentials and pH of lake waters and lake sediments. Trans. Wisconsin Acad. Sci. 33: 115-133.

Allgeier, R. J., Peterson, W. H., and Juday, C. 1934. Availability of carbon in certain aquatic materials under aerobic conditions of fermentation. Internat. Rev. ges. Hydrobiol. u. Hydrog. 30: 371-378.

Allgeier, R. J., Peterson, W. H., Juday, C., and Birge, E. A. 1932. The anaerobic fermentation of lake deposits. *Ibid.* 26: 444-461.

* Deceased (March 29, 1944).

Andrews, Jay D., and Hasler, A. D. 1943. Fluctuations in the animal populations of the littoral zone in Lake Mendota. Trans. Wisconsin Acad Sci. 35: 175-185.

Andrews, O. V. 1920. An ecological survey of Lake Butte des Morts Bog, Oshkosh, Wis. Bull. Wis. Nat. Hist. Soc. 13 (N.S.): 196-211.

Baker, Frank Collins. 1914. The molluscan fauna of Tomahawk Lake, Wisconsin, with special reference to its ecology. Trans. Wisconsin Acad. Sci. 17: 200-246.

——————— 1922. New Lymnaeas from Wisconsin and Minnesota with notes on shells from the latter state. Nautilus 36: 22-25.

——————— 1922. New species and varieties of Mollusca from Lake Winnebago, Wisconsin, with new records from this state. *Ibid.* 35: 130-133; 36: 19-21.

——————— 1924. The fauna of the Lake Winnebago region; a quantitative and qualitative survey with special reference to the Mollusca. Trans. Wisconsin Acad. Sci. 21: 109-146.

——————— 1926. Nomenclatorial notes on American freshwater Mollusca. *Ibid.* 22: 193-205.

——————— 1928. The freshwater Mollusca of Wisconsin. Part I. Gastropoda. xx-507 pp., 28 plates; Part II. Pelecypoda. vi-495 pp., 77 plates. Bull. No. 70, Wis. Geol. and Nat. Hist. Survey & Bull. No. 1527, University of Wisconsin. Published jointly by the Wisconsin Acad. Sci., the University of Wisconsin and the Wis. Geol. and Nat. Hist. Survey.

Bennett, George W. 1937. The growth of the large-mouthed black bass in the waters of Wisconsin. Copeia 1937: 104-118.

——————— 1938. Growth of the small-mouthed black bass in Wisconsin waters. *Ibid.* 1938: 157-170.

Bere, Ruby. 1931. Copepods parasitic on fish of the Trout Lake region, with descriptions of two new species. Trans. Wisconsin Acad. Sci. 26: 427-436.

——————— 1931. Leeches from the lakes of northeastern Wisconsin. *Ibid.* 26: 437-440.

——————— 1933. Numbers of bacteria in inland lakes of Wisconsin as shown by the direct microscopic method. Internatl. Rev. ges. Hydrobiol. u. Hydrog. 29: 248-263.

——————— 1935. Further notes on the occurrence of parasitic copepods on fish of the Trout Lake region, with a description of the male of *Argulus biramosus*. Trans. Wisconsin Acad. Sci. 29: 83-88.

Birge, E. A. 1873. The ant-lion. American Naturalist 7: 432.

——————— 1879. Notes on Cladocera. Trans. Wisconsin Acad. Sci. 4: 77-112.

——————— 1881. Notes on the functions of the spinal cord in the frog. Amer. Micros. Jour. 2: 210-213.

——————— 1882. On a convenient method of embedding. *Ibid.* 3: 73-75.

——————— 1882. On the first zoea stage of *Pinnotheres ostreum*. American Naturalist 16: 589-591.

——————— 1882. Über die Reizbarkeit der motorischen Ganglienzellen des Rückenmarks. Arch. f. Anat. u. Physiol. (Physiol. Abt.) 1882: 481-489.

——— 1882. Die Zahl der Nervenfasern und der motorischen Ganglienzellen im Rückenmark des Frosches. *Ibid.* 1882: 435-480.

——— 1883. Notes on the development of *Panopaeus sayi* Smith. Johns Hopkins Univ. Biol. Lab. Studies 2: 411-426.

——— 1885. On the motor ganglion cells of the frog's spinal cord. Trans. Wisconsin Acad. Sci. 6: 51-81.

——— 1892. Notes and list of Crustacea Cladocera from Madison, Wisconsin. *Ibid.* 8: 379-398.

——— 1893. Notes on Cladocera, III. *Ibid.* 9: 275-317.

——— 1894. The Cladocera. Bull. Mich. Fish. Com. No. 4: 45-47.

——— 1895. Cladocera (of Turkey Lake, Indiana). Proc. Ind. Acad. Sci. 5: 244-246.

——— 1895. On the vertical distribution of the pelagic crustacea of Lake Mendota, Wisconsin, during July, 1894. Biol. Centralbl. 15: 353-355.

——— 1897. The vertical distribution of the limnetic crustacea of Lake Mendota. *Ibid.* 17: 371-374.

——— 1898. Plankton studies on Lake Mendota. 2. The crustacea of the plankton from July, 1894, to December, 1896. Trans. Wisconsin Acad. Sci. 11: 274-448.

——— 1901. The cone net. Jour. Applied Micros. 4: 1405-1407.

——— 1901. Report of Limnological Commission. Trans. Amer. Micros. Soc. 22: 193-196.

——— 1904. A biological reconnaissance of some elevated lakes in the Sierras and Rockies. (H. B. Ward) Report on the Cladocera. Studies Zool. Lab. Univ. Nebr. No. 60: 149-152.

——— 1904. The thermocline and its biological significance. Trans. Amer. Micros. Soc. 25: 5-32.

——— 1907. Gases dissolved in the waters of Wisconsin lakes. Trans. Amer. Fish. Soc. 1906: 142-163. (Reprinted in Rept. Wis. Commissioners of Fisheries, pp. 118-139, and in Proc. of Fourth Internat. Fish. Cong. Part II: 1273-1292, 1908.)

——— 1907. The respiration of an inland lake. *Ibid.* 1907: 223-241. Also Pop. Sci. Mo. 72: 337-351. 1908.

——— 1910. The apparent sinking of ice in lakes. Science, N.S. 32: 81-82.

——— 1910. Notes on Cladocera IV. Trans. Wisconsin Acad. Sci. 16: 1017-1066.

——— 1910. On the evidence of temperature seiches. *Ibid.* 16: 1005-1016.

——— 1910. An unregarded factor in lake temperatures. *Ibid.* 16: 989-1004.

——— 1913. Absorption of the sun's energy by lakes. Science 38: 702-704.

——— 1915. The heat budgets of American and European lakes. Trans. Wisconsin Acad. Sci. 18: 166-213.

——— 1916. The work of the wind in warming a lake. *Ibid.* 18: 341-391.

———— 1918. The water fleas (Cladocera). In Ward & Whipple's Freshwater Biology, pp. 676-740.

———— 1922. A second report on limnological apparatus. Trans. Wisconsin Acad. Sci. 20: 533-552.

———— 1923. The plankton of the lakes. Trans. Amer. Fisheries Soc. 52: 118-130.

———— 1929. Fish and their food. *Ibid.* 59: 188-194.

———— 1936. Biology of Lake Mendota. Technical Club of Madison. 1936: 11-12.

Birge, E. A., and Juday, C. 1908. A summer resting stage in the development of *Cyclops biscuspidatus* Claus. Trans. Wisconsin Acad. Sci. 16: 1-9.

———— 1911. The inland lakes of Wisconsin. I. The dissolved gases and their biological significance. Bulletin, Wis. Geol. and Nat. Hist. Survey 22: 259 pp.

———— 1914. A limnological study of the Finger Lakes of New York. Bull. U. S. Bureau Fisheries 32: 525-609.

———— 1920. A limnological reconnaissance of West Okoboji. Univ. Iowa Studies Nat. Hist. 9: 1-56.

———— 1921. Further limnological observations on the Finger Lakes of New York. Bull. U. S. Bureau Fisheries 37: 211-252.

———— 1922. The inland lakes of Wisconsin. The plankton. I. Its quantity and chemical composition. Bulletin, Wis. Geol. and Nat. Hist. Survey No. 64: (Scientific series 13), ix-222 pp.

———— 1926. Organic content of lake water. Bull. U. S. Bureau of Fisheries 42: 185-205.

———— 1926. The organic content of lake water. Proc. Nat. Acad. Sci. 12: 518-519.

———— 1927. The organic content of the water of small lakes. Proc. Amer. Phil. Soc. 66: 357-372.

———— 1929. Penetration of solar radiation into lakes as measured by the thermopile. Bull. Nat. Res. Counc. No. 68. Trans. Amer. Geophys. Union, 9th Ann. Meeting, pp. 61-76.

———— 1929. Transmission of solar radiation by the waters of inland lakes. Trans. Wisconsin Acad. Sci. 24: 509-580.

———— 1930. A second report on solar radiation and inland lakes. *Ibid.* 25: 285-335.

———— 1931. A third report on solar radiation and inland lakes. *Ibid.* 26: 383-425.

———— 1932. Solar radiation and inland lakes. Fourth Report. Observations of 1931. *Ibid.* 27: 523-562.

———— 1934. Particulate and dissolved organic matter in inland lakes. Ecol. Monog. 4: 440-474.

Birge, E. A., Juday, C., and March, H. W. 1928. The temperature of the bottom deposits of Lake Mendota: A chapter in the heat exchange of the lakes. Trans. Wisconsin Acad. Sci. 23: 187-231.

Birge, E. A., Olson, O. A., and Harder, H. P. 1895. Plankton studies on Lake Mendota. I. The vertical distribution of the pelagic crustacea during July, 1894. *Ibid.* 10: 421-484.

Birge, E. A., and Rich, W. H. 1927. Observations on Karluk Lake, Alaska. Ecology 8:384.

Black, C. S. 1929. Chemical analyses of lake deposits. Trans. Wisconsin Acad. Sci. 24: 127-133.

Brackett, Sterling. 1940. Studies on Schistosome dermatitis. V. Prevalence in Wisconsin. Amer. Jour. Hyg. 31(3): 49-63.

——————— 1940. Studies on Schistosome dermatitis. VIII. Notes on the biology of the snail hosts of schistosome cercariae in Wisconsin and epidemiological evidence for the life cycles of some avian schistosomes. Amer. Jour. Hyg. 32: 85-104.

——————— 1940. Two new species of schistosome cercariae from Wisconsin. Jour. Parasitol. 26(3): 195-200.

——————— 1940. Two new species of strigeid cercariae in Lymnaeid snails from the United States. *Ibid.* 25(3): 263-268.

Broughton, W. A. 1941. The geology, ground water and lake basin seal of the region south of the Muskellunge Moraine, Vilas County, Wisconsin. Trans. Wisconsin Acad. Sci. 33: 5-20.

Buckley, Ernest Robertson. 1901. Ice ramparts. *Ibid.* 13: 141-162.

Bundy, W. F. 1883. The crustacean fauna of Wisconsin, with descriptions of little known species of Cambarus. Geol. of Wis. 1: 402-405.

Carpenter, Phillip L. 1939. Bacterial counts in the muds of Crystal Lake—an oligotrophic lake of northern Wisconsin. Jour. Sedim. Petrol. 9: 3-7. April.

Chase, Wayland Johnson, and Noland, Lowell E. 1927. The history and hydrography of Lake Ripley (Jefferson County, Wisconsin). Trans. Wisconsin Acad. Sci. 23: 179-186.

Clarke, George L., and James, Harry R. 1939. Laboratory analysis of the selective absorption of light by sea water. Jour. Optic. Soc. Amer. 29: 43-55.

Conger, Paul S. 1939. The contribution of diatoms to the sediments of Crystal Lake, Vilas County, Wisconsin. Amer. Jour. Sci. 237: 324-340. May.

——————— 1939. Origin and utilization of diatomaceous peat deposits. Scientific Monthly 49: 509-523.

——————— 1942. Accumulation of diatomaceous deposits. Jour. Sedim. Petrol. 12: 55-66.

Couey, F. M. 1935. Fish food studies of a number of northeastern Wisconsin lakes. Trans. Wisconsin Acad. Sci. 29: 131-172.

Creaser, Edwin P. 1932. The decapod crustaceans of Wisconsin. *Ibid.* 27: 321-338.

Cross, S. X. 1934. A probable cause of non-specific immunity between two parasites of ciscoes of the Trout Lake region of northern Wisconsin. Jour. Parasitol. 20: 244-245.

——————— 1935. The effect of parasitism on the growth of perch in the Trout Lake region. *Ibid.* 21: 267-273.

——————— 1938. A study of the fish parasite relationships in the Trout Lake region of Wisconsin. Trans. Wisconsin Acad. Sci. 31: 439-456.

Curtis, John T., and Juday, C. 1937. Photosynthesis of algae in Wisconsin lakes. III. Observations of 1935. Internatl. Rev. ges. Hydrobiol. u. Hydrog. 35: 122-133.

Davis, Francis J. 1941. Surface loss of solar and sky radiation by inland lakes. Trans. Wisconsin Acad. Sci. 33: 83-93.

Denniston, Rollin Henry. 1921. A survey of the larger aquatic plants of Lake Mendota. *Ibid.* 20: 495-500.

Deutsch, H. F., and Hasler, A. D. 1943. Distribution of a vitamin B_1 destructive enzyme in fish. Proc. Soc. Exptl. Biol. and Med. 53: 63-65.

Dickinson, W. E. 1936. The mosquitoes of Wisconsin. Bull. Pub. Museum, Milwaukee 8: No. 3.

Domogalla, B. P., and Fred, E. B. 1926. Ammonia and nitrate studies of lakes near Madison, Wisconsin. Jour. Amer. Soc. Agron. 18: 897-911.

Domogalla, B. P., Fred, E. B., and Peterson, W. H. 1926. Seasonal variations in the ammonia and nitrate content of lake waters. Jour. Amer. Water Works Assoc. 15: 369-385.

Domogalla, B. P., Juday, C., and Peterson, W. H. 1925. The forms of nitrogen found in certain lake waters. Jour. Biol. Chem. 63: 269-285.

Dutton, Herbert, and Juday, C. 1944. Chromatic adaptation in relation to color and depth distribution of freshwater phytoplankton and large aquatic plants. Ecology 25: 273-282.

Dutton, Herbert J., and Manning, W. M. 1941. Evidence for carotenoid-sensitized photosynthesis in the diatom *Nitzschia closterium.* Amer. Jour. Bot. 28: 516-526.

Edmundson, W. T. 1940. The sessile Rotatoria of Wisconsin. Trans. Amer. Micros. Soc. 59: 433-459.

Enteman, Minnie Marie. 1900. Variations in the crest of *Daphnia hyalina.* Amer. Naturalist 34: 879-890.

Erikson, Dagny. 1941. Studies on some lake-mud strains of Micromonospora. Jour. Bact. 41: 277-300.

Fassett, N. C. 1930. The plants of some northeastern Wisconsin lakes. Trans. Wisconsin Acad. Sci. 25: 155-168.

——————— 1940. A manual of aquatic plants. McGraw-Hill, N. Y. 382 pp.

Fenneman, N. M. 1902. On the lakes of southeastern Wisconsin. Wis. Geol. and Nat. Hist. Survey, Bull. No. 8, 178 pp. Reprinted in 1910.

Field, John B., Elvehjem, C. A., and Juday, C. 1943. A study of the blood constituents of carp and trout. Jour. Biol. Chem. 148: 261-269.

Field, John B., Gee, Lynn L., Elvehjem, C. A., and Juday, C. 1944. The blood picture in furunculosis induced by *Bacterium salmonicida* in fish. Arch. Biochem. 3: 277-284.

Field, John B., Herman, Elmer F., and Elvehjem, C. A. 1944. Increased growth produced by gelatin in trout fed meatless diets. Proc. Soc. Exptl. Biol. and Med. 55: 222-225.

Flanigon, Thomas H. 1942. Limnological observations on three lakes in eastern Vilas County, Wisconsin. Trans. Wisconsin Acad. Sci. 34: 167-175.

Fred, E. B., Wilson, F. C., and Davenport, Audrey. 1924. The distribution and significance of bacteria in Lake Mendota. Ecology 5: 322-339. October.

Freeman, S., Meloche, V. W., and Juday, C. 1933. The determination of the hydrogen ion concentration of inland lake waters. Internatl. Rev. ges. Hydrobiol. u. Hydrog. 30: 346-359.

Frey, David Grover. 1940. Growth and ecology of the carp, *Cyprinus carpio*, Linnaeus, in four lakes of the Madison region, Wisconsin. Manuscript Ph. D. Thesis. 248 pp. Library, University of Wisconsin.

——————— 1942. Annulus formation in the scales of the carp. Copeia, 1942: 214-223.

Frey, D. G., and Pedracine, H. 1938. Growth of the buffalo in Wisconsin lakes and streams. Trans. Wisconsin Acad. Sci. 31: 513-525.

Frey, David G., Pedracine, Hubert, and Vike, Lawrence. 1939. Results of a summer creel census of Lakes Waubesa and Kegonsa, Wisconsin. Jour. Wildlife Management 3: 243-254. July.

Frey, David G., and Vike, Lawrence. 1941. A creel census on Lakes Waubesa and Kegonsa, Wisconsin, in 1939. Trans. Wisconsin Acad. Sci. 33: 339-362.

Fries, Carl, Jr. 1938. Geology and ground water of the Trout Lake region, Vilas County, Wisconsin. *Ibid.* 31: 305-322.

Gee, Lynn L., and Sarles, W. B. 1942. The disinfection of trout eggs contaminated with *Bacterium salmonicida*. Jour. Bact. 44: 11-126.

Gifford, Elizabeth M., and Peckham, Geo. W. 1882. Temperature of Pine, Beaver and Okauchee lakes. Trans. Wisconsin Acad. Sci. 5: 273-275.

Greene, C. W. 1926. An ichthyological survey of Wisconsin. Papers Mich. Acad. Sci., Arts and Let. 7: 299-310.

——————— 1935. The distribution of Wisconsin fishes. Wisconsin Conservation Department. 235 pp.

Hardman, Yvette. 1938. Some filamentous bacteria from Wisconsin lakes. A thesis submitted to the faculty of the Graduate School of the University of Minnesota for M.S. degree. June, 1938. 25 pp. Ms.

——————— 1941. The surface tension of Wisconsin lake waters. Trans. Wisconsin Acad. Sci. 33: 395-404.

Hardman, Yvette, and Henrici, Arthur T. 1939. The distribution of *Siderocapsa treubii* in some lakes and streams. Jour. Bact. 37: 97-104. January.

Harring, H. K., and Myers, F. J. 1922. The rotifers of Wisconsin. Trans. Wisconsin Acad. Sci. 20: 553-662.

——————— 1924. The rotifer fauna of Wisconsin. II. A revision of the notommatid rotifers, exclusive of the Dicranophorinae. *Ibid.* 21: 514-549.

——————— 1926. The rotifer fauna of Wisconsin. III. A revision of the genera Lecane and Monostyla. *Ibid.* 22: 315-423.

——————— 1927. The rotifer fauna of Wisconsin. IV. The Dicranophorinae. *Ibid.* 23: 667-808.

Hasler, A. D. 1935. The physiology of digestion of plankton crustacea. Biol. Bull. 68: 207-214.

——————— 1937. The physiology of digestion in plankton crustacea. II. Further studies in the digestive enzymes of (A) Daphnia and Polyphemus and (B) Diaptomus and Calanus. *Ibid.* 72: 290-298.

——————— 1945. Observations on the winter perch populations of Lake Mendota. Ecology 26: 90-94.

Hasler, Arthur D., and Faber, Wm. M. 1941. A tagging method for small fish. Copeia, 1941: 162-165.

Hasler, A. D., and Meyer, Roland K. 1942. Respiratory responses of normal and castrated goldfish to teleost and mammalian hormones. Jour. Exptl. Zool. 91: 391-404.

Hasler, A. D., Meyer, R. K., and Field, H. M. 1939. Spawning induced prematurely in trout with the aid of pituitary glands of the carp. Endocrinology 25: 978-983.

——————— 1940. The use of hormones for the conservation of muskellunge, *Esox masquinongy immaculatus* Garrard. Copeia, 1940: 43-46.

Hathaway, E. S. 1927. Quantitative study of the changes produced by acclimatization in the tolerance of high temperatures by fishes and amphibians. Bull. U. S. Bureau Fisheries 48: 169-192.

——————— 1927. The relation of temperature to the quantity of food consumed by fishes. Ecology 8: 428-434.

Henrici, A. T., and McCoy, Elizabeth. 1938. The distribution of heterotrophic bacteria in the bottom deposits of some lakes. Trans. Wisconsin Acad. Sci. 31: 323-361.

Higley, W. K. 1889. Reptilia and Batrachia of Wisconsin. *Ibid.* 7: 155-176.

Hile, R. 1936. Age and growth of the Cisco, *Leucichthys artedi* (Le Sueur), in the lakes of northeastern Highlands, Wisconsin. Bull. U. S. Bureau Fisheries 48: 211-317.

——————— 1936. Summary of investigations on the morphometry of the Cisco, *Lcucichthys artedi* (Le Sueur), in the lakes of the northeastern Highlands, Wisconsin. Papers Mich. Acad. Sci., Arts and Let. 21: 619-634.

——————— 1937. Morphometry of the Cisco, *Leucichthys artedi* (Le Sueur), in the lakes of northeastern Highlands, Wisconsin. Internatl. Rev. ges. Hydrobiol. u. Hydrog. 36: 57-130.

——————— 1941. Age and growth of the rock bass, *Ambloplites rupestris* (Rafinesque), in Nebish Lake, Wisconsin. Trans. Wisconsin Acad. Sci. 33: 189-337.

——————— 1942. Growth of the rock bass, *Ambloplites rupestris* (Rafinesque), in five lakes of northeastern Wisconsin. Trans. Amer. Fisheries Soc. 71: 131-143.

——————— 1942. Mathematical relationship between the length and age of the rock bass, *Ambloplites rupestris* (Rafinesque). Papers Mich. Acad. Sci., Arts and Let. 28: 331-341.

Hile, Ralph, and Deason, Hilary J. 1935. Growth of the whitefish, *Coregonus clupeaformis* (Mitchill), in Trout Lake, northeastern Highlands, Wisconsin. Trans. Amer. Fisheries Soc. 64: 231-237.

Hile, Ralph, and Juday, C. 1941. Bathymetric distribution of fish in lakes of northeastern Highlands, Wisconsin. Trans. Wisconsin Acad. Sci. 33: 147-187.

Holmes, Samuel Jackson. 1909. Description of new subterranean amphipod from Wisconsin. *Ibid.* 16: 77-80.

——————— 1910. Description of a new species of Eubranchipus from Wisconsin with observations on its reaction to light. *Ibid.* 16: 1252-1255.

Hoy, P. R. 1871. Abstracts of a paper on the fauna of Lake Michigan off Racine. *Ibid.* 2: 34-35.

——————— 1872. Deep-water fauna of Lake Michigan. *Ibid.* 1: 98-101.
——————— 1872. Mortality of fish in the Racine River. Proc. Amer. Assoc. Adv. Sci. 1872: 198-199.
——————— 1876. Fish culture. Trans. Wisconsin Acad. Sci. 3: 37-39.
——————— 1876. On the extent of the Wisconsin fisheries. (An abstract of notes sent by Dr. Hoy.) *Ibid.* 3: 65-67.
——————— 1877. Catalogue of the cold-blooded vertebrates of Wisconsin. Geol. Surv. Wis. 1873-1879. Vol. I, Part 2; Chap. 9: 422-435.
——————— 1882. Water puppy, (*Menobranchus lateralis* Say). Trans. Wisconsin Acad. Sci. 5: 248-250.
Hubbs, C. L., and Greene, C. W. 1935. Two new sub-species of fishes from Wisconsin. *Ibid.* 29: 89-101.

Jackson, H. H. T. 1912. A contribution to the natural history of the amphipod, *Hyalella knickerbockeri* Bate. Bull. Wis. Nat. Hist. Soc. 10: 49-60.
James, Harry R., and Birge, E. A. 1938. A laboratory study of the absorption of light by lake waters. Trans. Wisconsin Acad. Sci. 31: 1-154.
Jewell, Minna E. 1935. An ecological study of the fresh-water sponges of northern Wisconsin. Ecol. Monog. 5: 461-504.
——————— 1939. An ecological study of the fresh-water sponges of Wisconsin. II. The influence of calcium. Ecology 20: 11-28.
Juday, C. 1896. Hydrographic map of Turkey Lake. Proc. Ind. Acad. Sci. (Frontispiece) 1895.
——————— 1897. The plankton of Turkey Lake. *Ibid.* 1896: 287-296.
——————— 1903. The plankton of Winona Lake. *Ibid.* 1902: 120-133.
——————— 1904. The diurnal movement of plankton crustacea. Trans. Wisconsin Acad. Sci. 14: 534-568.
——————— 1904. Fishes of Boulder County, Colorado. Univ. of Colo. Studies 2: 113-114.
——————— 1905. List of fishes collected in Boulder County, Colorado, with description of a new species of Leuciscus. Bull. U. S. Bureau Fisheries 24: 223-227.
——————— 1906. The food of the trout of the Kern River region. *Ibid.* 25: 43-49.
——————— 1906. Ostracoda of the San Diego region. I. Halocypridae. Univ. Calif. Pub. Zool. 3: 13-38.
——————— 1907. Cladocera of the San Diego region. *Ibid.* 3: 157-158.
——————— 1907. Notes on Lake Tahoe, its trout and trout-fishing. Bull. U. S. Bureau Fisheries 26: 137-146.
——————— 1907. Ostracoda of the San Diego region. II. Littoral forms. Univ. Calif. Pub. Zool. 3: 135-156.
——————— 1907. Studies on some lakes in the Rocky and Sierra Nevada Mountains. Trans. Wisconsin Acad. Sci. 15: 781-793.
——————— 1907. A study of Twin Lakes, Colorado, with especial consideration of the food of the trouts. Bull. U. S. Bureau Fisheries 26: 147-178.
——————— 1908. Resume of recent work on lakes by the Wisconsin Geological and Natural History Survey. Internatl. Rev. ges. Hydrobiol. u. Hydrog. 1: 240-242.

——— 1908. Some aquatic invertebrates that live under anaerobic conditions. Trans. Wisconsin Acad. Sci. 16: 10-16.

——— 1910. Some European biological stations. *Ibid.* 16: 1257-1277.

——— 1913. Air in the depths of the ocean. Science, N.S. 38: 546-547.

——— 1914. The inland lakes of Wisconsin. II. The hydrography and morphometry of the lakes. Wis. Geol. and Nat. Hist. Survey Bulletin 27: xv-137pp.

——— 1914. A new species of Diaptomus. Trans. Wisconsin Acad. Sci. 17: 803-805.

——— 1915. Limnological studies on some lakes in Central America. *Ibid.* 18: 214-250.

——— 1916. Horizontal rainbows on Lake Mendota. Monthly Weather Review 44: 65-67.

——— 1916. Limnological apparatus. Trans. Wisconsin Acad. Sci. 18: 566-592.

——— 1919. A freshwater anaerobic ciliate. Biol. Bull. 36: 92-95.

——— 1920. Cladocera. Report of Canadian Arctic Expedition 1913-1918, 7: Part H, pp. 1-8.

——— 1920. Horizontal rainbows. Science, N.S., 51: 188.

——— 1920. The plankton of Lake Maxinkuckee. In "Lake Maxinkuckee. A physical and biological survey." By B. W. Evermann and H. W. Clark. II: 105-110. Department of Conservation, State of Indiana. See also: Trans. Amer. Micros. Soc. 23: 61-62. 1902.

——— 1921. Observations on the larva of *Corethra punctipennis* Say. Biol. Bull. 40: 271-286.

——— 1922. Limnological observations on Lake George. A biological survey of Lake George, New York. N. Y. Cons. Comn. 1921, pp. 37-51.

——— 1922. Quantitative studies of the bottom fauna in the deeper waters of Lake Mendota. Trans. Wisconsin Acad. Sci. 20: 461-493.

——— 1923. An interesting copepod from the Finger Lakes, New York. Science 58: 205.

——— 1923. The water-fleas. In "A scientific survey of Turners Lake, Isle-au-Haut, Maine." N. Y. State Museum. August. Published privately, pp. 16-17.

——— 1924. The productivity of Green Lake, Wisconsin. Verhandl. Internatl. Ver. f. Limnol. 2: 357-360.

——— 1924. Summary of quantitative investigations on Green Lake, Wisconsin. Internatl. Rev. ges. Hydrobiol. u. Hydrog. 12: 1-12.

——— 1925. *Sencella calanoides*, a recently described freshwater copepod. Proc. U. S. Nat. Mus. 66: 1-6.

——— 1926. Freshwater Cladocera from southern Canada. Canadian Field Nat. 40: 99-100.

——— 1926. Sand flotation on lakes. Science, N.S., 64: 138.

——— 1926. A third report on limnological apparatus. Trans. Wisconsin Acad. Sci. 22: 299-315.

——————— 1927. Freshwater Cladocera from the east shore of Hudson and James bays. Canadian Field Nat. 41: 130-131.

——————— 1929. Limnological methods. Arch. f. Hydrobiol. 20: 517-524.

——————— 1934. The depth distribution of some aquatic plants. Ecology 15: 325.

——————— 1934. Growth of game fish. Field and Stream, December, 1934: 7-72.

——————— 1935. Chemical composition of large aquatic plants. Science 81: 273.

——————— 1937. Trout Lake. The Limnological Laboratory. The Biologist 18: 177-182. March-May.

——————— 1938. Fish records for Lake Wingra. Trans. Wisconsin Acad. Sci. 31: 533-534.

——————— 1938. Wisconsin lakes and fish investigations. Prog. Fish Cult., June-July, 1938. No. 39: 18-21.

——————— 1940. The annual energy budget of an inland lake. Ecology 21: 438-450.

——————— 1943. The summer standing crop of plants and animals in four Wisconsin lakes. Trans. Wisconsin Acad. Sci. 34: 387-410.

——————— 1943. The utilization of aquatic food resources. Science 97 (2525): 456-458.

Juday, C., and Bennett, G. W. 1935. The growth of game fish in Wisconsin waters. Mimeographed report, 13 pp.

Juday, C., and Birge, E. A. 1927. Pontoporeia and Mysis in Wisconsin lakes. Ecology 8: 445-452.

——————— 1930. The highland lake district of northeastern Wisconsin and the Trout Lake limnological laboratory. Trans. Wisconsin Acad. Sci. 25: 337-352.

——————— 1931. A second report on the phosphorus content of Wisconsin lake waters. *Ibid.* 26: 353-382.

——————— 1932. Dissolved oxygen and oxygen consumed in the lake waters of northeastern Wisconsin. *Ibid.* 27: 415-486.

——————— 1933. The transparency, the color and the specific conductance of the lake waters of northeastern Wisconsin. *Ibid.* 28: 205-259.

——————— 1941. Hydrography and morphometry of some northeastern Wisconsin lakes. *Ibid.* 33: 21-72.

Juday, C., Birge, E. A., and Kemmerer, G. I. 1927. Phosphorus content of lake waters of northeastern Wisconsin. *Ibid.* 23: 233-248.

Juday, C., Birge, E. A., and Meloche, V. W. 1935. The carbon dioxide and hydrogen ion content of the lake waters of northeastern Wisconsin. *Ibid.* 29: 1-82.

——————— 1938. Mineral content of the lake waters of northeastern Wisconsin. *Ibid.* 31: 223-276.

——————— 1941. Chemical analyses of bottom deposits of Wisconsin lakes. II. Second report. *Ibid.* 33: 99-114.

Juday, C., Blair, J. Morris, and Wilda, E. F. 1943. The photosynthetic activities of the aquatic plants of Little John Lake, Vilas County, Wisconsin. Amer. Midland Nat. 30: 426-446.

Juday, C., Fred, E. B., and Wilson, F. C. 1924. The hydrogen ion concentration of certain Wisconsin lake waters. Trans. Amer. Micros. Soc. 43: 177-190.

Juday, C., Livingston, Clarence, and Pedracine, Hubert. 1938. A census of the fish caught by anglers in Lake Waubesa in 1937. Mimeographed report, 7 pp. January.

Juday, C., and Meloche, V. W. 1944. Physical and chemical evidence relating to the lake basin seal in certain areas of the Trout Lake region of Wisconsin. Trans. Wisconsin Acad. Sci. 35: 157-174.

Juday, C., and Muttkowski, R. 1915. Entomostraca of St. Paul Island, Alaska. Bull. Wis. Nat. Hist. Soc. 13: 23-31.

Juday, C., Rich, W. H., Kemmerer, G. I., and Mann, A. 1932. Limnological studies of Karluk Lake, Alaska, 1926-1930. Bull. U. S. Bureau Fisheries 47: 407-436.

Juday, C., and Schloemer, C. L. 1936. Growth of game fish in Wisconsin waters. Fourth report. Mimeographed form. 17 pp.

———————— 1938. Effect of fertilizers on plankton production and on fish growth in a Wisconsin lake. Prog. Fish Cult. 40: 24-27. August-September.

———————— 1938. Growth of game fish in Wisconsin waters. Fifth report. Limn. Lab. Wis. Geol. and Nat. Hist. Survey. 26 pp.

Juday, C., and Schneberger, E. 1930. Growth studies of game fish in Wisconsin waters. Mimeographed report. 7 pp.

———————— 1933. Growth studies of game fish in Wisconsin waters. Second report. Mimeographed report. 10 pp.

Juday, C., and Schomer, H. A. 1935. The utilization of solar radiation by algae at different depths in lakes. Biol. Bull. 69: 75-81.

Juday, C., and Vike, L. E. 1938. A census of the fish caught by anglers in Lake Kegonsa. Trans. Wisconsin Acad. Sci. 31: 527-532.

Juday, C., and Wagner, G. 1908. Dissolved oxygen as a factor in the distribution of fishes. *Ibid.* 16: 17-22.

Kemmerer, G. I., and Hallett, L. T. 1927. An improved method of organic microcombustion. Indust. and Eng. Chem. 19: 173-176.

———————— 1927. Improved micro-Kjeldahl ammonia distillation apparatus. *Ibid.* 19: 1295-1296.

———————— 1927. Micro determination of carbonate carbon. *Ibid.* 19: 1352-1354.

Kozminski, Zygmunt. 1937. The lake district of northeastern Wisconsin. Translated by J. A. Birkenmajer from an article in Polish in Wszechswiata (The Universe), No. 8.

———————— 1938. Amount and distribution of the chlorophyll in some lakes of northeastern Wisconsin. Trans. Wisconsin Acad. Sci. 31: 411-438.

———————— 1938. Ueber die Chlorophyllverteilung in einigen Seen von Nordost-Wisconsin (U.S.A.). Archiv. Hydrob. et Ichthyol. XI: 143-165.

Knudson, Harold W., Juday, C., and Meloche, V. W. 1940. Silicomolybdate method for silica. Indus. and Eng. Chem., Anal. Ed. 12: 270-273.

Knudson, Harold W., Meloche, V. W., and Juday, C. 1940. Colorimetric analysis of a two-component color system. *Ibid.* 12: 715-718.

Lapham, Increase A. 1872. Oconomowoc Lake, and other small lakes of Wisconsin, considered with reference to their capacity for fish-production. Trans. Wisconsin Acad. Sci. 3: 31-36.

Lehmann, Harriet. 1903. Variations in form and size of *Cyclops brevispinosus* Herrick and *Cyclops americanus* Marsh. *Ibid.* 14: 279-298.

Lohuis, D., Meloche, V. W., and Juday, C. 1938. Sodium and potassium content of Wisconsin lake waters and their residues. *Ibid.* 31: 285-304.

McKelvey, V. E. 1940. Beach sediments of Trout Lake, Wisconsin. Jour. Sedim. Petrol. 10: 65-77.

———————— 1941. The flotation of sand in nature. Amer. Jour. Sci. 239: 594-607. August.

Manning, W. M. 1938. Photosynthesis. Jour. Phys. Chem. 42 (6): 815-854.

———————— 1940. A method for obtaining continuous records of dissolved oxygen in lakes. Ecology 21: 509-512.

———————— 1943. Physical factors influencing the accuracy of the dropping mercury electrode in measurements of photochemical reaction rates. Trans. Wisconsin Acad. Sci. 35: 221-233.

Manning, W. M., and Juday, Richard E. 1941. The chlorophyll content and productivity of some lakes in northeastern Wisconsin. *Ibid.* 33: 363-394.

Manning, W. M., Juday, C., and Wolf, M. 1938. Photosynthesis in Chlorella. Quantum efficiency and rate measurements in sunlight. Jour. Amer. Chem. Soc. 60: 274-278. Notes and Reports No. 66.

———————— 1938. Photosynthesis of aquatic plants at different depths in Trout Lake, Wisconsin. Trans. Wisconsin Acad. Sci. 31: 377-410.

Marsh, C. D. 1891. Notes on the depth and temperature of Green Lake. *Ibid.* 8: 214-218.

———————— 1891. On the deep-water Crustacea of Green Lake. *Ibid.* 8: 211-213.

———————— 1892. On the Cyclopidae and Calanidae of central Wisconsin. *Ibid.* 9: 189-224.

———————— 1894. On the vertical distribution of pelagic Crustacea in Green Lake, Wisconsin. Amer. Nat. 28: 807-809.

———————— 1895. On two new species of Diaptomus. Trans. Wisconsin Acad. Sci. 10: 15-18.

———————— 1898. On the limnetic Crustacea of Green Lake. *Ibid.* 11: 179-224.

———————— 1899. Hydrographic map of Green Lake. Wis. Geol. Survey, Map No. 7.

———————— 1900. On some points in the structure of the larva of *Epischura lacustris* Forbes. Trans. Wisconsin Acad. Sci. 12: 544-548.

———————— 1901. The plankton of freshwater lakes. (Address of the retiring president.) *Ibid.* 13: 163-187.

———————— 1903. The plankton of Lake Winnebago and Green Lake. Wis. Geol. and Nat. Hist. Survey, Bull. 12, 94 pp.

———————— 1907. A revision of North American species of Diaptomus. Trans. Wisconsin Acad. Sci. 15: 381-516.

———————— 1910. A revision of the North American species of Cyclops. *Ibid.* 16: 1067-1134.

——————— 1914. Structural abnormalities in Copepoda. *Ibid.* 17: 195-196.

Marsh, Mrs. Florence W. (Mrs. C. D.) 1938. Professor C. Dwight Marsh and his investigation of lakes. *Ibid.* 31: 535-543.

Marshall, Ruth. 1903. Ten species of Arrenuri belonging to the subgenus Megalurus Thon. *Ibid.* 14: 145-172.

——————— 1914. Some new American water mites. *Ibid.* 17: 1300-1304.

——————— 1921. New American water mites of the genus Neumania. *Ibid.* 20: 205-213.

——————— 1929. The morphology and developmental stages of a new species of Piona. *Ibid.* 24: 401-404.

——————— 1930. The water mites of the Jordan Lake region. *Ibid.* 25: 245-253.

——————— 1931-1940. Preliminary list of the Hydracarina of Wisconsin. *Ibid.* 26: 311-319. (1931) Part II. *Ibid.* 27: 339-357. (1932) Part III. *Ibid.* 28: 37-60. (1933) Part IV. *Ibid.* 29: 273-296. (1935) Part V. *Ibid.* 30: 225-251. (1937) Part VI. *Ibid.* 32: 135-165. (1940).

Marshall, W. S. 1903. *Entocythere cambari* (nov. gen. et nov. sp.), a parasitic ostracod. *Ibid.* 14: 117-144.

——————— 1913. The development of the wings of a caddisfly, *Platyphylax designatus* Walk. Zeitsch. Wissenschaft. Zool. 105(4): 574-597.

——————— 1914. On the anatomy of the dragonfly, *Libellula quadrimaculata* Linne. Trans. Wisconsin Acad. Sci. 17: 755-790.

Marshall, W. S., and Gilbert, N. C. 1905. Notes on the food and parasites of some freshwater fishes from the lakes at Madison, Wisconsin. Report U. S. Bureau of Fisheries, 1904: 513-522.

——————— 1905. Three new trematodes found principally in black bass. Zoolog. Jahrb. Syst. 22: 477-488.

Marshall, W. S., and Severin, Henry. 1904. Some points in the anatomy of *Ranatra fusca* P. Beauv. Trans. Wisconsin Acad. Sci. 14: 487-508.

Mavor, J. W., and Feinberg, S. M. 1918. Lymphocystis vitrel, a new sporozoan from the pike-perch, *Stizostediom vitreum* Mitchill. *Ibid.* 19: 559-561.

Mavor, J. W., and Strasser, William. 1916. On a new myxosporidian, *Henneguya wisconsinensis*, n. sp., from the urinary bladder of the yellow perch, *Perca flavescens*. *Ibid.* 18: 676-682.

——————— 1918. Studies of Myxosporidia from the urinary bladders of Wisconsin fishes. *Ibid.* 19: 553-558.

Meloche, V. W., Leader, G., Safranski, L., and Juday, C. 1938. The silica and diatom content of Lake Mendota water. *Ibid.* 31: 363-376.

Meloche, V. W., and Lohuis, Delmont. 1938. Sodium and potassium in lake waters and lake water residues. *Ibid.* 31: 285-305.

Meloche, V. W., and Pingrey, Katherine. 1938. The estimation of magnesium in lake water residues. *Ibid.* 31: 277-283.

Meloche, V. W., and Setterquist, T. 1933. The determination of calcium in lake water and lake water residues. *Ibid.* 28: 291-296.

Merrill, Harriet Bell. 1893. The structure and affinities of *Bunops scutifrons* Birge. *Ibid.* 9: 319-342.

Miller, W. S. 1895. The anatomy of the heart of Cambarus. *Ibid.* 10: 327-338.

Morrison, J. P. E. 1929. A preliminary list of the mollusca of Dane County, Wisconsin. *Ibid.* 24: 405-425.

———— 1932. A report on the mollusca of the northeastern Wisconsin lake district. *Ibid.* 27: 359-396.

———— 1932. Studies on the life history of *Acella haldemani* ("Desh." Binney). *Ibid.* 27: 397-413.

Munro, Caroline Walker. 1921. A preliminary study of the digestive secretions of pickerel and perch. *Ibid.* 20: 269-273.

Muttkowski, R. A. 1918. The fauna of Lake Mendota. A qualitative and quantitative survey with special reference to the insects. *Ibid.* 19: 374-382.

Myers, F. J. 1930. The rotifer fauna of Wisconsin. V. The genera Euchlanis and Monommata. *Ibid.* 25: 353-413.

Neidhofer, James R. 1938. *Carteria tenosperma* Potts, a species of freshwater sponge new to Wisconsin. Trans. Amer. Micros. Soc. 57: 82-84.

———— 1940. The freshwater sponges of Wisconsin. Trans. Wisconsin Acad. Sci. 32: 177-197.

Nelson, Merlin M., and Hasler, A. D. 1942. The growth, food, distribution and relative abundance of the fishes of Lake Geneva, Wisconsin, in 1941. *Ibid.* 34: 137-148.

Nelson, T. C. 1915. *Rana palustris* in Wisconsin. Copeia 19: 13-14.

Noland, L. E. 1925. Factors influencing the distribution of freshwater ciliates. Ecology 6: 437-452.

———— 1925. A review of the genus Coleps with descriptions of two new species. Trans. Amer. Micros. Soc. 44: 3-12.

Noland, L. E., and Finley, H. E. 1931. Studies on the taxonomy of the genus Vorticella. *Ibid.* 50: 81-123.

O'Donnell, D. John. 1942. The fish population in three small lakes in northern Wisconsin. Trans. Amer. Fisheries Soc. 72: 187-196.

Olive, Edgar W. 1905. Notes on the occurrence of *Oscillatoria prolifica* (Greville) Gomont in the ice of Pine Lake, Waukesha County, Wisconsin. Trans. Wisconsin Acad. Sci. 15: 124-134.

Pearse, A. S. 1915. On the food of the small shore fishes in the waters near Madison, Wisconsin. Bull. Wis. Nat. Hist. Soc. 13: 7-22.

———— 1918. Food of the shore fishes of certain Wisconsin lakes. Bull. U. S. Bureau Fisheries 35: 245-292.

———— 1919. Habits of the black crappie in inland lakes of Wisconsin. Rept. U. S. Com. Fish. for 1918. Appendix 3: 5-16.

———— 1921. Distribution and food of the fishes of Green Lake, Wisconsin, in summer. Bull. U. S. Bureau Fisheries 37: 253-272.

———— 1921. Distribution and food of the fishes of three Wisconsin lakes in summer. Univ. of Wisconsin Studies No. 17.

———— 1921. Habits of the mudpuppy Necturus, an enemy of food fishes. Bur. Fish Economic Circ. No. 49, 8 pp.

———— 1923. The abundance and migration of turtles. Ecology 4: 24-28.

———— 1923. The growth of the painted turtle. Biol. Bull. 45: 145-148.

——————— 1924. Amount of food eaten by four species of freshwater fishes. Ecology 5: 254-258.

——————— 1924. Observations on parasitic worms from Wisconsin fishes. Trans. Wisconsin Acad. Sci. 21: 147-160.

——————— 1924. The parasites of lake fishes. *Ibid.* 21: 161-194.

——————— 1925. Chemical composition of certain freshwater fishes. Ecology 6: 7-16.

——————— 1934. Ecology of lake fishes. Ecol. Monog. 4: 475-480.

Pearse, A. S., and Achtenberg, Henrietta. 1920. Habits of yellow perch in Wisconsin lakes. Bull. U. S. Bureau Fisheries 36: 293-366.

Pennak, R. W. 1939. The microscopic fauna of the sandy beaches. In Problems in Lake Biology. Published by Amer. Assoc. Adv. Sci. Pub. No. 10: 94-106.

——————— 1940. Ecology of the microscopic metazoa inhabiting the sandy beaches of some Wisconsin lakes. Ecol. Monog. 10: 537-615.

Peterson, W. H., Fred E. B., and Domogalla, B. P. 1925. The occurrence of amino acids and other organic nitrogen compounds in lake waters. Jour. Biol. Chem. 63: 287-295.

Pietenpol, W. B. 1918. Selective absorption in the visible spectrum of Wisconsin lake waters. Trans. Wisconsin Acad. Sci. 19: 562-593.

Pope, T. E. B. 1938. Landlocked salmon in Wisconsin. *Ibid.* 31: 559-567.

Pope, T. E. B., and Dickinson, W. E. 1928. The amphibians and reptiles of Wisconsin. Public Museum of the City of Milwaukee. Bull. 8: 1-138.

Potzger, John E. 1942. Pollen spectra from four bogs on the Gillen Nature Reserve, along the Michigan-Wisconsin state line. Amer. Midland Nat. 28: 501-511.

——————— 1943. Pollen analysis of five bogs in Sawyer and Price Counties, Wisconsin. Butler Univ. Bot. Studies 6: 54-64.

Potzger, John E., and Keller, C. O. 1942. A pollen study of four bogs along the southern border of Vilas County, Wisconsin. Trans. Wisconsin Acad. Sci. 34: 149-166.

Potzger, John E., and Richards, Ruth R. 1942. Forest succession in the Trout Lake, Vilas County, Wisconsin area: a pollen study. Butler Univ. Bot. Studies 5: 179-189.

Potzger, John E., and Van Engel, Willard A. 1943. Study of the rooted aquatic vegetation of Weber Lake, Vilas County, Wisconsin. Trans. Wisconsin Acad. Sci. 34: 149-166.

Rickett, H. W. 1921. A quantitative study of the larger aquatic plants of Lake Mendota. *Ibid.* 20: 501-527.

——————— 1924. A quantitative study of the larger aquatic plants of Green Lake, Wisconsin. *Ibid.* 21: 381-414.

Robinson, Rex J., and Kemmerer, C. I. 1930. The determination of Kjeldahl nitrogen in natural waters. *Ibid.* 25: 123-128.

——————— 1930. Determination of organic phosphorus in lake waters. *Ibid.* 25: 117-121.

——————— 1930. Determination of silica mineral waters. *Ibid.* 25: 129-134.

Rodgers, Nelson E., and McCoy, Elizabeth. 1942. Some aspects of the microbiology of the beach sands of freshwater lakes. Ms.

Schloemer, Clarence L. 1936. The growth of the muskellunge *Esox masquinongy immaculatus* (Garrard) in various lakes and drainage areas of northern Wisconsin. Copeia 1936: 185-193.

——————— 1938. A second report on the growth of the muskellunge *Esox masquinongy immaculatus* (Garrard) in Wisconsin waters. Trans. Wisconsin Acad. Sci. 31: 507-512.

——————— 1939. The age and rate of growth of the bluegill, *Helioperca macrochira* (Rafinesque). Manuscript Ph.D. Thesis. 113 pp. Library, Univ. of Wisconsin.

Schloemer, Clarence L., and Lorch, Ralph. 1942. The rate of growth of the wall-eyed pike, *Stizostedion vitreum* (Mitchill), in Wisconsin's inland waters, with special reference to the growth characteristics of the Trout Lake population. Copeia 1942: 201-211.

Schnabel, Zoe Emily (Mrs. G. E. Albert). 1938. Estimation of total fish population of a lake. Amer. Math. Monthly 45: 348-352.

Schneberger, E. 1931. How old was that big fish you caught up in northern Wisconsin this summer? Wisconsin Magazine. July-August 1931: 3-4 and 22-23.

——————— 1933. Scales tell age of fishes, Wisconsin survey reveals. Our Own Out-of-Doors 2: 4-5 and 13-15. June.

——————— 1935. Growth of the yellow perch in Nebish, Silver and Weber Lakes. Trans. Wisconsin Acad. Sci. 29: 103-130.

——————— 1936. The biological and economic importance of the smelt in Green Bay. Trans. Amer. Fisheries Soc. 66: 139-142.

——————— 1937. Natural production of muskellunge. Wis. Cons. Dept. Report. 17 pp. Mimeographed.

——————— 1939. Does ice fishing aerate the water? Wis. Cons. Bull. 4: 33-35.

Schneberger, Edw., and Hasler, A. D. 1944. Brule River survey: Introduction. Trans. Wisconsin Acad. Sci. 36 (in press).

Schomer, Harold A. 1934. Photosynthesis of water plants at various depths in the lakes of northeastern Wisconsin. Ecology 15: 217-218.

Schomer, H. A., and Juday, C. 1935. Photosynthesis of algae at different depths in some lakes of northeastern Wisconsin. I. Observations in 1933 Trans. Wisconsin Acad. Sci. 29: 173-193.

Schuette, H. A. 1918. A biochemical study of the plankton of Lake Mendota. *Ibid.* 19: 594-613.

Schuette, H. A., and Alder, H. 1927. Notes on the chemical composition of some of the larger aquatic plants of Lake Mendota. Vallisneria and Potamogeton. *Ibid.* 23: 249-254.

——————— 1929. A note on the chemical composition of Chara from Green Lake, Wisconsin. *Ibid.* 24: 141-145.

——————— 1929. Notes on the chemical composition of some of the larger aquatic plants of Lake Mendota. III. *Castalia odorata* and *Najas flexilis*. *Ibid.* 24: 135-139.

Schuette, H. A., and Hoffman, Alice. 1922. Notes on the chemical composition of some of the larger aquatic plants of Lake Mendota. I. Cladophora and Myriophyllum. *Ibid.* 20: 529-531.

Shelford, V. E., and Kunz, J. 1926. The use of photoelectric cells of different alkali metals and color screens in the measurement of light penetration into water. *Ibid.* 22: 283-298.

Smith, B. C. 1911. The nests and larvae of Necturus. Biol. Bull. 20: 191-200.

Smith, C. M. 1913. Tetradesmus, a new four-celled coenobic alga. Torrey Botan. Club 40: 75-87.

——————— 1914. The organization of the colony in certain four-celled coenobic algae. Trans. Wisconsin Acad. Sci. 17: 1165-1220.

——————— 1916. A monograph of the algal genus Scenedesmus based upon pure culture studies. *Ibid.* 18: 422-530.

——————— 1916. New or interesting algae from the lakes of Wisconsin. Torrey Botan. Club 43: 471-483.

——————— 1916. A preliminary list of algae found in Wisconsin lakes. Trans. Wisconsin Acad. Sci. 18: 531-565.

——————— 1917. The vertical distribution of Volvox in the plankton of Lake Monona. Amer. Jour. Bot. 5: 178-185.

——————— 1918. A second list of algae found in Wisconsin lakes. Trans. Wisconsin Acad. Sci. 19: 614-654.

——————— 1920. Phytoplankton of the inland lakes of Wisconsin. Part I. Myxophyceae, Phaeophyceae, Heteronkonteae, and Chlorophyceae exclusive of the Desmidiaceae. Bull. No. 57, Wis. Geol. and Nat. Hist. Survey. 243 pp. 51 pls.

——————— 1924. Phytoplankton of the inland lakes of Wisconsin. Part II. Desmidiaceae. Bull. Part II. Wis. Geol. and Nat. Hist. Survey. 227 pp. Pls. 52-88. Also Bull. No. 1270, Univ. of Wisconsin.

Smith, Winslow Whitney. 1940. Production of anti-bacterial agglutinins by carp and trout at 10° C. Proc. Soc. Exptl. Biol. Med. 45: 726-729.

Snow, Letitia M., and Fred, E. B. 1926. Some characteristics of the bacteria of Lake Mendota. Trans. Wisconsin Acad. Sci. 22: 143-154.

Spoor, W. A. 1935. On the sexual dimorphism of *Catostomus commersonii.* Copeia 1935: 167-171.

——————— 1938. Age and growth of the sucker, *Catostomus commersonii* (Lacepede), in Muskellunge Lake, Vilas County, Wisconsin. Trans. Wisconsin Acad. Sci. 31: 457-505.

Spoor, William A., and Schloemer, C. L. 1939. Diurnal activity of the common sucker, *Catostomus commersonii,* and rock bass, *Ambloplites rupestris,* in Muskellunge Lake. Trans. Amer. Fisheries Soc. 68: 211-220.

Stadler, Janice, and ZoBell, C. E. 1939. Evidence of the aerobic decomposition of lignin by lake bacteria. Jour. Bact. 38: 115. Abstract.

Stark, W. H., and McCoy, Elizabeth. 1938. Distribution of bacteria in certain lakes of northern Wisconsin. Centralbl. f. Bakt., Parasitenk. u. Infektionskrank. 98: 201-209.

Steiner, John, and Meloche, V. 1935. A study of ligneous substances in lacustrine materials. Trans. Wisconsin Acad. Sci. 29: 389-402.

Symposium on Hydrobiology. 1941. Published by University of Wisconsin Press. Contains papers relating to various fields of hydrobiology. 405 pp.

Taylor, F. H. L. 1928. A complete systematical analysis of lake water residues by a new micro method. Unpublished thesis. 1928. 57 pp. Library, Univ. of Wisconsin.

Thomson, John W., Jr. 1940. Preliminary reports on the flora of Wisconsin. XXVII. Lentibulariaceae. Trans. Wisconsin Acad. Sci. 32: 85-89.

Thwaites, F. T. 1929. Glacial geology of part of Vilas County, Wisconsin. *Ibid.* 24: 109-125.

Titus, Leslie, and Meloche, V. W. 1931. Note on the determination of total phosphorus in lake water residues. *Ibid.* 26: 441-444.

———————— 1933. A microextractor. Indus. and Eng. Chem. 5: 286-291.

Trelease, William. 1889. The "working" of Madison lakes. Trans. Wisconsin Acad. Sci. 7: 121-129.

Tressler, W. L., and Domogalla, B. P. 1931. Limnological studies of Lake Wingra. *Ibid.* 26: 331-351.

Turner, C. L. 1919. The seasonal cycle in the spermary of the perch. Jour. Morphol. 32: 681-705.

Twenhofel, W. H. 1933. The physical and chemical characteristics of the sediments of Lake Mendota, a freshwater lake of Wisconsin. Jour. Sedim. Petrol. 3: 68-76.

———————— 1937. The bottom sediments of Lake Monona, a freshwater lake of southern Wisconsin. *Ibid.* 7: 67-77.

Twenhofel, W. H., and Broughton, W. A. 1939. The sediments of Crystal Lake, an oligotrophic lake in Vilas County, Wisconsin. Amer. Jour. Sci. 237: 231-252.

Twenhofel, W. H., Carter, S. L., and McKelvey, V. E. 1942. The sediments of Grassy Lake, Vilas County, a large bog lake of northern Wisconsin. *Ibid.* 240: 529-546.

Twenhofel, W. H., and McKelvey, V. E. 1939. Sediments of Devils Lake, a eutrophic-oligotrophic lake of southern Wisconsin. Jour. Sedim. Petrol. 9(3): 105-121. December.

———————— 1941. The sediments of freshwater lakes. Bull. Amer. Assoc. Petrol. Geol. 25: 826-849.

———————— 1942. The sediments of Little Long (Hiawatha) Lake, Wisconsin. Jour. Sedim. Petrol. 12: 36-50.

Twenhofel, W. H., McKelvey, V. E., Carter, S. A., and Nelson, Henry. 1944. The sediments of four woodland lakes, Vilas County, Wisconsin. Parts I and II. Amer. Jour. Sci. 242: 19-44.

Van Engel, W. A. 1940. The rate of growth of the northern pike, *Esox lucius* Lin., in Wisconsin waters. Copeia 1940: 177-187.

Vorhies, C. T. 1905. Habits and anatomy of the larva of the caddisfly, *Platyphylax designatus*, Walker. Trans. Wisconsin Acad. Sci. 15: 108-123.

———————— 1909. Studies on the Trichoptera of Wisconsin. *Ibid.* 16: 647-738.

Wagner, George. 1904. Notes on Polyodon I. Science, N.S. 19: 554-555.

———————— 1908. The tullibee (*Argyrosomus tullibee* Richardson) as a fish of economic importance. Bienn. Rept. Com. of Fisheries Wis. 1907/08, pp. 152-155.

——————— 1909. Notes on the fish fauna of Lake Pepin. Trans. Wisconsin Acad. Sci. 16: 23-37.

——————— 1910. *Argyrosomus johannae*, a new species of Cisco from Lake Michigan. Science, N.S. 31: 957-958.

——————— 1910. On the stickleback of Lake Superior. *Ibid.* 32: 28-30.

——————— 1911. The cisco of Green Lake, Wisconsin. Bull. Wis. Nat. Hist. Soc. 9: 73-77.

Wagner, George, and Juday, C. 1908. Dissolved oxygen as a factor in the distribution of fishes. Trans. Wisconsin Acad. Sci. 16: 17-22.

Whitney, L. V. 1937. Microstratification of the waters of inland lakes in summer. Science, N.S. 85: 224-225. Feb. 26.

——————— 1938. Microstratification of inland lakes. Trans. Wisconsin Acad. Sci. 31: 155-173.

——————— 1938a. Continuous solar radiation measurements in Wisconsin lakes. *Ibid.* 31: 175-200.

——————— 1938b. Transmission of solar energy and the scattering produced by suspensoids in lake waters. *Ibid.* 31: 201-221.

——————— 1941. A multiple electromagnetic water sampler. *Ibid.* 33: 95-97.

——————— 1941a. The general law of diminution of light intensity and the per cent of diffuse light at different depths in lake waters. Jour. Optic. Soc. Amer. (In press.)

——————— 1941b. The angular distribution of characteristic diffuse light in natural waters. Jour. Mar. Res. 4: 122-131.

Williams, F. T., and McCoy, Elizabeth. 1934. The role of microorganisms in the precipitation of calcium carbonate in the deposits of freshwater lakes. Jour. Sedim. Petrol. 4: 113-126.

——————— 1935. The microflora of the mud deposits of Lake Mendota. *Ibid.* 5: 31-36.

Williamson, Lyman O., and Schneberger, Edward. 1942. The results of planting legal-sized trout in the Deerskin River, Vilas County, Wisconsin. Trans. Amer. Fisheries Soc. 72: 92-96.

Wilson, L. R. 1935. Lake development and plant succession in Vilas County, Wisconsin. Part I. The medium hard water lakes. Ecol. Monog. 5: 207-247.

——————— 1937. A quantitative and ecological study of the larger aquatic plants of Sweeney Lake, Oneida County, Wisconsin. Bull. Torrey Botan. Club 64: 199-208.

——————— 1938. The postglacial history of vegetation in northern Wisconsin. Rhodora 40: 137-175. April.

——————— 1939. Rooted aquatic plants and their relation to the limnology of freshwater lakes. Problems in lake biology. Publ. by Amer. Assoc. Adv. Sci. Pub. No. 10: 107-122.

——————— 1939. A temperature study of a Wisconsin peat bog. Ecology 20: 432-433. July.

——————— 1941. The larger aquatic vegetation of Trout Lake, Vilas County, Wisconsin. Trans. Wisconsin Acad. Sci. 33: 135-146.

Wilson, L. R., and Cross, A. T. 1941. A study of the microfossil succession in the bottom deposits of Crystal Lake, Vilas County, Wisconsin, and the peat of a nearby bog. (In press.)

Wilson, L. R., and Galloway, E. F. 1937. Microfossil succession in a bog in northern Wisconsin. Ecology 18: 113-118.

Wilson, L. R., and Webster, R. M. 1942. Fossil evidence of a wider postglacial range of hickory and butternut in Wisconsin. Rhodora 44: 409-414.

——————— 1942. Microfossil studies of three north central Wisconsin bogs. Trans. Wisconsin Acad. Sci. 34: 177-193.

Wimmer, E. J. 1929. A study of two limestone quarry pools. *Ibid.* 24: 363-399.

Woltereck, R. 1932. Races, associations and stratification of pelagic daphnids in some lakes of Wisconsin and other regions of the United States and Canada. *Ibid.* 27: 487-520.

Woodbury, Lowell A. 1941. A sudden mortality of fishes accompanying a supersaturation of oxygen in Lake Waubesa, Wisconsin. Trans. Amer. Fisheries Soc. 71: 112-117.

——————— 1942. Vitamin B_1 deficiency in hatchery reared rainbow trout. *Ibid.* 72: 30-34.

Wright, Stillman. 1929. A preliminary report on the growth of the rock bass, *Ambloplites rupestris* (Rafinesque), in two lakes of northern Wisconsin. Trans. Wisconsin Acad. Sci. 24: 581-595. Figs.

ZoBell, C. E. 1940. Some factors which influence oxygen consumption by bacteria in lake water. Biol. Bull. 78: 388-402.

ZoBell, C. E., and Stadler, Janice. 1940a. The effect of oxygen tension on the oxygen uptake of lake bacteria. Jour. Bact. 39: 307-322.

——————— 1940b. The oxidation of lignin by lake bacteria. Arch. f. Hydrobiol. 37: 163-171.

ADDENDA

Bangham, Ralph V. 1944. Parasites of northern Wisconsin fish. Trans. Wisconsin Acad. Sci. 36: (In press).

Birge, Edward A. 1945. The effect of dissolved color on the vertical transmission of light in filtrates of lake waters. Trans. Wisconsin Acad. Sci. 36: (In press).

Cole, Arch E. 1921. Oxygen supply of certain animals living in water containing no dissolved oxygen. Jour. Exptl. Zool. 33(1): 293-320.

Colmer, Arthur Russell, and McCoy, Elizabeth. The genus Micromonospora in relation to some Wisconsin lakes. Trans. Wisconsin Acad. Sci. 35: 187-220.

Field, John B., Herman, Elmer F., Elvehjem, C. A., and Schneberger, Edward. 1944. Note on a controlled feeding technique in nutrition studies in trout. Copeia: (In press.)

Jansky, Mary A. 1936. The characterization of some bacteria from northern Wisconsin lakes with emphasis on the chromogens. Ms. M.S. Thesis. 32 pp. Library, University of Wisconsin.

Kinkel, Dorothy E. 1936. A study of chitin-, pectin-, and cellulose-destroying bacteria from lake mud. Ms. M.S. Thesis. 34 pp. Library, University of Wisconsin.

Prescott, G. W. 1944. New species and varieties of Wisconsin algae. Farlowia. 1(3): 349-385.

Schneberger, Edward, and Woodbury, Lowell A. 1944. The lake sturgeon, *Acipenser fulvescens* Rafinesque, in Lake Winnebago, Wisconsin. Creel census, age, length, and weight. Trans. Wisconsin Acad. Sci. 36: (In press).

Stark, William H. 1939. Part I. Factors influencing the bacterial populations of freshwater lakes. Ms. Ph.D. Thesis. 18 pp. Library, University of Wisconsin.

tors. II. Centers of activity in lakes. Ms. M.S. Thesis. 62 pp. Library,
Stark, William H. 1937. Growth of freshwater bacteria. I. Controlling fac-
University of Wisconsin.

Wolf, F. T. 1944. The aquatic oomycetes of Wisconsin. Part I. Univ. Wis. Press. 64 pp.

PROCEEDINGS OF THE ACADEMY

SEVENTY-FOURTH ANNUAL MEETING

The seventy-fourth annual meeting of the Academy was held in Memorial Union at the University of Wisconsin, Madison, Wisconsin, on Friday and Saturday, April 14 and 15, 1944. Three other organizations participated jointly in the meeting,—the Wisconsin Archeological Society, Wisconsin Museums Conference, and the Wisconsin Folklore Society. The Academy section met in Room 119, Science Hall, while the other sections held meetings in the Reception Room, University Memorial Union. Approximately 100 persons attended the various meetings. The annual business meeting and election of officers was held on Friday afternoon. The following program of papers was presented.

ARCHEOLOGICAL, FOLKLORE, AND MUSEUMS SECTION

Friday morning

Esther Hemingway, Madison, Museum Exhibits; Nancy Oestreich, Milwaukee, Wampum; G. Wm. Longenecker, Madison, The University of Wisconsin Arboretum; Edna McChesney Bullard, Madison, The Powder Room at Eden Dale; George Urdang, Madison, The Story of Cinchona; Vivien J. Dube, Superior, Early Water Craft of the Head of the Lakes; Dorothy Moulding Brown, Madison, Americana; P. E. McNall, Madison, Tall Tales of Kansas; J. F. Wojta, Madison, German Household Admonitions; L. P. Jerrard, Winnetka, Illinois, Three Marquette County Indian Mound Groups; Jean Gordon Smith, Madison, Nature Study at the Wisconsin Orthopedic Hospital; Mrs. Peter Diedrich, Lake Mills, Activities of the Lake Mills-Aztalan Historical Society; Olive Jacobs, Hudson, St. Croix River Legends; Victor S. Taylor, Lake Mills, Graveyard Tales from the Jefferson County area.

ACADEMY SECTION

Friday afternoon

H. P. Thomsen, University of Wisconsin (Introduced by Arthur D. Hasler), Territories of the Red Winged Blackbird of the University Bay Region; Elizabeth Jones, University of Wisconsin (Introduced by Arthur D. Hasler), Aquatic Plants in Winter; Benson H. Paul, Forest Products Laboratory (Introduced by Arthur Koehler), Second Growth May Supply Timber of Exceptional Quality; H. P. Thomsen, University of Wisconsin, The Social Behavior of the Whitefooted Mouse in Winter; Aldo Leopold, Ernest F. Bean, and Norman C. Fassett, University of Wisconsin, Report of the Conservation Committee of the Academy; Michael F. Guyer, University of Wisconsin, Memorial to Chancey

Juday, Past President and Life Member of the Academy; Clayton S. Moses, Forest Products Laboratory (Introduced by C. Audrey Richards), Oak Wilt in Wisconsin; Eric Miller, University of Wisconsin, Snow Cover in Wisconsin; Ruth Marshall, Wisconsin Dells, Wisconsin, A Revision of Part I, Preliminary List of the Hydracarina of Wisconsin (By Title).

ARCHEOLOGICAL, FOLKLORE, AND MUSEUMS SECTION

Friday afternoon

Zida C. Ivey, Fort Atkinson, The Preservation of the Hoard Mounds; Dorothy J. Kundert, Monroe, Green County Folktales; Harvey Leaman, Neenah, The Grand Loggery; J. S. Slotkin, Madison, The Earliest Racial Classifications of the 17th and 18th Centuries; Allie Freeman, Horicon, Dodge County Territorial Post Offices; Helene Stratman-Thomas, Madison, Kentucky Folksongs in Wisconsin; Mrs. Merton Smith, Beloit, The Beloit Historical Museum; Mrs. Ethel Stauffacher, New Glarus, The New Glarus Museum Project; W. C. English, Wyocena, Wisconsin Cave Museums; George Overton, Butte des Morts, The Poygan Playground; Herbert W. Kuhm, Milwaukee, Indian Decorative Uses of Shell.

ACADEMY SECTION

Saturday morning

Edward A. Birge, University of Wisconsin, Changes in the Transmission of Light Through Filtered Lake Waters, Produced by the Presence of Dissolved Color Material; C. L. Fluke, University of Wisconsin and F. M. Hull, University of Wisconsin, A Review of the Syrphid Flies of the Genus Cheilosia, subgenus Chilomyia; Banner Bill Morgan, University of Wisconsin, Bovine Trichomoniasis in Wisconsin; Frederick L. Browne, Forest Products Laboratory, When and Why We Paint Houses; Elizabeth McCoy and Wayne W. Umbreit, University of Wisconsin, The Bacteriological Problems in the Retting of Hemp; Kenneth P. Buchholtz, University of Wisconsin (Introduced by R. J. Muckenhirn), Agronomic and Breeding Investigations on Hemp; Harland W. Mossman, University of Wisconsin, Observations on the Breeding of Wisconsin Squirrels; John P. Limbach, Forest Products Laboratory (Introduced by Louise Gerry), An Inexpensive Exposure Meter for Photomicrography (Demonstration); H. A. Schuette and F. J. Schubert, University of Wisconsin, Hydrogen Ion Concentration of Honey; Arthur D. Hasler, University of Wisconsin, Depth Distribution in Winter of the Perch in Lake Mendota; Myles Dillon, University of Wisconsin, Italic and Celtic; Carroll V. Sweet, Forest Products Laboratory, Gasogens; Dr. W. D. Stovall, University of Wisconsin, Blood Groups and Hemolytic Reactions Following Blood Transfusions; K. C. Berger and E. Truog, University of Wisconsin, Boron Deficiency in Beets as Revealed by Yields and Soil Tests; H. C. Greene, University of Wisconsin, Fungi of the University of Wisconsin Arboretum; R. I. Evans, University of Wisconsin, L. S. Cheney's "Mosses of Wisconsin" (By Title).

ARCHEOLOGICAL, FOLKLORE, AND MUSEUMS SECTION

Saturday morning

Ella Stratton Colbo, Racine, Harriet Stewart Hartington, Civil War Nurse; Frederic G. Cassidy, Madison, The Names of the Madison Four Lakes; Earl Seidlinger, Columbus, The Florida Mosquitos, Service Tall Tales; Albert O. Barton, Madison, A Pioneer Scotch Cooperative in Dane County; Ted Mueller, Milwaukee, Some Old Milwaukee Folktales; J. Stanley Dietz, Madison, Civil War Songs; Charles E. Brown, Madison, Wisconsin Indian Trailside Shrines; Louis A. Maier, Milwaukee, Mystic Knights of the Blue Ox; Warren Wittry, Robert Linck and Robert Hall, Green Bay, Discovery of an Indian Rockshelter in Brown County.

ANNUAL ACADEMY LECTURE

The annual Academy dinner was held on Friday evening, April 14, in Room 119, Science Hall. Two addresses were made. President A. W. Schorger of Madison presented his presidential talk, the title of which was "The Abundant Life." Professor Leon J. Cole of the University gave an illustrated talk on "Life of the Fur Seals of the Pribilof Islands."

ACADEMY BUSINESS MEETING

The annual business meeting was held in Science Hall on Friday afternoon, April 14, 1944.

Committee on nominations: R. J. Muckenhirn, E. F. Bean, Philo Buck, Jr. and H. W. Mossman presents the following slate of officers for the next Academy year:

President: H. A. Schuette, University of Wisconsin, Madison.
Vice Presidents:
- In Science—Ruth Walker, Milwaukee.
- In Arts—Walter Bubbert, Milwaukee
- In Letters—Helen White, University of Wisconsin, Madison.

Secretary-Treasurer: Banner Bill Morgan, University of Wisconsin, Madison.
Librarian: Halvor O. Teisberg, State Historical Society, Madison.
Curator: Edward P. Alexander, State Historical Society, Madison.

TREASURER'S REPORT

April 12, 1944

RECEIPTS

Carried forward in Treasury, April 20, 1943	$2,462.01
Receipts from dues, April 20, 1943-April 12, 1944	651.23
Final distribution by Trustees for liquidation of Chapman Building Company Certificates owned by Academy	382.20
Sale of publications	219.76
Sale of reprints to authors	180.57
Interest on endowment	89.00
Grant-in-Aid for research from A.A.A.S.	81.50
Extra printing costs paid by authors	34.75
Total receipts	$4,101.02

DISBURSEMENTS

Purchase of U. S. Savings Bonds, Series G	$1,600.00
Deposit on expenses for cuts for Vol. 35	100.00
Allowance to Secretary-Treasurer Loyal Durand for last one-half of 1942-43 Academy year	100.00
During the Academy year, 1936-1937, only $100 of his $200 annual allowance was withdrawn by the Secretary-Treasurer. Payment of the remaining $100 was deferred each year thereafter; such deferment is discontinued in the present year with the result that a total of $300 rather than the $200 provided for in the By-Laws is paid as Secretary-Treasurer's allowance for the 1943-1944 Academy year.	
Allowance to Secretary-Treasurer (¾ to Loyal Durand, ¼ to R. J. Muckenhirn) for 1943-44 Academy year	200.00
Grant-in-Aid for research to Harold C. Hanson	81.50
Stamps, envelopes, and express charges	32.02
Printing programs for 1943 and 1944 meetings	35.75
Ledger sheets, rubber stamp, and record book	3.85
Rental, safe deposit box	3.60
Total disbursements	$2,156.72

BALANCE, April 12, 1944, $1,944.30.

A check for $2.00 received from a Canadian bank is not credited by the bank as of April 12, 1944, pending collection and determination of discount and exchange charges.

R. J. MUCKENHIRN
Acting Secretary-Treasurer
BANNER BILL MORGAN
Secretary-Treasurer

Endowments and Assets of the Wisconsin Academy of Sciences, Arts and Letters

March 17, 1944

1.	Home Owners Loan Coupon Bond Series A—AM383877H	$1,000.00
2.	Home Owners Loan Coupon Bond Series A—AR163667H	50.00
3.	U.S. Treasury-Coupon Bond 1692B	1,000.00
4.	U.S. Treasury-Coupon Bond 12894D	500.00
5.	U.S. Savings Bond Registered Series G-M1696059G	1,000.00
6.	U.S. Savings Bond Registered Series G-C1563347G	100.00
7.	U.S. Savings Bond Registered Series G-C1563348G	100.00
	Total Amount of Endowment	3,750.00
8.	U.S. Savings Bond Registered Series G-2386504G	100.00
9.	U.S. Savings Bond Registered Series G-2386505G	100.00
10.	U.S. Savings Bond Registered Series G-2386506G	100.00
11.	U.S. Savings Bond Registered Series G-2386507G	100.00
	Current Assets of Academy Invested in U.S. Bonds	400.00
	Total	$4,150.00

The auditing committee has examined the accounts of the Treasurer and the contents of the safe deposit box belonging to the Academy and has found them in order.

H. A. Schuette (signed)
Raymond J. Roark (signed)