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ADOLPH A. SUPPAN

48th President of the

WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

THE CREATIVE TEMPER IN A COMPUTERIZED SOCIETY*

Adolph A. Suppan

I

I begin this talk with a short poem. I ask all of you to reserve your aesthetic judgment until I reveal the author.

Darling sweetheart
You are my avid fellow feeling
My affection curiously clings to your
    passionate wish.
My liking yearns for your heart.
    You are my wistful sympathy,
    My tender liking.
Yours beautifully,
                    M.U.C.[1]

You will notice that the initials of the author are M.U.C. I am certain everyone realizes that the quality of the writing is somewhat below the standard of Shakespeare, Keats or T. S. Eliot; that is, of course, because M.U.C. is a beginner, and it may be some time before he rates a "B" in creative writing.

M.U.C. is the Manchester University Computer, and I let him introduce this talk to show that in an age of technology, in a society already dominated by the computer, its tentacles reach everywhere.

We are all personally aware of the prevalence of the computer; it is programmed for everything from manufacturing automobiles to finding ideal mates for single people. Hospitals employ computers to analyze a patient's ailment, count his blood cells, and compare his symptoms with the size of his bank account. Department stores use them not only in their business offices (for inventories, purchasing, billing) but to regulate escalators and revolving doors. Schools use data-processing systems to enroll their students, grade their examinations, and decide how much to sock (hit) them for in the alumni gift campaign.[2] An aircraft factory, wanting to know the equation concerning the distance a plane could fly on a given

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* Address of the retiring President, delivered at the 99th annual meeting of the Academy, May 3, 1969.

[1] Quoted in A. J. Parisi, "The kinetic movement: technology paces the arts," *Product Engineering,* Dec. 2, 1968, p. 34.

[2] Corey Ford, "A Guide to Thinking," *Think,* Jan. 1961, p. 12.

amount of fuel, with a certain type of wing, had the answer in seven minutes. A man with an old-fashioned desk calculator would have taken seven years; pencil and paper calculation would have taken six generations. In what we call our ordinary lives, computers provide everything from bank balances to ticket reservations to personal horoscopes.[3]

The computer does have its flaws and its disadvantages. Recently, translating a Russian proverb, "Time flies like an arrow," a computer came out with "Time flies enjoys eating arrows."[4] More seriously, some authorities wonder if programmed learning might not affect man's reasoning process to the extent that he might accept ideas without studying or questioning them; some scientists also worry that constant graphic presentation might alter the ability to conceptualize.[5] Others fear that the computer will enable governments to exert almost continuous surveillance over every citizen.[6]

II

These are some phases of the overall thrust of the computer in our lives; I come now to the main theme of my talk today—the influence of a technological age and the computer upon the creative artist in our society.

It is, of course, to be expected that artists react individually and differently to massive developments and events. It is also natural that the reaction can be both benevolent and malevolent. Certainly many painters, sculptors, composers, playwrights, and choreographers show by their works that they have been influenced by the technological thrust of our society. A reputable music critic, Frederic Grunfeld, has judged Europe's most successful piece of avant-garde music to be Rolf Liebermann's *Lés Echanges,* an automated symphony for business machines, which proved to be the major attraction of a trade exhibit at the Swiss National Exposition in Lausanne. Liebermann, known in the United States for his *Concerto fcr Jazz Band and Symphony Orchestra,* has scored this percussive composition:

> . . . for 156 office machines and mechanical devices, including typewriters, adding machines, cash registers, perforators, tape-moisteners, telephones and what-have-you, led by a computer with a mambo beat. The whole thing takes less than three minutes, but it points the way to a solution of all those problems with temperamental prima donnas and dictators of the baton.[7]

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3 John Lear, "Can a Mechanical Brain Replace *You?," Collier's,* Apr. 4, 1953, p. 62.
4 Dr. Warren S. McCullock, quoted in *New York Times,* Apr. 24, 1966.
5 "Obsolescence for the Printed Word," *Think,* Jan.-Feb., 1969, Vol. 34, No. 7, p. 19.
6 Zbigniew Brzezinski, quoted in Arthur P. Mendel, "Robots and Rebels," *The New Republic,* Jan. 11, 1969, p. 16.
7 Frederic Grunfeld, *Hi Fi/Stereo-Review,* Dec., 1964.

Two years ago in New York, more than forty artists and engineers produced nine evenings of kinetic art which they titled "Theatre and Engineering."[8] In Los Angeles recently, the County Museum of Art announced a project to "mate" art and industry, involving thirty-one companies and twelve artists at work in five plants.[9] Leading artists-in-residence will stay at the company plants for twelve weeks. Larry Bell, one of the artist-constructionists involved, is "group-thinking" with staff members of the Rand Corporation. He says:

> . . . we're discussing light, color perception, architecture, what art really is. We've found out that artists and corporations and technologies can co-exist and make each other's lives productive.[10]

A recent exhibition in New York's Whitney Museum of Modern Art was filled with objects that simply would not leave the viewer alone. According to a review in the *Milwaukee Journal,* all of them were electronic, all of them glowed, and some of them did even more than that: they growled, spun, flashed and hummed; they didn't just sit there, they performed. The review went on:

> The theatricality of the exhibition hits the viewer from the start. The show is called "Light: Object and Image," and it is installed entirely in the dark. The darkness sets the mood, as one steps into those darkened galleries, as the light goes dim and the catalog becomes unreadable, one waits with fascinated expectation for the performance to begin. Mysterious machinery bleeps and hums. Magical surprises have been promised. The intangible aura of show biz is in the air.[11]

The highly-respected American painter, Robert Rauschenberg, has created a "theatre piece" which begins with an authentic tennis game with rackets wired for transmission of sound. The sounds of balls hitting rackets control the lights. During the game, the sounds turn out the lights one by one. At the game's end, the hall is totally dark. But the darkness is illusory; the hall is actually flooded with infrared light invisible to the human eye. A modestly choreographed cast of from 300 to 500 persons enters to be observed and projected by infrared television onto the screens.[12] Another artist is producing computer drawings based on mathematical equations and using a light source or cathode-ray tube.[13]

One might suggest that the artists who are "collaborating" with the computer might have some reason to fear its ultimate victory

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[8] "Single Channeled You Mustn't Be," *New York Times,* Feb. 5, 1967.

[9] Grace Glueck, "Coast Art—Industry Project Blossoms," *New York Times,* Apr. 17, 1969, p. 54.

[10] Larry Bell quoted in *Ibid.*

[11] Paul Richard of *Washington Post,* in "Light Show Flashes in New York," *Milwaukee Journal,* Aug. 25, 1968, Part 5, p. 6.

[12] Richard Kostelanetz, "The Artist as Playwright and Engineer," *New York Times Magazine,* Oct. 9, 1966, p. 22.

[13] A. J. Parisi, *op. cit.,* p. 36.

over them. A. M. Noll tells of an ingenious experiment which, to all intents and purposes, revealed that the computer could possibly out-create the creative artist. He (Noll) gave 100 people an original Mondrian drawing and a drawing made by a computer in Mondrian's style. He asked them to judge which drawing was artistically superior, and which was produced by a machine.

> Of all those asked, only 28 per cent correctly identified the computer picture and 59 per cent preferred it to the Mondrian . . . People who said they liked modern art preferred the computer-drawn picture, three to one.[14]

Noll comments: "I don't know whether this is overestimating the computer's artistic ability or underestimating Mondrian's."[15]

Some artists, however, are not too fearful. John R. Pierce says that:

> . . . it isn't too early for artists and programmers to study man and his arts on the one hand, and the computer and its potentialities on the other, hotly and realistically. We must decide whether men and machines should work gravely or wackily to produce works that are portentous or delicious. The choice is open, and I hope it won't be made too solemnly.[16]

The jarring question for the artist, however, remains: Can the computer itself produce art, thus by-passing the artist?[17] You will remember both the computer poem I used in the introduction and the episode of the fake Mondrian.

III

As I have already shown, there is a trend of cooperation toward the computer and its possibilities, evidenced by numbers of artists in our society. This is countered by a mood of rebellion which is also evident in other directions taken by the arts. In saying this, I am, of course, fully aware that the artist, being the type of personality he is (more of that later), has often been a revolutionary in any age. I need only cite such a giant as Beethoven, whose works are now selected for the conservative portions of our symphony programs. His third symphony, considered by many to mark a tremendous advance in the entire history of music, outraged convention by its inclusion of a funeral march. His fifth symphony was condemned by a contemporary composer and critic as "an orgy of vulgar noise."[18]

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[14] A. M. Noll in John R. Pierce, "Portrait of a Machine as a Young Artist," *Science, Art and Communications*, C. N. Potter, New York, 1968, p. 151.
[15] John R. Pierce, *Ibid.*, p. 151.
[16] John R. Pierce, *Ibid.*, p. 158.
[17] A. J. Parisi, *op. cit.*, p. 27.
[18] Wallace Brockway and Herbert Weinstock, *Men of Music*, New York, 1950, p. 190.

Some artists of our time, like Jean Tinguely, design machines that make their own commentary on the machine. In a recent work titled *Homage to New York,* he presented an assemblage of a piano, machine parts, bicycle parts, a weather balloon, and fireworks, which was programmed to be seen by an audience for a number of hours; after which the "machine" destroyed itself.[19] Nor is this tendency in the arts limited to sculpture. In theatre there is also a trend toward improvisation in the form of "happenings." The "aleatory" music of John Cage, dependent entirely upon contingency or chance, is drawing crowds (and some Brooklyn cheers) wherever he appears. One of his compositions, titled *4 minutes, 33 seconds,* consists of a pianist sitting at the piano without playing a note and then leaving. I understand that when asked "Where is the music?" Cage replied that it is in the sounds you hear in the audience while they are just sitting there.[20] The distinguished critic of the *New York Times,* Harold Schonberg, writes:

> Basically the entire avant-garde manifestation is revolt, unease, a profound dissatisfaction with current social, religious and cultural standards. At basis is the feeling that nothing *means* anything, certainly not when the Bomb has taken the place of God in so many minds as the ultimate disposer of the earth. The avant-garde in the arts, deriding the romantic concept of "beauty," has deliberately substituted an anti-ethical concept that is intended to demolish the great ethos upon which all art of the past was based.[21]

Joseph Wood Krutch testifies further to this rebellion. He suggests that artists have, "in their own way, signed off from their civilization almost as effectively as has the cultivated manufacturer of the shapeless dream."[22]

Another observer predicts that:

> If today's trend continues in theatre, we may all look forward to an influx of poorly-constructed plays covering up their inadequacy with a generous hunk of pornography, a liberal sprinkling of four-letter words and a sugar coating of poetry. This pretense at "free expression" is really no more avant-garde than a ready-mix cake.[23]

The jarring messages given by the rebellious artist to his society correspond with the free admission that he is disgusted with its dehumanization of human life as well as its despoilation of nature. This *is* a revolt, whether we relate it to our military-industrial complex or to our mass-society. Even the individual's name is on the

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[19] Nathan Knobler, *The Visual Dialogue, New* York, (n.d.), p. 204.

[20] Summarized from *Look Magazine,* Jan. 9, 1968, p. 45.

[21] Harold C. Schonberg, "Art and Bunk, Matter and Anti-Matter," *New York Times,* Sept. 24, 1968.

[22] Joseph Wood Krutch, "The Creative Dilemma," *Saturday Review,* Feb. 8, 1964, p. 17.

[23] "To the Editor," *New York Times,* July 28, 1968.

way to becoming meaningless. He is identified merely as a group of numbers by his student admissions office, his insurance man, or his gas station attendant.

IV

This evidence relating to the artist's confrontation with technology and the computer should be followed by the direct question: Why is the creative temper even more necessary to our technological society than to any past society?

A recent psychological study of creativity—The Creative Person—made by a group of psychologists on the University of California-Berkeley campus, is very informative here. It concludes (and I summarize) that the creative person is inclined to be interested and curious, more open and receptive than others; that he is strongly motivated to achieve in situations where independence of thought and action are called for;[24] that he has an openness to experience, a freedom from crippling restraints and impoverished inhibitions, and a delight in the challenging and unfinished.[25]

These characteristics marking the creative temper (and I must quickly point out that the creative scientist, as well as the creative artist, was considered) make me ask: In our society—shadowed by urbanization, mechanization, and over-population—where the person is in danger of becoming a non-person, is not the creative individual a last defense?

It is by now a truism to state that these qualities of character—independence, originality, open-mindedness—are more needed than ever by our society. These qualities are needed to challenge the forces a technological society has set in motion, forces that obliterate personality psychologically, not to speak of what can take place when computer-programmed missiles obliterate us *physically*.

Truly, as the arts of a civilization have often served to symbolize a nation's achievement or failure, the treatment of its artists has revealed the degree of freedom or oppression within its borders. One might therefore say that our age, more than any other, will be judged by future historians in relation to how it realizes the debt it owes to these free, independent spirits who might help prevent a society from melting its men into ciphers.

This implies, of course, the need for a greater recognition of the creative individual and his contribution to our culture. As Archibald MacLeish has said:

> What's wrong is not the great discoveries of science . . . What is wrong is the belief . . . that information alone will change the world. It won't.

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[24] Donald W. MacKinnon, "What Makes a Person Creative?," *Saturday Review*, Feb. 10, 1962, p. 17.

[25] *Ibid.*, p. 69.

> Information without human understanding is like an answer without its question—meaningless. And human understanding is only possible through the arts.[26]

The arts and humanities provide meaning and purpose to our lives. The artist—in many different ways—probes, searches, and reinterprets reality so as to make our lives deeper, wider, and richer because of his efforts. When we need a jolt, he jolts us, with dissonances or happenings; when we need a shock, he shocks us, often to tell us that we're taking the wrong road.

I am fully aware of Plato's overt reason for excluding poets from his *Republic*—fear of the emotional influence of great art. But I've always had a sneaking suspicion that what Plato was really worried about was that the rebellious, independent, poets would upset the applecarts in his neat, controlled, structured, little state.

Certainly *our* nation is in danger of being computerized beyond belief, organized beyond belief, and benumbed beyond belief by the offerings of the mass media—so much so that the high prophet of the electronic revolution, Marshall McLuhan, has changed his gospel from "the medium is the message" to "the medium is the massage."

The creative temper, as I have emphasized in this talk, can remind, prod, and inspire us to sustain the value of the person in a non-personal world.

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[26] Archibald MacLeish, "Thoughts on an Age that Gave us Hiroshima," *New York Times*, July 9, 1967, Section 2, p. 1.

TOWARD DESIGN IN THE VERNACULAR

William A. King

There exists in this country a discontent, an almost voiceless potential, with little direction and few spokesmen. This discontent is the result of our lack of aesthetically satisfying visual and tactile experiences. It is a voiceless potential because it is the unspoken yearning for harmony and proportion that every man seeks consciously or unconsciously in his surroundings. There is little direction because few in positions of decision-making are concerned with the yearning. Little effort is directed toward giving a unity of expression.

Each one of us is part of this underground potential. Its basis is in the biological and psychological needs which should be reflected in the way we live and in the things we use. The way we live is expressed in a jumble of diversions. We are surrounded by cacophony, foul air to breathe and offensive visual experiences.

Phonographs look like antique chests, plastics imitate marble, kitchens imitate other factories and are merely as efficient. From the design of the development house (boxes within a box) to the form of the latest automobile, there is no effort at appealing to any one aesthetic sense. There is instead only a confusion of many directions. The recent epidemic of ludicrous tail fins on our automobiles is symptomatic of our plight. But if there is discontent, it may be asked, why is there no public protest? Perhaps because man, in his infinite capacity to adapt, shuts out what is intolerable. He no longer notices the unacceptable, just as the soldier in battle can ignore sights of death and mutilation.

In this paper I wish to trace the development of this phenomenon of life today.

In eighteenth-century America, before the industrial revolution had a strong grip, the objects of daily use expressed in a natural way the lives of the people of that time. There was a dialogue between the artisan and the user of his product. The consumer knew what he wanted and he got it; the craftsman was qualified by his sensitivity and his apprenticeship. Since there was this natural alliance between the artisan and the consumer, the results were generally satisfying. It was in the design of useful things that the American showed his creative genius. Creative impulses, untrammelled by tradition, were released. The character of early American design was summed up by James Fenimore Cooper, in *Notions of the Americans* (1828): "I have seen more beautiful, graceful and convenient ploughs in positive use here, than are probably to be found in the whole of Europe united. In this single fact may be traced the . . . character of the people, and the germ of their future greatness. Their axe is admirable for form, for neatness, and for precision of weight . . . the actual necessities of society supply an incentive to ingenuity and talent, that are wanted elsewhere . . . the vast multitude of their inventions ought to furnish food for grave reflection to every stranger."

Mass production was possible in the 1830's, and it gave almost everyone machine-made chairs, carpets and wallpaper. Designers tested the limits of the machine in their competition to come up with the most ornate product. Expediency took the place of art.

> Walter D. Teague writes of this industrialization: "While the Revolution had none of the grace and charm of childhood, it had the clumsiness, the ineptness, the unintentional cruelty and the pains of a gigantic, lumbering, grimy, immaturity. It had, too, the eagerness and vitality of youth . . . It accepted as a matter of course that the new industrial system on which the whole new scheme of life was based should proliferate in sinister black factories that blighted the lives of their workers . . . It received with uncritical acceptance the floods of crudely embryonic wares that poured from these factories to supply our needs ineptly, while they swamped our lives in ugliness."

The end result of the surfeit of badly designed products in this country was that no one was satisfied, as the craftsman and consumer were satisfied in a less complex age.

The disparity between man striving for beauty and the ugliness of the world is not new. In England Josiah Wedgewood endeavored to solve the problem in the mid-1700's by enhancing commercial pottery with applied decoration, which emphasized already existing beauty. William Morris a century later counseled, through modified medievalism, that man should ignore the machine entirely and return to the days of handicraft. "As a condition of life, production by machinery is altogether an evil . . . art must be produced by the people and for the people, as a happiness for the maker and the user." And he insisted on the importance of aesthetic considerations in the design of even insignificant objects, an idea which has had far ranging implications up until the present. Perhaps his most important contribution was the establishment of arts and crafts schools throughout England where young designers studied the possibilities for functional yet beautiful design.

Morris' ideas were followed in Europe by the movement called *Art Nouveau. Art Nouveau,* as its name suggests, attempted to create a new style. International in character, it was known as *Art Nouveau* in Belgium and France, *Sezession* in Austria, *Jugendstil* in Germany and *stile libertà* in Italy. The Belgian Henry van de Velde, one of its leaders, urged ". . . a logical structure of products, uncompromising logic in the use of materials, proud and frank exhibition of the working processes."

Significantly for industrial design, the German Hermann Muthesius advocated the study of "railway stations, exhibition halls, bridges and steamships . . . whose shapes are completely dictated by the purposes they are meant to serve." In 1907 Muthesius founded the Deutscher Werkbund, which was a step away from the arts and crafts *(kunstgewerbe)* toward a true industrial art. Its ideal was stated in Muthesius' inaugural address: "There is no fixed boundary between tool and machine. Work of a high standard can be created with tools or with machines, as soon as man has mastered the machine and made it a tool." Standardization was the goal, and it was only through it that reliable taste could be achieved.

The arts and crafts movement inspired by William Morris in England made its impact in the United States in the 1880's. Examples of this influence are the glassware of Louis Comfort Tiffany in New York and the Rookwood pottery of Maria Storer in Cincinnati. These were aesthetic protests against the poor quality of factory production.

In more modern times serial production, since its standard is that of indefinite repetition of objects, has changed the attitude of the consumer. Uniqueness or skill of craftsmanship is no longer a consideration; only the design is important. Novelty, however, has increasingly occupied the minds of merchandisers. Designers have borrowed criteria from cybernetics and feel that overfamilarity produces obsolescence. The greatest amount of pleasure is derived from newness, because of its ability to surprise us. These ideas have their roots in the writings of the English empiricist Burke, who formulated a functionalist attitude toward art.

Burke writes in *A. Philosophical Inquiry into the Sublime and Beautiful* (1756): "When we examine the structure of a watch, when we come to know thoroughly the use of every part of it, satisfied as we are with the fitness of the whole, we are far enough from perceiving anything like beauty in the watch work itself . . . the effect is previous to any knowledge of the use, but to judge of proportion, we must know the end for which any work is designed." He shows the distinction between beauty and proportion and fitness and knowledge of use. And in the same work he states: "Indeed beauty is so far from belonging to the idea of custom, that in reality what affects us is that manner is extremely rare and uncommon. The beautiful strikes us as much by its novelty as the deformed itself . . . For as use at last takes off the painful effect of many things, it reduces the pleasurable effect in others in the same manner."

Concepts such as those expressed by Burke underwent considerable change in the late 19th and early 20th centuries. Functionalism, which was originally understood in its materialistic meaning, now took on psychological implications. Beauty became synonymous with function. Louis Sullivan maintained that "form follows function." In the 1920's the Bauhaus set out to educate the industrial designer in the premise that beauty and utility meet in the well-designed object. Such men as Klee and Kandinsky, the architects Mies van der Rohe and Marcel Breuer, adapted the new principles of the arts to the unique requirements of serial production. It was hoped that the lowest possible cost would produce the best aesthetic result. Industry would be furnished with functional designs which were clearly made by machines.

With the rise of the Nazis in Germany the Bauhaus was closed. Many of its faculty came to America, and the works of Gropius at Harvard, Moholy-Nagy at the Chicago School of Design, Kepes at M.I.T. and Mies van der Rohe in the Chicago area have had their impact. America's own Frank Lloyd Wright had more influence on Europe than on his own country. Walter D. Teague, Henry Dreyfuss, Raymond Loewy, and Charles Eames have also made an impact with designs ranging from steamships and telephone receivers to bent plywood chairs.

In America the emphasis is on styling. The change is on the surface. Objects change form with what is thought to be the latest mood of the consumer. When aerodynamics occupies the primary concern all objects take on free flowing lines. The theory of entropy of communications hopes to produce the maximum amount of surprise by a deluge of new styled products. It is held that the greatest amount of information is supplied by a form which, because of its newness and unforeseeableness, gives the greatest amount of surprise. The amount of information is in direct proportion to its degree of surprise. When the form is repeated too often, there is a diminishing amount of information (the form is ignored by the consumer.) The idea that novelty produces aesthetic pleasure takes on cynical overtones and gives rise to planned obsolescence.

The benefits of the machine are obvious in our time, and there can be no turning back. The Bauhaus offered an answer to the problem of designing intelligently for the machine. It seems that much of the message has fallen on deaf ears. It would seem that the manufacturer has not discovered that additional dimension, and this keeps his product from being well designed. Much of the problem centers around the appropriateness of form and the function of decoration. Surely novelty is not the only thing which will appeal to the public.

Many business establishments are aware of the necessity of presenting an image in plant and administrative office appearance. The best architects are often engaged for this purpose. Why then is the consumer product shoddy in so many instances? An industrial designer, Richard S. Latham, says: "The quality of materials used and the characteristic details become more skimpy and inappropriate, until finally it appears that the worst design, the most inept craftsmanship and the least beautiful workmanship have been relegated to the individual consumer, with higher orders of skill and execution reserved for industrial products, and the highest order of concept and execution reserved for products that human beings will hardly ever see."

Industrial design is the only really popular art form. It has the influence to educate the public in the positive values of modern art. Our condition suggests that manufacturers are not seeking professional ideas in the solution of design problems. College and university departments of industrial design have been trying to educate students for more than a quarter of a century to solve these problems in an honest way. And yet their efforts are not very apparent. Imitation of handicraft is not an honest solution, and the machine does not do it willingly. Perhaps the market analysts are second guessing the public. Perhaps businessmen are afraid to disturb the situation which has arisen from the misuse of machines by misguided men.

Susanne K. Langer addressed herself to the problem in *Feeling and Form:* "The artisan-craftsman has been superseded by the industrial designer; and industrial design is next to architecture in shaping the visual scene. So it is in our things—our countless things, multiplied fantastically *praeter necessitatem*—that we must find some significance: a look of simple honesty in ordinary utensils, of dignity in silverware, and of technological elegance in our machines."

The time is long overdue for industry to bring its products into line with the limitations and the advantages provided by machine production. Forceful leadership by designers and businessmen is called for. Design in the vernacular can be achieved. It can bring a grace to our lives which has been absent.

MUSIC AS VIBRATIONS AND AS FLYSPECKS

Observations of a Music Bibliographer on the Unifamiliar Effects and Inherent Perniciousness of His Chosen Objects of Research.

Donald W. Krummel

It is one of the curiosities of our language that "live" music should be that which will not survive. Like fruit, music keeps in cans or when frozen.

Like so many other human achievements, music has been preserved in written records. We know the past not through our memory of events but through documentary evidence, most of it preserved on paper. Axiomatically, that music which predates our written records is pre-historic; so then also is any music which we may hear which has not been notated or recorded. Paper enables the musician to benefit from the past. As we shall see, it also commits him to the past, developing his art into one of understanding, interpreting, learning from, and building on the basis of the past.

This study undertakes to survey the relationship between music and its documents, in terms briefly of (1) basic reasons; (2) history; (3) effects; and (4) future prospects. The subject itself inevitably evokes a wide range of responses, from precarious speculations to the most painful of truisms ("tear up his scores, and where is Beethoven?"). While I shall hope to develop the speculations out of some of the more significant of the truisms, quite clearly my conclusions are contemporary and highly personal rather than the product of any timeless reasoning. The activity of handling musical documents, I believe, could not have found the meaning which I am here proposing without the benefit of rather basic and widespread changes in our general intellectual attitudes during the past few years.

To be sure, we have always had misgivings about our musical heritage being preserved on paper. We concede that, until recordings came along, we were completely dependent on notation for saving our great musical masterworks. But we still feel the need to be both skeptical and demeaning of the paper. The notes we laughingly pass off as flyspecks, of which there are two varieties: the dead dots which our tiresome scholars study and analyze, and the silly dots which our mad composers trace in order to make the great idiotic compositions of today. The flyspecks are a mere reflection of the action, the harmonious vibrations in which is embodied music itself. The fact remains that, without notation and its painstaking formulation and study, our music itself would be an achievement far less significant than what we know and enjoy today—considerably less well developed, clearly an anachronism in our age, truly pre-historic.

What has led Western Man to go to the trouble of committing music to paper? First and most obvious is our belief that a musical entity is suitable for and deserves re-performance, which can best be accomplished through preservation—that its sounds, or at least their component relationships, ought to be heard again. This belief may be based on two attitudes. One is a moral, even a religious responsibility ("we must save this"), the other a volition which comes from enjoyment ("we want to save this"). We believe—and quite correctly—that oral tradition is fallible, that the passing of a message by word of mouth is not trustworthy, especially when the message is complicated.

Apart from preservation, we wish or need to accommodate a middle man. Divisions of labor usually result as our civilization becomes more sophisticated; in this instance the creator becomes separated from the re-creator, that is, the composer from the performer. Sound itself is transmitted by performer to audience; the notation enables the composer to communicate with the performer. Behind both, apart from but governing both, as something of a Platonic ideal, is the abstract concept of the work of music itself.

Third, we seek a wider circulation of a work. The music becomes part of the repertoire, not of one performer exclusively, but of many. Thanks to notation, the performer no longer needs to commit the work to memory. We are thus involved in the act of publishing, which requires promotion and publicity.

Implicit is the attitude that music should be shared by performers—an admirable sentiment at any time, and probably the exception in the larger course of music history. Such generosity departs from the practice of the artist's repertoire being a closely guarded secret. In eras of great virtuosity, to be sure, the notation may become the merest of outlines, in which case the publication is no act of generosity at all. The masterful performer shares the text with his colleagues, and then in comparison to them shows his superiority of skill and taste.

Finally, somewhat opposite to altruistic sharing is sharing for profit. Music becomes a commodity, a means of making money, a basis for commercial gain. Subject to copyright—a "literary" or "intellectual property," of all things—it provides the musician with a means of survival. He can flout the gods who had prescribed his lot as one of starvation, and, with exceptional luck, get rich and lose his musical soul entirely.

Out of such considerations, notation on paper—for all intents and purposes a permanent medium—has joined forces with an art form which is essentially fleeting and impermanent, made up of vibrations which are produced, resonate for an instant, and are gone—which live and die in the tragedy of immediacy. (The word "evanescent" was a favorite in describing it in the Romantic era.) In their essence sound waves, and therefore musical compositions, are momentary, and this we should not forget: such is their limitation, also their virtue, and their significance today.

The commitment of music to paper thus results in an alliance between two media, one visual and the other aural, one directed to the ear and the other to the eye. When the occasional and inevitable family conflicts arise between the two, the notation always loses. This is as it should be, since music was originally, and is essentially, sound and not paper.

We can see the way notation loses out as we follow the current fashion of pondering our everyday idioms. We adapt an old military expression and speak of a performer "facing the music," meaning that he has chosen to do his own thing which is not J. S. Bach's own thing. The printed page then brings him rudely back to orthodoxy. (Thus, in current colloquialism, have our flyspecks functioned as the fall guys in the Great Creative Cop-out of Western civilization.)

We also use the German term *Augenmusik*—music of the eyes—in speaking of a composition which is more rewarding in study than in listening. The term is not precisely appropriate: a better term might be *Kopfmusik*—"head" music, or at least "heady" music. If the fact be known, there has been very little true *Augenmusik* in the sense of music pleasing to the eye. As a graphic art, musical notation through history has fared very badly indeed. There have been very few great masterpieces of music book production. The thrilling prints of Petrucci, the first great music printer, and the handsome early engraving of Domenico Scarlatti's sonatas come to mind; but beyond this even the most experienced music bibliographer will have trouble finding examples of which he can be proud. The early twentieth century saw several attempts to make music beautiful on the page through specially prepared music type faces, fine paper, elegant design, and tasteful decoration. The results were hardly successful. Music which is visually attractive almost inevitably, and most unfortunately, becomes affected in its appearance. The performer wants his instructions stated in as clear and unornamented a version as possible—and in view of the speed and exactitude with which he must grasp his instructions, his needs are indeed critical. In printing, better an ugly legible statement than a beautiful illegible one. Similarly in publication: better an ugly edition of good music than a handsome edition of bad music.

Through the course of Western history, at least up to the twentieth century, music has found permanence by imitating the printed book. Music has enjoyed a free ride in the vehicle of literary texts; and as a result music has had to go where the literary vehicle was willing and able to go. This influence has yet to be extensively studied or appreciated. At this point, then, a survey of the main events in this history is in order.

We find the earliest notation of Western music, as it is traced back to the Middle Ages, already involving either numbers or words. Pitch levels are based on mathematical relationships. The names of these levels are assigned with word syllables, as in solmisation, or later with the letters of the alphabet themselves. Musical rhythm is derived either from the natural rhythm of spoken words, or later from mathematical subdivisions of time duration.

With the invention of printing in the mid-fifteenth century, the development of music printing a few decades later, and the emergence of music publishing soon after 1500, music becomes all the more strongly committed to words. One admires and is fascinated by the achievement of the early craftsmen who conceived the first music type faces; one also respects their output, which provided the permanence for most music written during a span of two centuries. Musical notation by 1500 had already come to resemble what we know today, to the extent that it consisted of symbols arranged in a line, like the letters of a word. To be sure, the staff lines themselves caused the printer some difficulties which he never solved completely; but it is hard to doubt that movable type, as soon as it was invented in the days of Gutenberg, was destined to be applied to music. Early type could not directly designate instructions for musical color or harmony. These two elements, we might observe, are in themselves less significant in Renaissance and early Baroque music than they were to be later.

Someone someday will perhaps defend the hypothesis that printing contributed to the transition from polyphonic music to that of the continuo period. Would figured bass have been adopted if performers could have had printed chords to read (and, by having had more of them to read, would have learned to sight-read them)? Was there also in the late Renaissance, as part of some larger subconscious arch of civilization, a need and desire for "line," for simple linear construction in music? For the first time, man dealt extensively with books, where one thing happens at a time; and at this time his imagination and interests were first being stimulated by a knowledge of exploration and travel, involving a person going to only one place at a time: perhaps such factors helped to discourage polyphony, in which several lines are presented at one time.

The great sixteenth-century commercial empire of music publishing, based on movable type, finally collapsed and was replaced around 1700. As early as 1620, new music type faces were seldom being designed. This is only a detail in the story of this period, to be sure—the Thirty Years War and the various forms of puritanism had ravaged Europe, and in fact new type faces of any kind were rarely to be seen. In music, the old type was used in religious service books, in treatises—again reflecting a tie to the printed word—and in popular song anthologies. Progressive instrumental music suffered in particular. No notes were available for rapid passage-work, and chords could be constructed only by carefully chipping two or more pieces of type and fitting them together.

We can thus add the upheaval of 1700 to our list of those musical revolutions which have obligingly happened every century, on the century. In this instance, liberation was not from a tired and corrupt artistic tradition, but from a book trade best suited to doing other things. Music from this time forward was on its own course in the publishing world, using engraved plates rather than movable type. With independence came also the loss of the usual channels of distribution and registration control: the librarian today can seldom rely on the standard historical bibliographies for evidence on published music. The circulation of some music even went underground, although partly for reasons of control over performance: Italian opera, for instance, conquered Europe not through transmission in typeset editions or even engravings, but through a highly developed manuscript copying network.

We can also plot a two-hundred-year historical cycle: music printing around 1500, music engraving around 1700, and sound recording around 1900. The implications of the last development are perhaps the most staggering of all. The marvelous Siamese-twin conveniences—permanent storage of the sound itself, and mass-media distribution of sound—are obviously very great technological "breakthroughs." Typically, they have eliminated production workers (i.e., musicians) and require more service workers (i.e., managers and electronics repairmen). At the same time, the surviving production workers are infinitely more effective: they reach a wider audience, and incidentally get paid slightly better. But typically the inventions have also led to many of the ills which beset music today: the virtual elimination of regional non-conformity; audience apathy; the decline of "live performances," at least of the institution of formal concerts; and in time perhaps the elimination of the performer, the composer in the de-specialized world of tomorrow communicating directly with his audience by creating his own sounds. Even now, the craft of music engraving is dying. Nobody is really sure what music publishers themselves are up to, and while they claim to be happy, neither the composers nor Wall Street seems to care much for them. The era of music on paper may thus now be regarded as the proper domain of the historian. It has become part of the past from which we are expected to learn something. What then is our heritage of music on paper?

What characteristics of our music are the result of paper? We have considered what we want when we commit music to paper: more important is what we actually get. In what ways—*pace* McLuhan and the ambiguous verb which he has taught us to say together—"is" the medium the message? We speculate and surmise, but with no real certainty: there is of course no parallel civilization with music not committed to paper with which we could make a clinical comparison. Even so, we can develop several lines of reasoning which tell us what the marriage has done to one of the partners. From this we can anticipate the freedom and to a lesser degree the loneliness which will characterize the newly found single life.

Let us begin with McLuhan's concept of the linear—the idea of progression from one point to another, such as we experience in countless ways: reading a text from one word to the next, traveling from one place to another, reasoning logically step by step, growing from childhood to adulthood. Before printing we communicated in "auditory" rather than "physical" space. Our communication, being mostly oral, took place in time rather than through the two-dimensional visual surface of paper or other documents.

It is wrong to say that auditory space is not linear, as I sometimes think (but am really not quite sure) McLuhan would have us believe. In its various forms—primitive, pre-Renaissance, and that since the invention of printing—music is always committed to a temporal "line." Line as perhaps been emphasized, or more systematically conceived, since the invention of printing. The devices for notating the elements of music were fixed long before the Renaissance, and then accommodated in movable type. Rameau's formulation of the harmonic progressions in the eighteenth century, the monumental Western codification of its practices, is a complex system of rhetoric and logic rather than a grammar or spelling guide, the appropriate counterpart to the succession of words on a printed page. When confused by new music even today we say "I don't follow," as if we were lost in an argument or discussion.

Line, the term we use for the sequence of sounds in time, is an essential dimension to all music, the other dimension being the variety of the sounds occurring in a single moment—color, and in a static sense, harmony. Line has certainly been conspicuous in the art music which we most highly esteem. We admire and are moved by music which brings out the "long line," be it an *Urlinie* in Schenker's musical analysis or the delicate *spinto* affectations of a great lyric soprano. Italian and German music, one might speculate, are generally more linear than French. The frequent abandonment of line is regarded as a hallmark of the new music, foreshadowed by the Romantic color made possible by the technology which produced the modern symphony orchestra. Composers are supposed to delight now in bright bursts of sonority—perhaps for purposes of being non-linear, unconsciously or self-consciously, possibly also to wake us up and keep us awake, and perhaps because the two are one in the same. In many of the non-Western musics, I am told, the linear element is also less conspicuous. Even in the most advanced music of the future, line is inevitable, since time—like physical space—has dimensions. Music always has a line, although it is possible that because of printing the line is more conspicuous.

Second, the printed page of music offers escape—a refuge from the bright glare of musical sound. The metaphor of a "bright glare" of course, is logically inappropriate, and in the same way as musical "color" is. Coming from the world of light rather than sound, it is useful only by way of suggesting the peculiar way in which sound engulfs us. Sound varies in loudness, and usually the hearer can locate the source of the sound. But we can not avoid sound by turning our head as we can avoid looking at a visual object.

It is important for a listener to be able to get away from music. This was felt as early as the Renaissance, when the audience came to be placed further away from the performers, especially the large groups of performers. Thanks to opera, the proscenium arch tended to be used for music as soon as it was devised for the theatre. In more recent eras the classic escape at a concert has of course been sleep. Today earphones offer a further element of privacy. Having the music we want when we want it is an unprecedented and staggering blessing, the only limitation being our ability to absorb very much of it at one time. We will still want and need to get away from it at times. It may prove to be one of the typical ironies of history that, at the very moment when we have the totality of the musical repertoire available, we will least care about it or need it.

Third, paper makes possible analysis: the printed page helps us comprehend music by allowing us a limited and a different access to it, enabling one set of senses to be reinforced by another. Music on paper lends itself to a varied manner of comprehension, the laying out flat on a two-dimensional surface making possible an impression of the totality at a glance. The score becomes a map of the terrain; and while there is admittedly no way to know the countryside better than through a good walk, we can correct many of our errors if we take along the map.

Fourth, and most important in many ways, is the prospect of betterment made possible largely through analysis. The composer can study the past and learn from it. He learns to hear his music "in his mind's ear" as interpreted through his eyes; and from this he can discover his own errors and correct them, his weaknesses and strengthen them. In an abstract way, his work can evolve in its perfection. He can work as a Beethoven, re-examining his achievements and thereby building an organically conceived type of music—keeping in mind all the time, of course, that there are also Mozarts who are no less great for having comprehended intuitively so many of the relationships which are to him so thoroughly a rational process.

Fifth, paper offers tangibility. Sound, being impermanent, is also undependable. We ask the man we deal with to "put it in writing"; and we argue endlessly after a concert, always about what the performer accomplished, often even about what sounds actually were heard. Control becomes possible with the printed page—the performer's job becomes one of making music in terms of conditions spelled out, the degree of freedom depending on the music. Stravinsky would have the conductor of *Le Sacre* acting largely as a cuing metronome; the composer of Neapolitan opera, of a concerto arriving at a cadenza, or of a pop tune intended for a jazz combo, draws in only the rough sketch, asking the improvising performer to take off like a liberated bird, making sure only that the flight follows the suggested course or lands at the right airport. In all such situations, the written notes, being fixed, are the means of control. Through our copyright laws, they take on the characteristics of real estate and personal property. They get bought and sold, and have resulted in music industries as concerned with self-perpetuation as our great corporations. The notes engender their own laws and rules; and they get hauled into court because of those regulations.

Finally, they also get us into heaven, if they're good enough. Permanence, and the prospect for improvement, together lead to immortality—to timeless musical monuments, the concept of the heroic Romantic musical genius leaving footprints on the sands of time. Through paper, music, long assailed by puritanism as sinful and ungodly, achieves revenge, offering its favored practitioners its own brand of salvation apart from the rules and regulations of the church: in effect, "instead of getting to heaven by being good, live it up, write a great symphony, and you'll make it."

It is thus much in order here to recall a lovely old German canon with the following text:

> Himmel und Erde mussen vergeh'n,
> Aber die Musici, bleiben besteh'n.

Literally translated, "Heaven and earth must pass away, but the musicians will always remain." Really quite outrageous. Today the words would probably read instead,

> Soon the Establishment ceases to swing,
> Leaving musicians a-doing their thing.

Or, as our feelings may become more specific, "When our institutions collapse of their own cumbersomeness, our cultural centers go bankrupt, our paper turns to pulp—then we'll be left with music." The innocuous *Sängervereine* who perpetuated this ditty certainly never thought of doing any such thing, but they have indeed brought us face to face with the doom of the flyspecks, the fall of the gods, the movement of the tide which will smooth the sand, erasing the footprints of the 3 B's.

The Armageddon we are talking about is not in itself the great battle going on today for social change, the eradication of poverty, or the rise of the non-white races—although the two are connected: music is part of society, and there are obvious parallels between our social and our musical establishments. By way of a brief digression, we might observe that even if the parallels did not exist, music would almost surely play a conspicuous role in social conflict. Its well-known emotional appeal is only half of the picture. Existing as it does in time, music is the very essence of change, of creating beauty in a context of impermanence. In days of uncertainty, it is symptomatic that we should so often hear the expression, "Play it by ear." To the musician the phrase means memorizing the notes and then executing them. The world of commerce flatters him by defining it even more broadly, as going into a difficult situation with no fixed course of action at all in mind.

Music's message is less obvious than that of words and pictures; thus it becomes the medium for reflecting those pulses and rhythms, those subconscious feelings and sensations which other forms are unable or unwilling to express or reflect. Music may be harmless and lovely in its purity as an autonomous art form; but as a means to an end, it can much too easily also be highly potent, intellectually stultifying as only an emotional appeal can be. If musicians are less "involved" today than their music is, perhaps this is because they can see the whole process of reform as merely one more mind-blowing operation, at least at the stage where music gets into the act. They can be sympathetic with the cause of social justice; but they also have strong impressions of how democracy in America has preferred mayhem and inanities on television to live artistry—how popular education has produced technicians rather than humanists, and how the more abundant life resulting from the battle against poverty is conceived largely in terms of Gross National Product.

Musicians perhaps have a better pipeline than we give them credit for. Their music has frequently revealed some important things about ourselves which we were not ready to accept. But they have also been all too quickly ridiculed for the attitude "My kingdom is not of this world" or "after all the blue meanies get bumped off, we meek little rascals will inherit the earth—the Bible tells us so." Thus it is well to return to the little German canon to note that the word is "Musici," and not "Musica": what will remain is not the music itself, but the musicians. We really must be allowed to stretch the point here and say that music-making is what will remain. The musicians' bodies and talents, like their compositions, must be regarded as part of the *Himmel und Erde* which will pass away. The musical experience is fixed in the human condition, and beyond this in the vibrations of the stars.

Music on paper has obviously played a large role in the process by which music has become increasingly committed to the past. Fifty to a hundred years ago, concerts came to favor the "tried and true" at the expense of the present. Within the past fifty years, our musicologists have sought to fill in the gaps in the panorama of Western musical development. Today the musical experience is largely an archival experience, our values those of the historian. What we make of our musical past may bother our sense of honesty, and quite appropriately. Hitler loved and used his Wagner; and the modern administrator loves and uses his Machiavelli. But to deny that our most cherished musical experiences are important to us and in some way bettering is dangerously close to a denial of that vague but important link between the humanities and humanity.

We all piously insist on a need for musical vitality. The price may be expensive indeed. Probably we would need to abandon the institutions which encumber our music, not only the flyspecks and recordings in our libraries but also the stultifying etiquette of our concert life. Also vulnerable are the concert halls themselves—indeed they are probably the very proof of Parkinson's "law" about institutions deteriorating when they move into an edifice properly suited to their image of themselves. Along with all of these monuments, alas, must go the *Art of Fugue* and *Messiah,* the Mozart concertos and the Beethoven quartets, *Otello* and even *Wozzeck.* We will never excel them—such is one of the obvious assumptions today, and whether inherently true or false, it will be true as long as we believe it.

With this in mind, I must take exception to a well-intentioned but wrong-minded defense of the arts in our society today on the basis of their excellence. We do indeed need excellence; and the level of excellence in the arts is indeed high enough to be a model for other activities today. The experience of music, like that of her sister arts, is one of stimulation, accomplishment and pleasure; and such being the case, the already high level of excellence will be further heightened by competition in an inevitably overcrowded profession. In practical terms, the results are likely to be less happy. For economic reasons—supply and demand, together with the technological "breakthrough" in sound recording mentioned earlier—the *Gradus ad Parnassum* is missing some steps near the top. The boy who practices seldom gets to Carnegie Hall. The excellence toward which the vast army of our educators must work must be fitted into a context in which amateurism, rightly and understandably, equals amateurishness, in which local pride is often an emotionally charged but valid excuse for quality. The ascent from the great plains, vast if less arid than we imagine, to the Olympian heights, is sudden, steep, and with frightening odds against survival. "It's warm in here—yes, perhaps for violinists"; and therefore, "If you can't stand the heat, get out of the cotton patch." And as a result, the Global Village Philharmonic will soon be impeccably performing the *opera omnia* of Western music, giving us with pushbutton convenience all the listening pleasure we want. Rather than justify music on the practical grounds of its excellence, one should perhaps accept its total uselessness as its greatest virtue—it does less harm than politicians or scientists. Far better one should hope and work for the impractical, unpredictable, but now highly possible: an aesthetic right-headedness of some sort, comparable to the recent moral righteousness over Viet Nam in this country, serving to remind us that the musical experience is more rewarding in achievement than in gratification, being in essence a creative art rather than a consumer commodity.

Rather than justifying music in terms of an administrative value in our society today, it would be nice to think that we might seek to apply one of the administrator's favorite laws of positive thinking: when faced with two alternatives, come up with a third which, with instinct and effort going for it, will prove to be brilliantly appropriate. Can we keep the past without being its slave? The mind boggles at what the answer might involve: but experience leads to the hunch that somebody will be singing about it before the mind stops boggling.

A dispassionate and analytical glace at the popular music of today will perhaps help to renew our faith. Its texts usually tend to strengthen our respect for the social values of adolescents; and similarly, its musical content leads to a sanguine hope that a new creative era is at hand. In comparison with most of the popular (and much of the classical) music of the past, its content is indeed richly varied, imaginative, and frequently quite skillful in its construction.

As for the future of music on paper, this is altogether more predictable: the dictator is alive and well and living in central Siberia, available for academic appointment. As long as performers and scholars continue to work with the past, the examination of a composer's documents will be a necessary experience, not to mention a moving one. As for the composer today, the notion that he learns from the past appears to be temporarily out of fashion. The Romantic genius saw the past as irrelevant in the light of a divine blessing, and so the composer of today sees it as subverting his originality, no longer relevant. The fact of the matter of course is that composers of any age develop their craft, a skill in the handling of their materials. In the learning experience, musical documents will maintain their importance. They are the giants, in the medieval metaphor of Bernard of Chartres, from whose shoulders the dwarfs of succeeding generations will be able to see more, and more distant things.

It is more than a cunning trick of a parsimonious librarian to suggest that our repertoire be shifted, quietly and *en bloc*, to his watchful custody. The care and feeding, and to a degree even the protection of the giants (sensitive as they are, and susceptible to disease, despite their great strength) should belong to specialists, and not the general public. Rather than become infatuated with the giants, or throw stones at them, our society will be far happier helping our midget composers climb onto the giants' shoulders—perhaps watching a few of them become giants in their own right.

Musicians learn first to read music, then to recognize the danger of playing the notes and missing the musical experience. As historians we examine our notation and come to appreciate what it has enabled us to have in our music; we should then look to its larger function, as both a preserver of and a stimulant to music itself.

VICTOR BERGER: SOCIALIST CONGRESSMAN

Frederick I. Olson

Between 1910 and 1929 Victor Berger had not one but three congressional careers.[1] A single term from 1911 to 1913 coincided with, indeed was a major element in, the high tide of the Socialist party movement, both in Milwaukee and in the nation. His second career included no service in the House of Representatives, simply two election victories without seating in 1918 and 1919, and it signified his constituents' distaste for the first World War and their defiance of the federal government and the Wilson administration. Berger's triumphal return to Congress after his election in 1922, and his reelection in 1924 and 1926, were personal victories, devoid of the Socialist party import of 1910 and the anti-Wilson political symbolism of the 1918 and 1919 triumphs.[2] His defeat for a fourth consecutive term in 1928 removed the greatest prop for his pride and the major recompense for his party's decline. Nearing 70 and deprived of the regular income from his congressional salary, he now prepared to sell his majority stock interest in the Milwaukee Socialist daily which he had dominated since its founding in 1911, as a further step in the reorientation of his personal life. His party and his movement shattered, his Congressional seat gone, his newspaper about to pass under the control of others, Berger may have lacked that will to live which could overcome the injuries he sustained in a streetcar accident in the summer of 1929. On August 7, 1929 he died.

Nonconformity in politics came early to Berger. Born and educated in the decaying Austro–Hungarian empire, he migrated with his family to America in his late teens. He settled down in Milwaukee in the 1880's, amidst social and political turbulence which exposed him to emerging labor politics and to single tax, anarchist, and socialist solutions to the social problem.[3] An omnivorous

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[1] This paper was read at the annual meeting of the Organization of American Historians in Dallas, April 19, 1968.

[2] For a somewhat different analysis of Berger as congressman, see Sally M. Miller, "A Socialist Represents Milwaukee," *Historical Messenger* (Milwaukee County Historical Society), 22:132–138 (December 1966).

[3] Edward J. Muzik, Victor L. Berger, A Biography, unpublished Ph.D. dissertation, Northwestern University, 1960; and for shorter sketches of Berger: Max and Edna Albers Lerner, "Victor L. Berger," *Dictionary of American Biography,* XXI (N.Y., 1944), 72–75, and "Victor Louis Berger" in Dwight L. Agnew et al., eds., *Dictionary of Wisconsin Biography* (Madison, Wis., 1960), 33–34.

reader, he built a large personal library on social issues. He loved disputation and found in German Milwaukee of the 1880's and '90's, with its Turn societies and its beer saloons, congenial companions to argue with. Such reading and discussion convinced him that one could accept a comprehensive theory for the solution of social ills.[4]

Through the 1890's Berger evolved a workable social philosophy to account for the future in terms of the past. This was Marxian socialism with its major components of the class struggle, economic determinism, social revolution, and wage, profit, and capital concepts. Like so many other Americans of the age who embraced Marxian socialist doctrine, Berger acquired a point of view, a system of analysis, and stereotyped rhetoric which clung to him for life. But he was soon convinced by socialist revisionism, especially of the Bernstein variety, and he was sufficiently American to realize the inapplicability of pure scientific Socialism to conditions in the United States. Moreover, he seems to have been impressed by the openness of American political institutions, their availability to all, even the immigrant, through easy naturalization, universal manhood suffrage, liberal qualifications for public office holders, and, at least locally, a fluid party system. Berger became above all a conservative or reform socialist politician with a burning desire to win public office for himself and for his fellow socialists.[5]

Even while evolving their socialist theories in informal discussions during the 1890's, Berger and his Milwaukee colleagues had participated in local politics through the Populist party. But Berger also sought to convert Eugene V. Debs to socialism and his American Railway Union into a socialist political movement. The founding of the Social Democracy of America in July 1897, followed by the chartering of the first branch in Milwaukee, was to Berger a first step toward the very political action which the leadership of the new organization had prohibited. Thus, in order to nominate a candidate for mayor in Milwaukee's spring 1898 elections, Berger's branch was obliged to seek special permission from the Social Democracy's national executive committee.

The next decade was critical in the evolution of an effective socialist movement in the United States and of a powerful Socialist party in Milwaukee. Berger's approach to the propagation of socialism was strongly political from the start. He persuaded the

[4] Part of Berger's impressive personal library may be identified in the collections of the University of Wisconsin–Milwaukee Library. Among his less scholarly Socialist party associates and among Milwaukeeans generally Berger's library and his reading habits took on a legendary character.

[5] In addition to Muzik's dissertation, see Roderick Nash, "Victor L. Berger: Making Marx Respectable," *Wisconsin Magazine of History,* XLVII (Summer 1964), 301–308, and two convenient collections of Berger's own views: *Berger's Broadsides* (Milwaukee, 1912) and *Voice and Pen of Victor L. BergerT: Congressional Speeches and Editorials* (Milwaukee, 1929).

Milwaukee Socialists after 1898 to endorse candidates for almost all elective offices in metropolitan Milwaukee and many in Wisconsin, until they matched the Republican and Democratic slates in city, school board, county, state, and congressional elections. Socialist candidates won seats in the city council, the county board, and the state legislature as early as 1904; for the remaining quarter century of Berger's life his Milwaukee party always held a substantial number of elective public offices.

Under Berger's leadership the Socialists not only ran candidates for office—they ran them to win. Berger adjusted Marxian theory and party doctrine in order to gain votes, particularly when an election victory was in sight. For electoral expediency he accepted regulation of utilities as a practical, short term alternative to public ownership. And on many other occasions he shrewdly calculated the effect of platform planks and candidate selection on Socialist vote tallies, not excluding the tactical advantages to be gained by an occasional abstention from competing with the two old parties for an office. Indispensable to Berger's party was its alliance with local trade unions and union leaders, without incorporating such unions into the party structure.[6]

Berger carried his absorption in Socialist politics two steps further. He adapted to Milwaukee and Wisconsin an essentially European concept of party organization and party discipline, contrary to Republican and Democratic traditions. Berger's party imposed stringent requirements and procedures on access to membership. It organized ward and foreign language branches as its basic units and coordinated them through a strong county central committee. It eschewed the open direct primary in the very state which popularized that device. Instead it determined party nominees through its own machinery. Candidacies for public office were intended to be, and to a large degree were, party not personal affairs. In theory this meant that a faithful party member dutifully accepted any draft and as faithfully swallowed his personal ambition if someone else were preferred to him. In fact it obviously wasn't that simple. Reputations, brokerage, personal friendship, and personal popularity all played a role in party endorsements. Proven vote getters and popular party figures like Berger, Hoan, Seidel, Gaylord, Ameringer, Minkley, and Heath usually received the election opportunities they wanted. They were nonetheless expected to campaign as Socialist party agents. This meant endorsing the party

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[6] Marvin Wachman, *History of the Social-Democratic Party of Milwaukee 1897–1910* (Urbana, Illinois, 1945); Frederick I. Olson, The Milwaukee Socialists, 1897–1941, unpublished Ph.D. dissertation, Harvard University, 1952; and Olson, "The Socialist Party and the Union in Milwaukee, 1900–1912," *Wisconsin Magazine of History,* 44 (Winter 1960–61), 110–116.

platform and guaranteeing, if elected, to carry it out, on penalty of expulsion from membership or even involuntary removal from office. Campaigning had to be ticketwide, but the party handled all campaign arrangements and expenses, financing the latter through monthly dues, a checkoff from the salaries of officeholders, party benefit functions, and levies on the treasuries of friendly labor bodies. Never in American history, perhaps, has a political organization woven so tight a web over so many members as that which enmeshed the Milwaukee Socialists. It is not surprising that some opportunists joined the party to gain the support of so formidable an organization. And there were always some members who rebelled at the required pledges of loyalty and of money, at the expulsions and the purges, at the irritating limitations on their political independence, and their number grew when party fortunes waned and party decay appeared. As the genius who conceived and organized this tight structure, Berger was charged with being a boss, at first by his anti-Socialist political opponents, but soon by his enemies within the party.[7]

Berger's masterplan for pragmatic political action also included influence in national party affairs in order to protect Milwaukee autonomy from national interference. For years his nearly impregnable spot on the party's national executive committee provided Berger the necessary oversight. His vigilance extended to the national party's constitution, its election platforms, even the party name. Berger understood the need for a strong national movement to parallel Milwaukee's, but especially after the high tide of party ballots in 1912, he preferred to preserve the party's showplace in Milwaukee at almost any cost.[8]

Socialist political strength in New York, Chicago, and Los Angeles was always overshadowed by its major party opponents, however large their vote tallies by Socialist standards. Socialists were relatively more important in Berkeley, California, Haverhill, Massachusetts, Reading, Pennsylvania, Bridgeport, Connecticut, and elsewhere. But Berger's troops were the best organized and the most successful of all. Among the nation's large cities Milwaukee alone seemed to justify the "socialist" label.[9] The first Socialist victories in 1904 foreshadowed the landslide of 1910 when the party won city council and county board majorities and elected its candidate for mayor. Berger knew that as long as party labels prevailed in local elections, his Socialists could win pluralities in three way races. Beginning in 1912 Republican and Democratic fusion

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[7] Olson, Milwaukee Socialists, 55–84.

[8] David A. Shannon, *The Socialist Party of America, A History* (N.Y., 1955), 17, 21–25, 62–63, 258–60.

[9] Shannon, *Socialist Party,* 8–42, 188–89.

and non-partisan election laws virtually eliminated such leverage, yet the Socialists continued to win selected elections.[10]

If Berger was a boss, he declined to play the traditional role entirely behind the scenes. He ran for public office regularly, a visible target for his intraparty opponents and his anti-Socialist enemies. In the 1910 landslide he finally won election as an alderman-at-large and for a year or so played the major role in Mayor Seidel's administration.

But Berger's ambition was to be Congressman. He ran as early as 1904 in Wisconsin's Fifth Congressional District, and beginning in 1910 he never missed a campaign for that seat. Berger emerged in the 1904 balloting as a possible threat to the incumbent Republican William H. Stafford by polling over 10,600 votes, or 33.8% of the total, for second place. His opponent, a colorless conservative, was a native Milwaukeean, 35 years old, a graduate of Harvard law school and a bachelor, who had won the seat for the first time in 1902. Between that date and Stafford's last victory in 1930, he or Berger won every Fifth District election. Over that period the seat was vacant for 2 years, Stafford served for 20 years, and Berger for eight. Curiously enough Berger and Stafford faced each other only 9 times in 14 Congressional contests between 1904 and 1928.[11]

What kind of district could alternate between a colorless conservative Republican and the first Socialist ever elected to Congress? A major clue is found in the changing relationships among three major parties. While Stafford and Berger remained constants, their Democratic opposition varied. Moreover, old party fusion succeeded against Berger three times. And once Stafford failed to win the Republican nomination. But the Fifth clearly bore the marks of a swing district, even after Berger and Stafford were gone. From Stafford's defeat in the Roosevelt landslide of 1932 to the election of Democrat Henry S. Reuss in 1954, three Democrats and two Republicans divided 22 years into seven segments, the longest consisting of three consecutive terms. Reuss had already made the seat safely Democratic before reapportionment reshaped it out of all resemblance to its 1904 character. Altogether, fickle Fifth District voters changed Congressman 14 times in 52 years. Only Stafford, at the very beginning of this period, won as many as four consecutive terms. He also shared with Berger and Stafford's immediate successor in New Deal days a run of three con-

[10] For contrasting views, see Myron L. Anderson, "Milwaukee Election Law That Boomeranged," *Milwaukee Journal*, December 20, 1959, and Erich C. Stern, "The Non-Partisan Election Law: Reform or Anti-Socialism?", *Historical Messenger* (Milwaukee County Historical Society), 16:8–11 (September 1960).

[11] For election statistics, see the biennial *Wisconsin Blue Books* (Madison, Wisconsin, odd years), and biennial reports of the Board of Election Commissioners of the City of Milwaukee (Milwaukee, various dates).

secutive terms. But seven times the incumbent failed to win even a second consecutive term.

Redistricting created a district in 1901 which joined the north half of the city of Milwaukee and the north and west suburban and rural-farm areas of Milwaukee County with villages and wealthy farm sections of Waukesha County to the West, the latter accounting for slightly more than a fifth of the District's voters. The combination of rural-farm-village with big city was a major cause of party alternations. Across the near north side of the city of Milwaukee stretched a band of German settlement which provided the core of the Socialist strength. The Germans as a whole were frugal, law-abiding members of the working class or lower middle class. Many were Socialist party members; others were sympathizers who often voted Socialist. In the suburbs, as well as in the rural and farm areas of Milwaukee and Waukesha Counties, lived business, professional, and farm folks, typically middle class and traditionally Republican. Scattered in both counties, but heavier in the city of Milwaukee, were traditional Democrats who were predominantly Roman Catholic and Irish or German. To win, the Socialists and the Republicans were obliged to woo not alone the independent voter, but the normally Democratic voter as well.

The redistricting of 1901 put two Congressional seats within the grasp of city of Milwaukee voters for the first time. Ten years later the detachment of Waukesha County made the Fifth District even more urban in character; and nearly half a century later, with all of Milwaukee County urban, the central city portion was divorced from the north suburban, and the latter was joined once again to the contiguous suburbanizing portions of Waukesha County.

Berger's election in 1910 gave the Socialist party its first House member, and Milwaukee its first labor-oriented congressman since 1886. The only other Socialist party member ever to win a House seat was Meyer London of New York; his three terms between 1915 and 1923 neatly complement Berger's subsequent victories to suggest a unique character for all Socialist congressional triumphs. One of Berger's successors in the Fifth after the second World War was ex-Socialist Andrew J. Biemiller, who had passed through LaFollette Progressivism into the Democratic party.[12]

The propaganda value of Berger's election for the Socialist party all over the nation can hardly be exaggerated. Electing Socialists to common councils and state legislatures was clearly not enough, for only Congress could legislate the major components of socialist doctrine. The Socialists had to demonstrate their capacity to capture Congressional seats if they were to move the nation

[12] Olson, Milwaukee Socialists, 197–99, 271–72; *Milwaukee Journal,* September 30 and October 23, 1955; Shannon, *Socialist Party,* 9, 11–12, 158.

towards socialism, and up to 1910 their propaganda about the relentless tide of Socialist votes notoriously lacked confirmation on this point. Berger thoroughly enjoyed the personal glory of becoming the first Socialist congressman, but he had to picture himself as a foretaste of growing numbers of Socialists, not as an effective instrument itself. Quips about caucusing in a telephone booth merely emphasized his ineffectiveness, for as a minority of one he could be readily tolerated. Patronage and his other perquisites as a Congressman appealed strongly to Berger, but Milwaukee Socialists had gained far more tangible party benefits from their other local victories.

In the House Berger was no social revolutionary. He claimed that he represented not alone—or not primarily—the Fifth District, but the working class and all the Socialist voters of the nation. He often acted prudently by doing errands for any of his constituents, even the anti-Socialist or non-Socialist as well as his known supporters. As the sole Socialist Representative he tried to be true to his apocalyptic role. For their propaganda value he sponsored futile Socialist measures such as old age pensions and national ownership of railroads and communications. His speeches and news handouts were designed not to win votes in Congress but to present Socialist positions and gain Socialist converts outside the halls of Congress. His occasional deviations from the party line to please his Milwaukee constituents brought prompt censure from the party faithful while failing to secure his reelection. His most effective action, in calling for an investigation of the textile workers strike at Lawrence, Massachusetts, depended, as he well knew, on support from and tolerance by colleagues in Congress whom he felt obliged to castigate at every opportunity. A gregarious person who had enjoyed social acceptance by his ideological enemies in Milwaukee, Berger could not now isolate himself from the fellowship of the House of Representatives. Most evident was the gratification of his desire for personal acceptance by fellow Congressmen. That he never recovered from the fascination of his first Congressional experience is witnessed by his biennial efforts to regain his seat for the rest of his life.

But the cruelest dilemma in Berger's congressional service arose not from compromise of his socialism but from diversion of his energies. His central role in the Milwaukee party organization made his absence in Washington and his attention to Congressional duties costly to the Milwaukee movement. The persistent financial strain of ordinary party activities now extended to building a labor temple and founding a daily newspaper, the latter a part of the publishing complex from which Berger drew a salary. The long planned Socialist daily *Milwaukee Leader* appeared December 7, 1911, coincidental with the opening of the 62nd Congress. While Berger espoused Socialist doctrine on the floor of the House in the Spring of 1912, the *Leader* limped along, powerless to prevent a Socialist administration wiped out by a fusion ticket, and the Milwaukee rout in the municipal elections. From afar Berger saw the Seidel Socialists rent by dissension in their leader's absence.[13]

Nor could Berger return for the fall campaign in time to develop a winning tactic against Stafford's coalition with the Democrats. Berger's plurality in 1910 had been a slim 350 or 1% of 35,224 ballots. The resulting anti-socialist fusion, although incomplete, reduced Berger's vote but slightly from 38% to 35 or 36%, yet provided Stafford with margins of 1,908 in 1912, 3,946 in 1914, and 3,649 in 1916. After his 1912 defeat Berger adopted the correct party stance, lamenting that the millions of Americans who had voted Socialist were deprived of a voice in Congress.

Between Berger's defeat in 1912 and his khaki election victory of 1918 the Milwaukee Socialists entered a new era. The momentum of local and national election gains and party membership growth was lost between 1910 and 1912. Within Milwaukee and Wisconsin politics the Socialists settled down to a respected but limited role. When Dan Hoan was reelected city attorney in 1914 and recaptured the mayor's office for the Socialists two years later, no one could foresee how long he would hold it or how remotely Socialist his administration would become before his defeat in 1940.[14]

Some Socialists including Berger did foresee the catastrophic potential of the first World War as early as 1914. But America's Socialists were obliged to reconcile their doctrinaire war beliefs to the votes of their European brethren on the war credits. Initially Berger maintained in his *Milwaukee Leader* a peace posture which was distinguishable from pro-Germanism. Stafford rather than Berger embraced an opportunistic pro-German position in 1914 which helped him win easy reelection. Gradually, however, Berger's reaction to the war took on a more pro-German, anti-French and anti-British tone, not surprising in one who was born and educated in Central Europe. It became more difficult for Berger to apply simple Socialist tests to the events preceding the entry of the United States into the war, and he seems to have convinced himself that the defeat of Germany must be avoided because it would destroy the most promising socialist party in Europe and thus in turn weaken the American movement. Fortuitously, Berger's cultural preference for Germany coincided with the prejudices of his Mil-

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[13] Miller, *loc. cit.;* Olson, Milwaukee Socialists, 247–54; Olson, "Milwaukee's First Socialist Administration, 1910–1912: A Political Evaluation," *Mid-America,* 43 (July 1961), 197–207.

[14] Olson, Milwaukee Socialists, 271–72, 310–11.

waukee constituents and reinforced his concern for the fate of German socialism.

Stafford could outbid Berger for the critical German votes in the Fifth District as long as President Wilson did not invoke federal power against Berger. But when Wilson's Postmaster General revoked the *Leader's* second class mailing privilege on October 3, 1917, and his federal attorney brought indictments against Berger and four alleged Socialist co-conspirators under the Espionage Act on March 9, 1918, Berger was cast as a martyr to an all-powerful government which could not tolerate dissent. Berger, who had concurred in his party's condemnation of the American declaration of war, in his newspaper and by other acts and utterances had criticized many government policies and practices in prosecution of the war. But he had every reason to believe that he had remained within the letter of the law. That his opposition to the Wilson administration, or rather the latter's prolonged persecution of him for his beliefs, had election appeal was demonstrated in April 1918 when he polled 110,478 votes, or over 25%, in a senatorial election against a pro-war Republican and a Wilson Democrat. Most significant, concentration of Berger's votes gave him a plurality in the Socialist stronghold of Milwaukee.

In the November 1918 congressional race Berger won handily despite the pending federal indictment. The Democrats, hoping to convert Wilson's call for a Democratic Congress into their first victory in the Fifth District, defected from their fusion agreement to make their first serious challenge since 1908. But they merely gained second place while Berger drew enough traditional Republican and presumably German votes from Stafford to produce the largest plurality of his six victories, 5,470 votes.[15]

What Berger had regained at the polls, his erstwhile colleagues in the House now withheld. Between his election and the convening of Congress his indictment was converted in federal district court in Chicago into a conviction, with a sentence of 20 years from Judge Kenesaw Mountain Landis. While out on bail Berger fought to be seated, but the House refused him on November 10, 1919, by a 311 to 1 vote. Congressional reasoning was that Berger had given aid and comfort to the nation's enemies and thus invoked the third section of the Fourteenth Amendment, which required denial of his seat. Berger promptly stood for the Socialists in the December 1919 bye-election resulting from the vacancy, and as promptly was reelected by nearly 5,000 votes over his fusion opponent with the attractively Teutonic name of Bodenstab. Again Congress applied the Fourteenth Amendment to keep Berger from serving.

[15] *Ibid.*, 339–40, 355–56, 374–84.

By 1920 Berger could not so readily capitalize on anti-Wilson sentiment. For once fusion was so thorough it not merely weakened the Democratic effort as it had in 1912, 1914, and 1916, but it actually eliminated all non-Socialist candidacies but Stafford's. Even Berger was not safe from Republican exploitation of anti-war and anti-Wilson sentiment, and Stafford won by a 6,773 majority, the largest margin of any of their nine contests.[16]

Yet in defeat Berger was preparing for ultimate vindication. First of all, he appealed his conviction to the United States Supreme Court, which set aside Landis' sentence on January 31, 1921, and the Harding administration dropped the case without further effort. Next, in the favorable Wisconsin election climate of 1922, wherein a sympathetic Senator LaFollette also won triumphant reelection, Berger defeated Stafford by a 3,771 majority, or 6.7%, in another two way race, a most dramatic reversal of 1920. Without dissent he was now seated. And in the next two elections he survived the Coolidge landslide and the almost total eclipse of his own party everywhere, including serious setbacks in Milwaukee. But a presidential contest between Hoover and Smith in 1928 was too formidable for him to deal with. Hoover's candidacy capitalized on the fragile prosperity of the era, Smith's on Milwaukee's resentment over Prohibition. For the first time in 10 years the Democratic nominee for Congress polled over 20% of the vote, and Berger lost to Stafford by 709. It was his last race.[17]

As the first Socialist Congressman in 1911, Berger had symbolized his party's potential, and both his sense of party responsibility and his vision of the future had dictated the ideological role he must play. But by 1923 he had survived the terrible buffetings of the war period—persecution of his newspaper, prosecution of himself as a subversive, and double denial of a House seat—while his party, swollen by the transient growth of the war era, split wide open nationally over the Russian revolution and then declined sharply. What Berger salvaged of Milwaukee Socialism drew no nourishment from a national movement that struggled simply to maintain its name and headquarters. The hopefulness of its 1910 victories had given way to despair in the 1920's. The Berger brand of gradualist socialism, which had seemed so promising under Mayor Seidel, had deteriorated into a housekeeping version called sewer socialism under Mayor Hoan. It took great faith in a socialist

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[16] *Ibid.*, 384–88; Edward J. Muzik, "Victor L. Berger and the Red Scare," *Wisconsin Magazine of History*, XLVII (Summer 1964), 309–18; *Hearings Before the Special Committee Appointed under the Authority of House Resolution No. 6 Concerning the Right of Victor L. Berger to be Sworn in as a Member of the Sixty-Sixth Congress* (2 v., Washington, 1919); Zechariah Chafee, Jr., *Freedom of Speech* (N.Y., 1920), 310–33.

[17] Olson, Milwaukee Socialists, 388–90, 441–42, 448–50.

future even to maintain a party organization from election to election. Ideological disputation, long the stock in trade of Socialists, gave way to factionalism, personality differences, and a scramble for personal preferment.

Thus Congressman Berger no longer claimed a socialist, only a Milwaukee, constituency. Nó one seriously expected a Socialist revival, even in Milwaukee. All one hoped for was to sustain the present officeholders and quiet the dissidents who wondered aloud what had happened to the fiery zeal of 1900. The respect Berger had once sought for his party and his movement he now craved for himself. He was not so much a lone Socialist in Congress; London had been that too, for three terms. He was rather the vindicated victim of a war time hysteria. The U. S. Supreme Court, Fifth District voters, and the House itself had in turn confirmed this. While he retained his love for the stereotypes of non-revolutionary socialist programs and socialist rhetoric, he spoke in Congress most commonly about international affairs and the issues and consequences of the war. Set apart from most Congressmen by his Central European upbringing and his informed interest in the larger movements of Europe and the world, he addressed himself to the deepening American disillusion with the war and the war settlement and to relations among the great powers of Europe. Here and there an underlying socialist analysis shone through, but generally the viewpoint was more personal and his major concern over civil liberties and Prohibition reflected election needs. Today his remarks reflect the shallowness of contemporary comment; then they drew attention to his education, his reading, and his essentially foreign cast of mind.[18]

If Berger continued to stand apart from his House colleagues as in 1911, it was due less to his Socialist label than to his personal independence. Yet he enjoyed far more than in 1911 friendships with other House members. The respect of some who differed from him most like John Nance Garner is reflected in their farewell remarks, while the friendly Fiorello LaGuardia saw Berger as "a pioneer, popularizing ideas of political and social reform long before they are accepted by the many, and while they are still frowned upon by the majority and denounced by political leaders."[19]

Berger's election as the first Socialist in Congress had been a natural by-product of his obsession with local Socialist political activity. He had fashioned in Milwaukee the most thoroughgoing and durable political organization the American Socialists ever saw, and thus won for himself not only a Congressional seat but

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[18] *Ibid.,* 442–48. Berger, *Voice and Pen, passim.*
[19] *Congressional Record,* 70 Cong., 2 sess. LXX (Mar. 4, 1929), 5275.

a place in the Socialist pantheon along with Debs, Hillquit, London, Hoan, and Thomas. But before his death in 1929, the socialist conviction and optimism which had sustained his early party activity had given way to personal advancement and despair. "The Socialist party of Milwaukee," he had told his closest friends, "will not survive my death by six months." He was wrong. He had already outlived it.[20]

[20] Olson, Milwaukee Socialists, 451–52, 573–74.

WHEN SEDITION LAWS WERE ENFORCED: WISCONSIN IN WORLD WAR I

John D. Stevens

Today, with television and Broadway shows satirizing public officials, with militants calling for armed rebellion, with young men chanting, "Hell no, we won't go," it is important to remember that it was not always so.

Certainly it was not so during World War I, when men went to prison for chance remarks in bars, rooming houses and on street corners, when the Post Office hounded foreign language papers out of business, when wearing an Industrial Workers of the World pin made you, automatically, a disloyalist.[1] Such "crimes" were prosecuted under local ordinances, state sedition laws, and primarily under federal statutes. This paper attempts to examine the enforcement of these federal laws in Wisconsin, which had the nation's highest proportion of German descendants and one of the nation's most active and successful socialist parties.[2]

Although President Wilson had been urging an internal security law since December, 1915, Congress could not agree on one, so the United States entered the war with only the Conspiracies Act of 1861[3] and the Treason Act of 1862.[4] Neither reached individual utterances.

The federal security package included five major laws which curtailed expression: Threats Against the President Act,[5] Selective Service Act,[6] Espionage Act,[7] Trading-with-the-Enemy Act,[8] and Sabotage Act.[9] These were supplemented by many presidential

[1] See e.g. Chafee, Zechariah Jr., *Free Speech in the United States* (1941) ; Johnson, Donald, *The Challenge to American Freedoms* (1963) ; Scheiber, Harry N., *The Wilson Administration and Civil Liberties* (1960).

[2] See Peterson and Fite, *Opponents of War 1917–1918* (1957) ; Preston, William Jr., *Aliens and Dissenters* (1963), and Maxwell, Robert S., *Emanuel L. Philipp, Wisconsin Stalwart* (1959), discuss Wisconsin's reputation for disloyalty.

[3] 12 *U.S. Statutes* 284

[4] 12 *U. S. Statutes* 589. This law was used to convict some anarchists; cf., *Goldman v. U.S.*, 245 U.S. 474 (1918)

[5] 39 *U.S. Statutes* 919.

[6] 40 *U.S. Statutes* 76.

[7] 40 *U. S. Statutes* 217, with amendment, 40 *U.S. Statutes* 553. The 1918 amendment sometimes is referred to as the Sedition Law.

[8] 40 *U.S. Statutes* 425.

[9] 40 *U.S. Statutes* 533.

orders and directives.[10] These five laws will be discussed in chronological order, with particular emphasis on their enforcement and effects in Wisconsin.[11]

THREATS ACT

Spurred by the growing menace of war, the House of Representatives passed the act in June, 1916; the Senate concurred in February, and the President signed it on Valentine's Day, 1917. There had been suggestions for such a law since the 1901 assassination of President McKinley.

The brief law provided up to five years and $1,000 fine for mailing any "threat to take the life or to inflict bodily harm upon the President of the United States." Federal courts interpreted "threats" quite broadly, to mean something akin to the fifteenth-century English high treason law which made it a crime to imagine the death of the sovereign. By June 1918, 35 persons had been convicted under the law, and in Wisconsin nearly twice that many had been indicted.[12] Two men were convicted and five others pleaded guilty during the war. Penalties ranged from $100 to 18 months in prison. Without a broad interpretation of "threats," it seems unlikely any of them would have been convicted.[13]

A Racine policeman was the first person indicted under the law in Wisconsin. Allegedly he told another man that Wilson would be shot within 30 days and that if no one else did it, he would do it himself. During his trial in May, 1918, he denied making the last part of the statement and said the first was based on astrology. He said he was discussing astrology with another man when a third person overheard the conversation and reported it to federal officials. The jury was not impressed, and he was sentenced to 18 months in Leavenworth Prison.

Both indictments brought in the Eastern District were against Shawano County men, and both were joint actions under the Threats and Espionage Acts. One man had allegedly said, "If I was drafted I would take a straight shot for President Wilson's house and would do away with him if I got the chance." His case was dismissed in March, 1919, without coming to trial. The other was indicted and tried for saying in a private home in the presence of

[10] E.G., Alien Enemies Proclamation (April 6, 1917); Federal Employees Loyalty Order (April 7, 1917); Order Creating Committee on Public Information (April 14, 1917); Cable and Telegraph Order (April 28, 1917); Order Establishing Board of Censorship (October 12, 1917).

[11] Unless otherwise specified, information on Wisconsin cases was taken from federal court records in the Federal Records Depository at Chicago; in some cases, details were added by contemporary newspapers.

[12] *Report of the Attorney General* (1918), p. 56.

[13] Among decisions holding that the threat need not be communicated to the President were *U.S. v. Strickrath*, 242 F. 151 (1917); *U.S. v. Jasick*, 252 F. 931 (1918); *U.S. v. Metzdorf*, 252 F. 933 (1918); *U.S. v. Stobo*, 251 F. 689 (1918).

three other persons, "The President is the one that caused this war. He ought to be killed and if I had the chance I would kill him in a minute." The jury refused to convict him, perhaps because the trial came a month after the Armistice. It should be noted that the only Threats Act indictment which resulted in a conviction in the Eastern District was also the first one brought there.

On the other hand, in the Western District the first man indicted entered a plea of guilty and got off with the lightest penalty of all, a $100 fine. In October, 1917, he allegedly said:

> We ought to clean out the White House. Wilson wants to be shot before they shoot the Kaiser. If Wilson is not shot before he gets out of office, he will be after he gets out of office if he doesn't get out of the country.

Indictments were returned in March, 1918, against three men and one woman. The case against an Ashland man who was also indicted under the Espionage Act for saying "I'd kill the President like a dog" never came to trial. A German-American from Marathon County was sentenced to six months in the Milwaukee County House of Correction for saying, "I am a socialist. President Wilson is a son of a bitch and I would hang him if I had my way."

A young Eau Claire County farmer was indicted for saying that if he had an airplane he would "get that damned Wilson" and that if he were drafted he "would like to kill that goddamned Wilson." He pleaded guilty but told the judge he had been drunk. Unmoved, Judge Sanborn sent him to Leavenworth for a year and a day. The wife of a butcher at Milladore in Wood County, after hearing of the sinking of the *Tuscania* troop ship, which was carrying a large contingent of Wisconsin troops, allegedly threatened to put a bullet in the head of President Wilson. She was convicted in a one-day trial in August, 1918, and sentenced to six months in the Eau Claire County Jail or a fine of $500. She chose the latter.

A Dunn County man pleaded guilty in March, 1918, to saying, "The President ought to have been killed long ago, and if somebody does not do it, I will." He served 30 days in the Eau Claire County Jail for his indiscretion.

The final case was not related to the war at all and indicates how broadly the statute was being interpreted by federal judges. A Prairie du Chien man, three weeks after the Armistice, allegedly said, "I will shoot Wilson, the son of a bitch, if the country goes dry July 1." He was indicted May 12, 1919, and two weeks later entered a guilty plea. He was sentenced to 30 days in the Dane County Jail.

By most standards, none of these 10 persons posed much of a threat to President Wilson. For that reason, it might be instructive to review the only statement recorded about the purpose of the law by the author himself. During the congressional debate, Representative Webb said, "The man who makes the threat is not himself very dangerous, but he is liable to put devilment in the mind of some poor fellow who does try to harm him (the President)."[14]

Although no one can tell how much "devilment" the quoted remarks put in the minds of hearers—especially since the indictments did not indicate the context of most of the remarks—it seems unlikely that the hearers in Wisconsin posed much threat to the President. The same could be said about other persons reported in the newspapers as arrested under the Threats Act but who were not actually indicted.

From 1921 until World War II, the law was a virtual dead letter. Three cases under the Threats Act were appealed during the war and two have been appealed since. The Threats Act remains on the statute books, in peace as well as war time, and in 1962 was broadened to protect the Vice-President or other person next in line for the presidency, as well as the President-elect and the Vice-President-elect. It was 1965, in the aftermath of the Kennedy assassination, before Congress passed a law which protected the life of a President.[15]

Selective Service Act

The conscription law of 1917 made it a crime to discourage men from registering or serving in the military services. There were widespread fears of draft riots such as those of the Civil War, but they were not realized.

In spite of Governor Philipp's later recollection that there was no opposition in the state to the draft "save now and then an individual," the dockets of the two federal courts in the state contain the names of hundreds of men indicted for draft violations, most of which were quietly dropped when the men "volunteered" for immediate army duty. Attorney General Gregory assured a congressman in July, 1918, that this was the usual procedure for men failing to register. He said that through June 8, there had been 8,802 actions under the draft laws through the nation; of these, 4,064 dealt with failure to register.[16]

From among the many indictments under the draft act, five Wisconsin cases have been singled out which resemble closely in-

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[14] *Congressional Record,* 65 Cong., 2d Session, 9377.

[15] The Threats Act now is 18 *U.S. Code Annotated,* Section 871.

[16] Philipp, "Wisconsin's War Activities," *Wisconsin Blue Book,* (1919), pp. 301–303; *Congressional Record,* 65 Cong., 2d Session, 528.

dictments brought under the Espionage Act for expression. One, in fact, was a joint draft-espionage action.

This involved nine members of a "Holy Roller" fundamentalist religious colony in Barron County who were indicted in March, 1918. When they appeared in court June 3, they refused to plead, but instead made anti-war religious speeches. The judge ordered a not guilty plea entered in their behalf and placed them in jail when they refused to post bond. The men were indicted on 13 counts based on 16 separate speeches, personal letters, personal advice, and articles in their paper. After a three-day trial which ended July 20, all were found guilty. The leader was sentenced to 15 months at Leavenworth, and three other members were sent there for a year and a day. The other six were given terms of three to six months in county workhouses, although four of the six were permitted the option of paying fines of $250 to $500.

In another case, in June, 1918, three men were indicted jointly under the draft and espionage measure, but the indictment has been lost. A newspaper reported that their arrest at Ashland was for saying Wilson was responsible for the war and for the sinking of the *Lusitania.*

A wealthy Grant County farmer was convicted by a jury in 1918 and sentenced to a year and a day at Leavenworth plus a fine of $1,000. He was indicted on five counts and convicted on two, including the following statement made to draft-age men:

> This is a rich man's war and we would not have this war if it had not been for the rich girls in the United States marrying English lords. We had no business to start this war. The issue that Wilson was elected on was not to start war. They loaded supplies for the Allies on boats and hired a few Americans and put them on those boats and they were killed and this started the war. We had no cause to be in this war. The Germans killed no Belgian citizens and there are no orphans in Belgium or France that were caused by the war. The Germans have done no worse than Americans have done to Germans. We have no business in this war. We went into it to protect the money that was loaned to the Allies. The money interests hired a few Americans to ride on those ships so that if they were killed we could get into the war.

The jury, according to a newspaper, was out for only a half hour in convicting the 58-year-old father of seven.

This was the only case in which the judge's charge to the jury was preserved in the archives. It was given by special judge Evan A. Evans. In his charge, Evans denied the defense attorney's contention that such words had to be spoken to a person already in the service or who was about to be called; it was enough that they be spoken and there be some reasonable chance that they might somehow be conveyed to a soldier or potential soldier.

The fourth draft case involving expression was that of a Wood County man whose remarks were made in Polish in the summer of 1918 to some prospective draftees. After a one-day trial he was sentenced to six months in the county workhouse and fined $500 for saying:

> The kaiser will fare along better than ever because he has made peace terms with Ukrania, but the kaiser will pay no attention to the papers that were signed. It is coming to it that President Wilson will have to crawl on his knees to kiss the kaiser's boots. The submarines will work havoc with American boats. They have sunk nine boats and of a total of 1,000 persons on those boats, only 40 were saved.

It is difficult to imagine where the Wood County man got his "facts," but the jury decided that his remarks could frighten some rural Wisconsin lads enough that they might not fulfill their military duties.

The most celebrated draft case in the state had nothing to do with free expression directly but much to do with it indirectly. This was the action against Congressman John M. Nelson of Madison and his draft-age son, Byron.

To understand the free expression implications of the case, one needs to bear in mind that Nelson had voted against most war measures, including the declaration of war. He had been in Congress since 1906 and was clearly identified with the La Follette wing of the Republican Party. (In 1924, he managed La Follette's presidential campaign.) He had alienated many Republican "regulars" in Congress by his role in the 1908–1910 fight to prune the powers of Speaker Joe Cannon.

When, in August, 1917, the federal district attorney announced that he would seek indictment of the congressman's son for not registering for the draft, Nelson realized that he was the real target. Nelson knew his way around Capitol Hill and had many friends. On September 4, he sent a long letter to Attorney General Gregory refuting one by one the charges against his son. Byron was charged with not registering on "Duty Day"; however, those residing in foreign countries were specifically excluded from the registration requirement, and Byron had been managing a family farm in Alberta since May 5. This was 15 days before the draft act was enacted, 28 days before the President's proclamation establishing the registration date, and a month and two days before the registration day itself. Nelson said that at the time he had asked his son to go north he had no way of knowing what the terms of the act would be. His son had worked on the farm during summers while attending the University of Wisconsin. Nelson even sent Gregory a published "Roll of Honor" which showed that his son ranked fourth among students in donating their time during the spring to work on the university farm. Nelson further assured Gregory that in May he had received assurances from the Provost Marshal General that persons living abroad did not have to register for the draft. He had reaffirmed this in person with the Provost Marshal on September 1 after reading of the district attorney's intention to prosecute. Nelson cashed in some of his other political debts. For example, he convinced Speaker Champ Clark to write a confidential note to the Postmaster General on his behalf.[17]

In October, Byron pleaded not guilty to the draft evasion charge in the federal court in Madison. In late November, the Congressman was indicted for conspiracy to avoid the draft and his son for failure to register. Both entered pleas of not guilty and were released on bond. One month later, on January 3, the federal judge quashed both indictments. Although the irate district attorney told the press that he would appeal the judge's decision, he did not. That was the end of the case, at least in the courts.

Although the Nelson case was over in the courts, it was "retried" at the polls in the spring primary, and Nelson lost; however, he won back his seat in 1920 and held it until defeated by a gerrymander in 1932.

Espionage Act

If, as John Roche suggested, World War I was a "black mass celebrated by the elected leaders of the American nation,"[18] then surely the Espionage Act must be considered its litany.

Only two provisions of the lengthy law affected free expression. Section 3 of Title I made it a crime to interfere with the military or recruiting services, while Title XII made it illegal to mail matter which violated other sections of the law. Strictly construed, these would have had little effect on expression.

That they were not so construed was shown by the number of prosecutions. Chafee wrote that 877 persons were convicted under Section 3 and more than 100 publications banned from the mails under Title XII. Chafee based his figure on annual reports of the Attorney General, which for the two federal courts in Wisconsin

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[17] Nelson to Gregory, May 4, 1917, and Clark to Nelson, December 14, 1917 in John M. Nelson Papers, State Historical Society of Wisconsin, Madison, Box 1.

[18] Roche, John P., *Quest for the Dream* 49 (1963).

were too low. Other estimates ran higher, but it seems likely that there were at least 2,000 actions and 1,000 convictions under Section 3. Virtually all were for expression.[19]

Punishments under the law were harsh. At least 35 persons went to prison for the maximum 20 years and another 58 for 10 to 15 years; others received shorter sentences and fines. Still, the man who directed the law's enforcement admitted that there was not a single proven case of sabotage in the nation after the declaration of war, and Charles and Mary Beard concluded the law did not catch one bonafide spy or saboteur.[20]

Twelve days after the United States declared war, Senator Lee Overman of North Carolina introduced an omnibus measure which covered such diverse security matters as the embargo, conveying secrets to foreign agents, passports, impounding enemy vessels and counterfeiting the government seal. He described it as substantially the same measure which the Senate passed during the previous session but which died in the House.

Both in the press and on the floor, most of the controversy centered on a section which provided five years in prison and a $10,000 fine for publishing information declared by the President to be useful or even possibly useful to an enemy. There was much less attention to Section 3 of Title I which, as enacted in 1917, provided 20 years in prison and $10,000 fines for anyone who while the United States was at war should willfully make or convey false reports or false statements with intent to interfere with the operation or success of the military or naval forces of the United States or to promote the success of its enemies: and whoever, when the United States is at war, shall willfully cause or attempt to cause insubordination, disloyalty, mutiny, or refusal of duty in the military or naval forces of the United States, or shall willfully obstruct the recruitment or enlistment service of the United States.

Title XII allowed the Postmaster General to refuse to convey any letter or printed matter "advocating or urging treason, insurrection, or forcible resistance to any law of the United States." Maximum penalties were set at $5,000 and five years in prison.

In introducing the measure, Senator Overman assured his colleagues the measure in no way limited freedom of the press or of individuals to comment on governmental policies. He assured them that the courts could be trusted to interpret the law in a reasonable manner.[21]

For three days, the Senate debated the press censorship section, but in the end rejected it. The House accepted the mail section with

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[19] Chafee, *op. cit., supra* note 1, at p. 52.

[20] O'Brian, John L., *National Security and Individual Freedom*, 49–50 (1955); Beard, Charles and Mary, *The Rise of American Civilization*, Volume II, 644 (1927).

[21] *Congressional Record*, 65 Cong., 1st Session, 778–781.

a few minor wording changes over the warnings of its only socialist member that Title XII would be the death knell for minority opinion press in this country. The bill passed, 260–106. The Senate then debated the bill for two days in executive session and for three more in public. On May 12, the Senate defeated the censorship section and later at attempt to reinstate it. The upper chamber prohibited postal inspectors from opening sealed letter and adopted the bill, 77–6. Wilson signed it June 15. Once shorn of its press censorship section, the Espionage Act was greeted by newspapers either with praise or with indifference.[22]

Early in 1918 the Attorney General requested an amendment to Section 3 to protect government bonds from criticism. The Senate Judiciary Committee broadened the amendment to cover disparaging remarks about the flag, the military forces, the Constitution or form of government. The amendment, sometimes called the Sedition Act of 1918, provided 20-year prison terms for remarks which interfered, even remotely, with the war effort or aided the enemy. The sponsoring committee admitted the amendment was quite superfluous since most district judges had interpreted the 1917 law to cover such offenses. During the seven days of debate, at least five senators said that such an amendment would help quell the mob spirit in the land. Gregory used the same argument in his 1918 report.[23]

The Senate strengthened Title XII, permitting the Postmaster General to refuse even to pick up or deliver mail during the war at addresses using the mails in violation of the act, thus crimping socialist and radical defense committee collections. On April 9, the Senate refused to incorporate even the protections of the 1798 sedition law, excluding truthful remarks made with good motives.[24]

Of the 92 indictments in Wisconsin under the Espionage Act—several in conjunction with the Threats, Draft or Trading acts—all but two involved expression. Since most judges and juries used ill tendency as their standard from the beginning, the 1918 amendment made little difference.

Analysis of the preserved indictments shows that the offensive remarks fell into certain logical categories, shown in Table 1. A few representative Wisconsin cases will be discussed for each category.

Thirty-six indictments included remarks praising Germany or the Kaiser or expressing the belief or hope that Germany would

[22] *Congressional Record,* 65 Cong., 1st Session, 847, 871–887, 1590–1596, 1698–1701, 1717–1720, 1750–1780, 1807–1841, 2055–2072, 2087–2113, 2166–2196, 2241–2270.

[23] *Congressional Record,* 65 Cong., 1st Session, 3002–3004, 4559, 4562, 4633, 4637, 4645–4646, 4710, 4764–4771, 4824.

[24] *Congressional Record,* 65 Cong., 1st Session, 4562–4563, 4637, 4784, 4826, 4835–4839, 4895–4898, 5541. Procedural safeguards did little to protect defendants under the 1798 law, according to Smith, James M., *Freedom's Fetters* 421–424 (1952).

TABLE 1. TYPES OF REMARKS INDICTED UNDER ESPIONATE ACT 1917–1918 IN WISCONSIN

Praising Germany	36
Criticizing U. S.	35
"Rich man's war"	32
Criticizing Allies	17
Insulting flag, uniform	9
Criticizing bonds	19
Criticizing food laws	9
Criticizing charities	15
Obstructing recruiting	17
Praising ship sinkings	3

(Total exceeds 90 because some indictments were for multiple remarks)

win the war. Such remarks seem more likely to produce a brawl than a breach of national security. While society has an interest in preserving peace and tranquility, punishing a man for remarks on this ground alone is like punishing a rich man for keeping money around to tempt thieves. A similar breach of peace rationale has all but disappeared from American criminal libel law.[25]

Two Wood County men were convicted for remarks favoring Germany in July, 1917. One, a 44-year-old native of Prussia, was sentenced to two years in prison for saying, "I wish the war would end and the Kaiser would win. Yes, God damn it. We will never have good times until the Kaiser wins." Although he had lived in the United States for seven years, his record showed that in 1914 he had been denied citizenship papers because he was not a "law abiding and peaceful" man. The jury was sworn in one morning, heard five government witnesses plus the defendant in the afternoon, and convicted him before nightfall.

The other man was a Pole employed at a Grand Rapids paper mill. Three fellow workers, through an interpreter, told the court the man had said the Kaiser was sure to win the war and to sink all the American troop ships. The defendant told the court that 25 years before he had fled Europe after killing a German officer who disciplined him. His court-appointed attorney told the jury that surely it could not find this man disloyal or pro-German. "He is the only man in this courtroom who bears on his body a scar inflicted by the brutality of Teutonic autocracy." After hearing the prosecutor tell them that their only duty was to decide if the words had been spoken, not to judge their criminality, the jury proved it certainly could find the Pole guilty. It took them only 90 minutes to convict him, and the judge imposed a six-month term in the county workhouse and a $500 fine. A Madison druggist who long

[25] Anon. "Constitutionality of the Law of Criminal Libel," 52 *Columbia Law Rev.* 521 (1952).

had been prominent in German-American societies pleaded guilty to similar remarks and was fined $2,000.

Even doubting the worst about the enemy could get a man in trouble, as it did a prosperous 68-year-old Grant County farmer who, among other statements, expressed disbelief about reports of German atrocities. (After the war, investigations showed that nearly all such tales were untrue.) The principal prosecution witness was a neighbor who had a long-standing grudge with the defendant over a land transaction. This hostile witness testified he heard the farmer say, "The Germans killed no Belgian citizens and there are no orphans in Belgium or France that were caused by the war. The Germans have done no worse than Americans have done to Germans. . ."

The farmer, the father of seven including a soldier in France, denied making such statements, but the judge ruled the neighbor's testimony admissable as he did that of two representatives of the Council of Defense who said there had been rumors about the farmer's disloyal remarks on other occasions. The jury took 35 minutes to convict. The sentence: a year and a day at Leavenworth prison plus a $1,000 fine.

Thirty-three indictments quoted criticisms, often quite pointed, of the American conduct of the war. Some of the offensive remarks said the Administration was too zealous, others that it was lethargic. Such opinions would seem to pose small danger to the success of a war; at least the United States managed to win World War II without prosecuting such criticisms.

One of the heaviest punishments—15 months in prison—was meted out to a 37-year-old Russellite evangelist from Milwaukee who was arrested at Plover in Portage County. He was convicted on four counts in a one-day trial at Eau Claire in July, 1918. His remarks, delivered in Polish, were translated thus in the indictment:

> The Constitution of the United States says that the government of the United States cannot compel a person to go to another country to fight, but Wilson has spoiled the Constitution, and is compelling men to go to other countries to fight. President Wilson started the war and he is now going to run away.

A socialist attorney at Milwaukee was indicted in October, 1918, for telling two men (including a judge) that the United States had no business in the war and that its army should not be in Europe. On another date, he allegedly told a woman at Whitefish Bay, "You are upholding the cruelest and most abominable form of government in existence."

A traveling salesman from Minneapolis was indicted in the Western District of Wisconsin for a remark he allegedly made in 1918 in a Portage store. He was accused of saying, "This Government was not ready for war. If Mexico were to rise up we could not protect our own country. The President and the Administration are to blame." He was indicted three weeks after the Armistice but his case was dismissed six weeks later.

A Milwaukee machinist was indicted for questioning the constitutionality of the draft law, and a former postmaster at Fall Creek got into trouble for questioning the constitutionality of the Espionage Act. Both cases were dropped without coming to trial, but the circumstances surrounding the Eau Claire County case are worth considering.

Six men called on the former postmaster to see why he had not taken his assigned "quota" of $500 in Liberty Bonds. Allegedly he told them, "The Government of the United States is dishonest. Freedom of speech has been abridged by the espionage law. Freedom of the press has been denied by the espionage law." The solicitors told the commissioner who heard the complaint that they had been chased off with a shotgun, but the ex-postmaster said he did not threaten them. He said he was carrying the gun because they were waiting for him when he came in from hunting. As to the remarks, he admitted criticizing the espionage legislation but denied saying the nation was dishonest. Although he never was penalized under the law, he was under indictment until July, 1920.

The most frequent words quoted in indictments were "rich man's war." The term had been part of the vocabulary of socialists, Wobblies and other anti-capitalist radicals for many years. In the case of the socialists, at least, they were saying the same things in Germany about the capitalist Junkers. Some of the remarks included under this heading were close equivalents, but all indicated a belief that it was a money war.

Since it is impossible to prove the cause of any war—historians have suggested more than 100 causes for the American Civil War, and a century after the shooting seem no closer to an agreement than they were at the time—a statement about its being a "rich man's war" can be considered no more and no less than an opinion. Certainly it is not a false report.[26]

A socialist who ran for the assembly from Sauk County in 1916 was indicated in 1918 for telling two neighbors it was a rich man's war. He pleaded guilty and was fined $500, the same fine imposed on a Medford physician who ran for sheriff as a socialist and made similar remarks during his campaign. A Wood County man was

[26] Anon., "The Espionage Cases," 32 *Harvard Law Rev.* 417 (1919).

sent to the workhouse for three months after pleading guilty to calling the war a "millionaire's graft."

Criticizing Great Britain or France was apparently as serious an offense as criticizing the United States' war effort. The first indictment under the war statutes brought in the Western District was for such remarks. The owner of a Madison hotel allegedly told some draft-eligible Italian-Americans that since the war was being fought for England's benefit they ought to head back to Italy to avoid the draft. At the time of his arrest in August, 1917, the federal district attorney was quoted in the press as saying, "This thing of saying we are fighting for England must stop. I am going to have all such persons tried if I can obtain indictments for them. Any other remarks tending to honeycomb our solid front and to give comfort to the enemy and cause disloyalty among our soldiers will be summarily dealt with if I have my way." The hotel owner pleaded not guilty and was released on bond. Two years later the case was dropped without coming to trial.

The 1918 amendment was a new wrinkle in American law, protecting symbols from offensive words. Nine Wisconsin indictments referred to verbal attacks on the flag or military uniforms.

On August 17, 1918, there was great excitement in the little Racine County town of Corliss. Men and women were scurrying about, stringing up bunting and flags for a Red Cross parade. The town marshal was just stepping back to admire the decorations when he saw a threshing rig heading straight for the biggest American flag, draped from a wire across the main street. Apparently the rig operator did not hear the warnings. Suddenly the top of his stream machine caught the flag, yanked it down, and devoured it.

Three or four men raced out and waved down the operator, who pulled over to the side of the road. Over the terrible roar of the machine, they carried on an animated conversation about how he had ruined the flag.

"Keep the damned flag out of the road," the operator shouted back. "It's a public highway."

Three months later, the operator was indicted for insulting the flag, not as one might expect for tearing it down, but rather for calling it a "damned flag." He pleaded guilty and was fined $200.

As was pointed out earlier, the original excuse for requesting the 1918 amendment was to protect government securities from disparaging remarks. Attacks on Liberty Bonds and Thrift Stamps were quoted in 19 Wisconsin indictments.

For telling three other men that the government "makes men buy bonds so that they can get their wages away from them," and that the bonds would be worthless after the war, a Richland Center socialist was sent to Leavenworth for a year and a day. It cost a man from near Wausau $500 to say that the bonds would not be worth 40 cents on the dollar after the war. Unfortunately for him, he made the remark in the presence of the vice-president of the local Loyalty Legion. A Washburn man told a Liberty Bond salesman that the bonds were no good for the poor man. Tried and convicted nearly a year after the Armistice, he was fined $200.

Truth certainly was no defense, since a Taylor County man was fined $1,250 for saying the money from bonds was being used to help England defeat Germany. A Grant County farmer who said "they can't make us buy any bonds" was fined $600.

Although there was no rationing, a federal Food Commissioner in each state enforced rules against hoarding and profiteering. Eight Wisconsin indictments mentioned criticisms of the food controls; however, of these cases, one stands out because it was one of only two to be reversed on appeal and one of the few to involve a prominent state politician, John M. Becker, circuit court judge at Monroe for 21 years.

Becker was a lifelong Democrat who supported La Follette's stand against the war; in fact, Becker promoted a referendum on whether the nation should enter the war. The election was April 3, 1917, the very day Wilson went before Congress to ask a declaration of war. The vote was 954 to 95 against entering the war.[27]

Two days later, Becker addressed a patriotic rally, urging all citizens to be loyal to the nation once war was declared. He threatened criminal libel actions against those circulating rumors he had been charged with "aiding the enemy." In August, Becker hinted and in January confirmed that he would run for governor on an anti-war platform. His candidacy, however, was short-lived, because the Attorney General announced that Wisconsin law prohibited anyone from holding a judicial post and running for another office.[28]

Becker's troubles were only beginning. In May he was indicted under the Espionage Act for saying on February 5:

> The idea of having an administrator of fuel and food is ridiculous. There is no shortage of food. The idea of a shortage of food is being preached by agents employed by corporations for their own gain, and going about the country on high paid salaries. This is a rich man's war. We won't have peace as long as these high-salaried fellows have jobs to protect. There is no labor shortage. There is no seed shortage. Farmers, beware of taxes, war taxes, which must be paid in July.

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[27] *Monroe Evening Times,* March 23–April 4, 1917.

[28] *Monroe Evening Times,* April 5–6, May 10 and November 19, 1917, and January 8, 1918.

(His jury refused to convict on a second count based on testimony from a German woman bitter at Becker over settlement of her husband's estate.)

The Circuit Court of Appeals detailed the circumstances surrounding the meeting at which Becker's food remarks were made. Because Green County had failed to meet its quota in the first two Liberty Loans, the state Council of Defense insisted the county council be reorganized. The county board called a meeting for this purpose, but because of a storm, only six of the 27 elected board members showed up. These six got into an informal discussion with 50 or 60 spectators, and in the ensuing session Becker spoke for 15 to 20 minutes. Two witnesses swore that the thrust of his remarks were patriotic and that the statements quoted in the indictment were taken out of context. Other witnesses admitted they were talking among themselves and could not hear what Becker was saying. The appellate court reversed the conviction on the grounds that the words were not unpatriotic. The court also objected to testimony introduced during the trial about how many Liberty Bonds the defendant had purchased and to the fact that one witness gave a Sunday dinner to the other witnesses.[29]

The trial was conducted at Eau Claire in August, 1917. One witness collapsed from the heat. Almost none of Becker's questions were about the food remarks but dealt with personal attitudes and his gubernatorial platform. At one point the special deputy district attorney called the platform "bunk." Two friends helped Becker down from the stand after the long afternoon. The jury consisted of 10 farmers, one miller and one mechanic. After a week of testimony, it took them six hours to convict Becker. Wolfe told reporters he considered the conviction an important one since it might "deter" lesser individuals who might be inclined toward disloyalty.

On August 16, Becker was sentenced to one year in federal penitentiary on each of three counts, the sentences to run consecutively. He was released on $20,000 bond, pending the appeal which was decided October 5, 1920.

Upon his conviction, the state Attorney General ordered Becker to vacate his office. A successor was appointed and sworn in. After the reversal, Becker sued to recover his lost salary, but the Attorney General ruled against him on the ground that state law required resignation only for conviction of an infamous crime and the Espionage Act did not so qualify. The Attorney General told Becker the earlier order had been only "advisory" and that he complied of his own volition.[30]

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[29] *Becker v. U.S.*, 268 F. 195 (1920).
[30] *Opinions of the Attorney General* (1920), pp. 529–534.

By April, 1917, there were 159 voluntary war relief agencies in the United States, all conducting fund drives. The Red Cross alone collected more than $400 million during the war.[31] Fifteen Wisconsin indictments quoted criticisms of the war agencies. It was in the conviction of Louis B. Nagler of Madison[32] that the legal principle was established that such criticism could be prosecuted under the Espionage Act.

Nagler, like Becker, was a prominent supporter of La Follette. While assistant secretary of state, he published a letter in the Madison paper defending the senator's anti-war stand. His indictment resulted from remarks in November, 1917, to solicitors for the Red Cross. He told them he was through "contributing to your private grafts." He named the YMCA, the YWCA and the Red Cross and said "not over 10 to 14 per cent of the money collected goes to the soldiers or is used for the purpose for which it is collected." His indictment reasoned that since the Red Cross was chartered by Congress, it was a "government agency" within the meaning of the Espionage Act. Although the YMCA and YWCA were not chartered, they were engaged in similar morale work and logically should be covered, too.

Nagler's trial was scheduled immediately before Becker's, and the district attorney made it clear they were to be showcase trials. His jury of 10 farmers, a miller and a railroad employee (five of whom had relatives in the army) wasted little time in convicting.

The Circuit Court of Appeals upheld the conviction, and to the defense contention that such a decision would encompass even the Jewish Relief Agency, the Knights of Columbus and the Salvation Army, the court wrote, "With this position I agree." In July, 1921, the United States Supreme Court remanded the case for a new trial, at which point it was quietly dropped. Nagler certainly was not cowed during the appeal. He even wrote a congratulatory letter to Victor Berger on his fine showing in the 1918 senatorial election.[33]

Among the other 14 Wisconsin indictments which included comments about voluntary agencies, all but one were based on replies to solicitors. The exception was a Milwaukee woman who said it was foolish to sew for the Red Cross since the rich people took all the garments and they never reached the soldiers. Her case was dropped without coming to trial.

The tragedy which brought the war home to many Wisconsin citizens was the sinking of the troop ship *Tuscania* in the spring of

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[31] Cutlip, Scott M., *Fund Raising in the United States* 110–139 (1965).

[32] *U.S. v. Nagler,* 252 F. 217 (1918). See Nagler, "A Fragment of War-Time History," 121 *The Nation* 568 (1925).

[33] Nagler to Becker, Nov. 8, 1918, in Socialist Party Papers, Milwaukee County Historical Society, Milwaukee, Box 23.

1918. Soldiers from many Wisconsin communities went down with the ship. Those who lost friends or relatives were not in the mood for snide remarks about the incident.

For example, a Port Huron man went to jail for six months for remarks about the effectiveness of German submarines. One man was fined $300 for saying he hoped the Germans sank every ship that we sent across the sea, while another pleaded guilty to a federal charge arising out of his remark that "All those who go across ought to be at the bottom of the ocean."

Section 3 seemed to be aimed at persons who tried to keep others from fulfilling their duties, either by not registering or enlisting or by disobeying superior officers; still, few prosecutions had anything to do with recruiting.[34]

Fifteen Wisconsin cases did involve some actual counseling. The most prominent man convicted for such an offense was a former state legislator and president of the Marathon County Telephone Company. During his eight-day trial in September, 1918, the prosecution called 27 witnesses, including the secretary of the Cassel town draft board who testified that Schilling had dissuaded more than 70 men from enlisting. The trial judge permitted testimony about his niggardly contributions to war charities and about his alleged hoarding of food, although neither was mentioned in the indictment. The jury was out only three hours before convicting. The next day the judge sentenced him to 18 months in prison plus a $3,500 fine.

A Lithuanian who had lived in this country for 16 years went to prison for a year and a day for saying he would not register and for telling others they were fools for doing so. A Racine man allegedly advised some Armenians not to report for the army if called, and he too was sentenced to a year and a day.

Four other indictments cited remarks questioning the legality, not of the draft but of sending drafted men overseas; however, none of these cases came to trial.

Trading Act

During the summer of 1917, the House devoted three days and the Senate two to enacting this omnibus measure, whose primary purpose was to establish guidelines for seizing and holding property owned by alien enemies, particularly German corporations. Not until the final 15 minutes of debate was there any mention of a provision affecting expression, and then there were two. One was virtually a carbon copy of the new Section 3 later added to the

[34] Apparently no prosecutor even attempted to prove injury to military procurement or allow a jury to consider possible effects of utterances. Nelles "In the Wake of the Espionage Act," 111 *The Nation* 684, (1920).

Espionage Act. After its defeat (because the sponsoring Commerce Committee did not want such an unrelated section in the act), Senator William H. King then proposed a requirement that all German-language publications print a parallel English translation. Penalties were to be $500 or a year in prison. King explained that he earlier had proposed a total ban on foreign-language publications, but that this measure was bottled in committee. The Utah Democrat asserted that his regulation "certainly works no great hardships" on any publisher while at the same time providing a good check on sedition for the postal officials and for neighbors. A spokesman for the Commerce Committee said he thought the Postmaster General already had sufficient censorship powers under the Espionage Act and expressed the hope that this irrelevant section would not be tacked on to the Trading Act. It was anyway, and the bill went to conference committee. The committee greatly expanded the mail section to cover publications in any foreign language. Instead of publishing English translations in adjoining columns, publishers now had to file such translations in advance of publication with local postmasters. Only material which dealt in some way with the war was covered by the requirement. The Speaker overruled objections that the conferees had exceeded their authority by adding new classes of crimes to the mail section, and the House adopted the report by voice vote.[35]

Most of the newspapers affected by the new regulations were one- or two-man operations, working on a tiny financial margin. Because filing translations cost both time and money, many foreign-language newspapers closed down. Others began publishing in English or tried to make their contents totally bland. That the latter tactic was not always successful for avoiding trouble with the federal officials is illustrated by the Auer case, described below. Auer's was one of seven actions brought under the Trading Act in Wisconsin. Three of the actions involved possession of explosives and had no expression connotations and are not considered here. Four actions did involve expression under the mail section of the Trading Act. One of these was a joint action with the Espionage Act.

Jacob J. Auer, a crotchety old man, was the editor and publisher of a little German-language weekly, the Eau Claire *Herold*. Most of his readers apparently were about his age. The younger generation had learned English in the schools and read "American" publications instead. Even his closest friends and relatives testified that old Jacob was senile and that sometimes he "acted strangely." He had been in this country more than 30 years and had been bitterly

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[35] *Congressional Record*, 65 Cong., 1st Session, 4840–4879, 4907–4930, 4968–4989, 6949–6958, 7007–7025.

disappointed a few years before the war when he was not appointed postmaster of Eau Claire.

In his edition of December 6, 1917, Auer published an editorial entitled, "Uncle Sam's Army Threatened by Slow Destruction." The menace he was describing was not the German army, but the United States Army's policy of giving all its recruits smallpox vaccinations. The article was long, rambling and none too coherent. Auer did not file a translation of it with the postmaster for advance clearance, nor did he submit the next week's issue, which quoted Hindenberg as charging the United States had used the submarine as an issue to enter the war on the side of the Allies. His December 27 edition carried an editorial which suggested Germany's enemies were on the verge of collapse. In subsequent weeks, he attacked those citizens who were persecuting everything which was German, praised the German-Russion peace treaty and cautioned his readers not to believe everything they read in the press about how many German ships the Allies were sinking. He did not file translations of any of these articles, the local postmaster told a citizens' protest committee meeting which met on March 15. The postmaster said Auer had filed translations of some other articles and editorials, however. The public meeting, which was sponsored by the county Council of Defense passed a resolution "to personally notify J. J. Auer that his attitude on the war, as expressed by said articles is seditious and disloyal, and warn him against publishing like articles in the future."

Auer hardly had the opportunity, since he was arrested by the federal marshal eight days after the meeting. The marshal waited until after Auer had put out that week's issue before taking him to Madison for arraignment. He was formally indicted in June, 1918, under both the Espionage and the Trading Acts.

He first entered a plea of not guilty and then tried to change it to *nolo contendere*. The special assistant federal district attorney objected because such a plea carried with it only a fine, not imprisonment. The judge refused the plea and Auer pleaded guilty.

Before sentencing, a Civil War veteran and long-time friend of Auer spoke on his behalf. He said there had been a noticeable decline in Auer's mental capacity during the last two years, a fact confirmed by both Auer's wife and his son. His relatives testified that the old man had purchased Liberty Bonds and had contributed to the Red Cross and other fund drives. The son told the judge that he did not think that his father really understood the translation regulation.

The prosecution charged the judge to show no mercy in assigning sentence. The judge said he was unmoved by the claims of mental incompetence since the articles seemed clearly written to him; however, he would be merciful because of Auer's advanced age. His version of mercy was a year and a day at Leavenworth.

If Auer's case seemed somewhat pitiful, consider the fate of poor Jacob Mueller, who edited the German-language *Dodge County Pioneer* at Mayville. In his edition of August 16, 1918, he ran a front-page story about Auer's conviction, adding at the end:

> Since October 6, 1917, the German newspapers have been under the knout and have not been permitted to print any war news unless a true translation is filed with the postmaster. Since we have no desires to pester police with translations we print absolutely no war news. We are not going to be caught.

Mueller was wrong about that. The district attorney thought Auer's conviction was "war news." With some earlier articles, this one formed the basis for his indictment in March, 1919. Mueller pleaded guilty and got off with a $50 fine. After all, the war had been over for four months.

Until March 4, 1918, there had been two German weeklies in Mayville, but on that date the *Dodge County Banner* had switched to English. Ever since, it had been attacking Mueller for supporting Victor Berger and for having no principles. When Auer was convicted the opposition paper wondered editorially if Mueller would relay that information to his readers. He did, much to his later regret.

On October 24, 1918, about two weeks before a special Senate election in Wisconsin in which he was a candidate, Victor Berger and four other officials of the Milwaukee *Leader* were indicted under both the Trading and Espionage acts. Among other charges, they allegedly had failed to file translations of some letters to the editor which had been written and published in German. The five were released on bond and the case finally was dropped in 1922.

Sabotage Act

That there were few prosecutions under this broad statute, which punished "malicious destruction or injury to property, no matter how essential the property might be to the conduct of the war," probably can be attributed to the fact that it was enforced by the Justice rather than the Post Office Department and that it was not signed until less than seven months before the Armistice. It is ironic that the federal government waited so long to prohibit overt acts of sabotage when it was so prompt to prohibit speech which might incite such overt acts.

There were three actions under the Sabotage Act in Wisconsin, two of them against employees of the E. I. du Pont Demours Company powder plant at Barksdale in Bayfield County. Plant guards were deputized by the sheriff and they kept a wary eye on "agitators." They were also stringent in their enforcement of the rule against having matches within the plant gates. One employee was arrested in July, 1918, and charged under the Sabotage Act for carrying four concealed matches in his socks. Two weeks later another employee was arrested for carrying 12 matches in his socks.

In the only Sabotage Act case tried in Wisconsin, a Milwaukee man was convicted by a jury for throwing ice tongs into plant machinery; however, the trial judge ordered the case dismissed for reasons not made clear in the preserved record.

There was a marked difference in enforcement in the two districts of Wisconsin. Not only were half as many persons indicted under the Espionage Act in the more populous, more socialist, more German Eastern District, but a far higher proportion of cases were dismissed without coming to trial. Table II compares the activity in the two districts.

Apparently the major variable was the vigor of the enforcers. Certainly the laws were interpreted quite differently by different federal judges.[36] Chafee pointed out that although Massachusetts

[36] The Department of Justice issued 204 "Interpretation of War Statutes" bulletins in an effort to increase consistency.

TABLE 2. ACTIONS UNDER FEDERAL WAR STATUTES IN WISCONSIN

	No.	Pled Guilty	Convicted	Acquitted	Dismissed
Espionage					
East	30	2	1	2	25
West	60	30	17	3	8
Threats					
East	3	0	1	1	1
West	7	5	1	0	1
Trading					
East	3	1	0	0	2
West	1	0	1	0	0
Sabotage					
East	1	0	1	0	0
West	2	0	0	0	2
Total					
East	37	3	3	3	28
West	70	35	19	3	11
GRAND TOTAL	107	38	22	6	39

had large military posts, a major port of embarkation, many war plants, and a large alien enemy population (to say nothing of the anti-English population of Irish), there was not a single Espionage Act indictment in the Bay State. The District Attorney simply refused to bring any, and Chafee said there was no rash of sabotage there as a result.[37]

Even more striking was the contrast in punishments in the two districts. In the East, the three defendants who pleaded guilty were fined a total of $900, and none of them went to prison. The three convicted in the Eastern District each went to Leavenworth for a year.

By contrast, the 35 defendants who pleaded guilty in the West were fined $600 but sentenced to 28 years and 2 months in prison. The 19 convicted were fined $13,100 and sentenced to prison and workhouses for a total of 26 years and 3 months.

The only prison sentences of more than a year and a day came in the Western District, where one man (Becker) was sentenced to three years, two others to two years, one to 18 months and another to 15 months. All were for violations of the Espionage Act. Thirteen men (10 of them in the West) received the year-and-a-day sentences. Eleven others were sentenced to terms of 30 days to six months in various county workhouses.

The two heaviest fines were both in the Eastern District and both were for violations of the Espionage Act. One man was fined $2,000 and another $1,250. No other fine exceeded $500.

In total, the 96 men convicted or entering guilty pleas to war statute violations of the Espionage Act in the two Wisconsin courts were sentenced to 57 years and 5 months in prison or workhouses[38] and fined $14,600.

During World War II, there were almost no actions against "disloyal" expression under any of these five laws, although all were on the books in slightly altered form. There were no such actions in Wisconsin. The civil liberty picture of World War II was a much brighter one in spite of the blot of the Japanese evacuation. Perhaps it was because the Administration was more enlightened, or the society was less naive, or there were fewer internal threats. Or perhaps it was because the nation profited from the black mass of World War I.

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[37] Chafee *op. cit., supra* note 1, at pp. 59–60.

[38] If Berger had not been convicted of Espionage Act violations and sentenced to 20 years in the Northern District of Illinois, *Berger v. U.S.*, 255 U.S. 22 (1921), it is likely he would have been tried on one of the three cases pending in the two Wisconsin federal courts; in such case, Wisconsin's penalty total might have been 20 years higher.

POLICE IN A LARGE SOUTHEASTERN WISCONSIN COMMUNITY

John C. H. Oh

ABSTRACT

This is a study of the local law enforcement personnel, who not only possess but often exercise a great deal of discretionary power in the course of administering the laws and ordinances in their local communities. Their general attitudes and the manner of contacting with the public have very important consequences upon the society. Yet, we know very little about these people.

The present study is based on the analysis of the survey questionnaires returned by police officers of a large southeastern Wisconsin community. It was designed to answer the following three questions:

1. How the police officers felt about the role of the Supreme Court in the criminal justice system in American society, particularly in regard to some of the recent Court decisions dealing with the constitutional rights of the suspect—in the area of criminal law and procedures;
2. How they felt about the law and order—their general attitudes toward violence, civil rights, and social order;
3. And, how they felt about themselves—their general attitudes toward their work and status in the community.

The study shows that police officers generally have a very low regard toward the U. S. Supreme Court, that the majority of police officers tend to develop an inferiority complex in their work (because they believe that the public does not extend due recognition to the police officers), and that they are excessively protective of their own work and quite unreceptive to any kind of criticism toward the police officers everywhere. It must be cautioned that these findings are only preliminary and suggestive; however, any concerned reader cannot help but to conclude that it is an urgent national task to intensify our efforts to train the police officers with the ideals of democracy and constitutionalism either through in-service or out-service training, or both.

INTRODUCTION

In recent years social scientists have made some significant contributions to the understanding of two related questions concerning the community power structure—"where power lies" and "who makes decisions" in the political communities. Consequently, we probably know more about the "men at the top" at both governmental and non-governmental levels in various political communities than ever before.[1] On the other hand, we know very little about the middle and/or lower level of the governmental personnel, because the same social scientists have generally shunned conducting any systematic studies on them. One such area of neglect is the local law enforcement personnel. These people—whether they are called constables or sheriffs or police officers—not only possess but often exercise a great deal of discretionary power in the course of administering the laws and ordinances in their local communities. Their general attitudes and their manner of contact with the public have very important consequences for the society.

The present study is based on the analysis of the survey questionnaires returned by 55 of 73 police officers of the Waukesha Police Department during the period of October 14–21, 1968. A brief description of the community being surveyed is in order. Waukesha has experienced one of the most rapid population increases among Wisconsin's cities and is a city of 36,339 people according to a special census of 1966, as compared to 30,004 in 1960 and 21,233 in 1951. (Waukesha County, which is seated in the city, had an increase of 326.5% during the period 1910–60, which was the fastest population growth rate among the state's 70 counties.) The city was the fourth largest in the Greater Milwaukee Standard Metropolitan Statistical Area,[2] which in 1968 contained an estimated population of 1,458,100, of which only 83,931 (or 5.8%) were Negro. The city itself had only a dozen or so Negro families, since the bulk of the Negro population in the area resided in the central city (Milwaukee). It must be noted, however, that the city is not a suburb of the central city in the strictest sense, because it is a booming industrial community on its own with a number of nationally-known manufacturing firms (i.e. It had some 23 banking and savings and loan associations with total assets of over $150 million at the end of 1966).[3]

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[1] See Floyd Hunter, *Community Power Structure* (1953), Robert Presthus, *Men at the Top* (1964), Robert A. Dahl, *Who Governs?* (1961), and Arnold M. Rose, *The Power Structure* (1967), among others.

[2] The area covers at least 38 separate governmental units which include four counties, 15 cities, 15 villages, and four towns.

[3] *U.S. Census of Governments, 1962;* State of Wisconsin, *Blue Book, 1968;* Milwaukee Sentinel, *1969 Wisconsin Almanac* (January 7, 1969).

Politically, Waukesha residents have generally voted for Republican candidates. In the latest election they again voted heavily Republican for the presidency, the state-wide ticket (for the governor and four other constitutional officers), the state assemblyman, the state senator, and for the U. S. congressman. The only Democrat who received the plurality of votes in the city was an independent-minded, popular U. S. senator.

As far as the incidence of crime is concerned, it was reported that Waukesha had a total crime index of only 295 in 1967, which was not only far below the national average of similar size cities but also lower than the state average of 1,121.1 and that of the Milwaukee SMSA's 1,613.2. This lower crime incidence may be partially due to the fact that Waukesha's full-time police employee rate of 1.8 was far in excess of an average number of officers per 1,000 inhabitants for the same size communities in the state and the nation as a whole.[4]

The present study was designed to answer the following three questions:

1. how the police officers felt about the role of the Supreme Court in the criminal justice system in American society, particularly in regard to some of the recent Court decisions dealing with the constitutional rights of the suspect in the area of criminal law and procedures;
2. how they felt about law and order—their general attitudes toward violence, civil rights, and social order;
3. and, how they felt about themselves—their general attitudes toward their work and status in the community.

We felt that October, 1968, was the most opportune time for this type of study because many of the questions used in the survey were the same kind of issues raised by the various candidates in their election campaigns. Our actual subjects included 37 uniformed patrolmen and 18 detectives and police executives. The data in *Table 1* show that there were some marked differences between these two groups of officers, in that patrolmen were in general younger (51% under age 30 compared to only one of 18 detectives in that age group), better educated (38% to 17% for some college work), and less experienced in police work (an average of six years service for the former as compared to 13 years for the latter) than detectives and executives.

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[4] Federal Bureau of Investigation, *Uniform Crime Reports, 1967* (August 27, 1968).

TABLE 1. AGE AND EDUCATION OF POLICE OFFICERS

AGE	ALL POLICE OFFICERS* (NUMBER: 55)	UNIFORMED PATROLMEN (NUMBER: 37) EDUCATIONAL BACKGROUND				DETECTIVES AND EXECUTIVES (NUMBER: 18) EDUCATIONAL BACKGROUND			
		Some H. S.	H. S.	Some College	Total	Some H. S.	H. S.	Some College	Total
Between 21–30	36%	—	7	12	51%	—	1	—	6%
Between 31–40	40%	—	12	2	38%	—	7	1	44%
Between 41–50	18%	1	1	—	5%	2	4	2	44%
Over 51	6%	—	2	—	6%	—	1	—	6%
	100%	(1) 3%	(22) 59%	(14) 38%	100%	(2) 11%	(13) 72%	(3) 17%	100%

*All officers educational backgrounds	Some H. S.	H. S.	Some College
	(3)	(35)	(17)
	5%	64%	31%

On the Supreme Court and the Criminal Justice

Our study shows that police officers generally have a very low regard for the U. S. Supreme Court, to such an extent that the very legitimacy of the highest court is being questioned. Almost unanimously (93%), they felt that the Court in its recent decisions dealing with criminal law and procedures has reduced sharply the effectiveness of the police. However, it was found that such general negative attitudes toward the Court did not prevail consistently when we asked them a series of questions concerning their particular attitudes toward several selected court decisions which dealt with the constitutional rights of the suspect. They were specifically asked about these five decisions of the Court: *Miranda vs. Arizona* (1966); *Mapp vs. Ohio* (1961); *Mallory vs. U. S.* (1957); *Gideon vs. Wainwright* (1963); and *Escobedo vs. Illinois* (1964). (In asking their reactions to these cases, we described the essence of the decisions and elicited their reactions, instead of by the official legal citations.)

First, as to their reactions to the *Miranda* decision, we asked the police officers whether the Court ruling that requires them to inform a suspect of his constitutional rights before questioning him interfered with their performance of duties. The data[5] show that a great majority of detectives and executives (72%) who must question the suspect in the course of their investigatory work felt that it interfered with their work, while only 22% felt it did not. The uniformed patrolmen were almost divided evenly. This change of attitude (from their general negative attitude toward the Court) is very significant in view of the fact that the *Miranda* decision was the most comprehensive requirement laid down by the Court to protect the constitutional rights of the suspect from being infringed upon by the law enforcement officials.

Surprisingly, in the next three cases we find that there were more police officers agreeing with Court opinions than disagreeing. In the *Mapp* decision, 49% agreed with the Court that evidence obtained by illegal searches and seizures cannot be introduced into a state court, while 47% opposed it. In the case of the *Mallory* decision, only 71% felt that the Court decision (requiring a prompt arraignment of the suspect) is a reasonable one, but 80% stated that it did not interfere with their work in any way. The overwhelming majority (82%) also said that they agreed with the *Gideon* decision (which requires a state to provide free counsel for defendants who cannot afford a lawyer).

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[5] Additional statistical supporting data are deleted throughout the paper. They are, however, available from the author upon request.

The police officers in general find the *Escobedo* decision most objectionable. The Court in 1964 ruled in this case that a defendant has a right to have his lawyer with him when he is being questioned by police officers. Seventy-one per cent of the respondents (83% of the detectives and executives and 65% of the uniformed patrolmen) indicated that this decision interfered with their investigative work. Altogether 56% of the officers felt that it was a bad decision. It must be emphasized that what they objected to most was not that the defendants should be given free counsel to defend themselves but the Court ruling that permits the presence of a lawyer at the time of their questioning of the suspects. In this sense, the *Escobedo* case is the main cause of the Supreme Court's unpopularity among the police officers.

On Social Order, Violence and Civil Rights

Our study shows that police officers are generally conservative toward issues such as social order, violence and civil rights. We first asked them the following open-ended question: "There is much discussion over the police action that took place during the 1968 Democratic National Convention in Chicago. Please indicate how you feel about the incident, including whether or not you feel that the Chicago police over-reacted in the situation." Almost all the respondents (95%) felt not only that the Chicago police did not over-react in the controversial incident but also that what they did was proper because, as one officer indicated, "the demonstrators were forewarned and if they didn't want to get hurt they should not have been there." Not one officer said that the Chicago police should have handled the situation differently—in direct contrast to the findings of the Walker Report. Even with Chicago Mayor Daley's very controversial order "to shoot to kill the looters" (as reported by the mass media during the disturbances), only 11% indicate that they did not agree with the mayor.

When asked "How do you feel about alleged police brutality?" 83% of the officers claimed that not only does it not exist but such a charge is part of a conspiracy to undermine the police throughout the country. In reply to another question on civil disorders in our cities and college campuses, 96% of the officers stated that maximum (rather than minimum) force should be used in quelling such disorders. A substantial majority (69%) also felt that there is too much violence on T.V. and in the movies.

It is significant to note that police officers in general felt that in order to stem the rising crime rate the criminal offenders must be given much stiffer penalties than they receive now. Fifty-one per cent of the officers (61% of the detectives and executives and

46% of the uniformed patrolmen) favor capital punishment for persons convicted of crimes such as first degree murder, kidnapping, sabotage or treason, in spite of the fact that the state of Wisconsin does not allow capital punishment. When asked "whether they felt we needed stiffer penalties in cases involving misdemeanors and/or felonies," 64% indicated that there should be stiffer penalties for misdemeanors, and almost all the officers (97%) felt the same way toward felonies (the major crimes). In a near unanimous opinion, they opposed the parole system as now being practiced in the United States, because they strongly feel that when a criminal is given a specific sentence—whether it is life imprisonment or a specified number of years of confinement—he should be forced to serve it without being released on parole.

Politically, too, police officers generally leaned toward the conservative side. They have a higher voting turnout than the general population, for 78% of them voted in 1964 (it would have been much higher if 12% were not under the voting age). In that election year, of those who revealed their actual vote (69%), they voted almost two to one in favor of Johnson (45%) to Goldwater (24%). However, when asked "Which of the candidates (Nixon, Humphrey, Wallace) have you decided to vote for in 1968?" 35% favored Wallace, 33% Nixon, 5% Humphrey, while 27% were either undecided or gave no response. What surprised us most was that this particular community had not experienced any civil disorder *per se* in recent years, and yet in view of their general attitude toward law and order, a substantial majority of officers (68%) were attracted to either Wallace or Nixon.

On the Role and Status Perceptions of Police Officers

Generally, police officers possessed a strong sense of community service, dedication, and altruism. Sixty per cent of all police people and at the same time serving the community best through law enforcement work. Another 29% felt that the profession gave them a sense of job security. Only 4% felt that police work gave them excitement and adventure not to be found in other lines of work, while 2% chose it because of family tradition.

However, they also agreed that the general public does not extend due recognition to the police officers. The data show that although higher ideals motivated them to choose the law enforcement profession, a majority of police officers (58%) tend to develop an inferiority complex in their work, for they believe that the public generally tends to look down on them socially. Eighty per cent of the officers also felt that they are not being rewarded in terms of salaries and fringe benefits as they think they deserve. (This salary schedules of this police department ranged from about $580 to $900 per month depending upon rank and seniority of the officers). One surprising finding was that when asked whether they would advise young people to go into police work, 74% answered affirmatively. It suggests that their lower reputational perception is largely due to the general public's apathy toward police work, because most police officers believe that they are contributing something positive to the general well-being of the community.

Finally, it must be pointed out that police officers are not only conscious of their own status but quite defensive about their work and the police everywhere. We have already shown how sensitive and defensive they were to the charges of police brutality and the Chicago convention incident. To further check on this feeling we asked them the following question: "What educational requirements do you feel police officers should have?" The data show that 51% of all the respondents felt that education beyond high school is needed, but only 4% felt they should have a college degree. There is, however, marked difference between the relatively younger uniformed patrolmen and the somewhat older detectives and executives, since 60% of the former stated that police officers should have more than a high school education as compared to only 34% of the latter. These attitudes tend to reflect their own educational background, for within this department not only is there no single college graduate but the formal education of the detectives and executives is comparatively lower than that of the uniformed patrolmen. (In this connection, it is interesting to not that the governor of Wisconsin early this year proposed the establishment of a state-run police academy to train all police officers within the state.)

CONCLUSION

These findings are not entirely unknown, for both the Kerner Report and the National Crime Commission Report made it clear that police officers in general have one of the lowest formal educational attainments among all the professional groups in the country. Some of the disturbing findings are that:

1. The majority of police officers tend to develop an inferiority complex in their work, in spite of the higher ideals that motivated them to choose the police profession (because they believe that the public does not extend due recognition to the police officers).
2. They are excessively protective toward their own work and quite unreceptive to any kind of criticism toward police officers anywhere (e.g. their reactions to the Chicago violence).

3. They generally believe that social order can best be maintained by the maximum use of force by law enforcement officers and by imposing much stiffer penalties upon the criminals than they are given today.
4. They apparently have very little faith in the Supreme Court of the United States—the highest court deciding questions of law and the official body for interpreting the U.S. Constitution.

It must be cautioned that these findings are only preliminary and suggestive; however, any concerned reader cannot help but conclude that it is an urgent national task to intensify our efforts to train police officers with the ideals of democracy and constitutionalism either through in-service or out-service training, or both. It may well be that eventually education beyond high school (either college education or relevant police education through police academies or special institutes) must become the mandatory requirement for all those who seek a police career.

TRENDS IN WISCONSIN'S TOURIST–LODGING INDUSTRY

L. G. Monthey

HIGHLIGHTS

This research study included all of Wisconsin's lodging establishments that were inspected by the State Board of Health during the years 1961 to 1968, inclusive. It reports significant changes in the number, distribution, seasonality, size, and type of tourist-lodging establishments in that period.

Wisconsin lost 1,019 establishments between 1958 and 1968; approximately two-thirds of these were seasonal businesses, primarily resorts. However, the State's total capacity in bedroom units (B.U.) has remained near 80,000 for 11 years or longer.

Since 1961 the total number of hotels dropped 21%; resort-type businesses declined 14%; motel establishments increased 16%.

Small establishments with less than 10 B.U. decreased 16%, while the number of large enterprises (30 B.U. or more) increased 17%.

Motels were the only type of T–L establishment that increased in all size classes, seasonal and year-round, during the 8 years.

Among the seasonal establishments (open 9 months or less) only the motel-type business showed a gain in both firms and B.U. capacity. Likewise, motels were the only type to show a large increase in average size, going from 13.8 to 18.5 B.U. in 8 years.

The number of year-round establishments also declined, but their total B.U. capacity went up about 5,000 during the period. The number of year-round resorts dropped 14% between 1961 and 1968.

The biggest losses in both number of establishments and total B.U. capacity occurred in the northeast and northwest regions of Wisconsin.

Tourist accommodations, and the housing enterprises which provide them, are an important part of Wisconsin's $900 million travel–recreation industry. However, significant changes have taken place within this business since 1960. This study is an attempt to determine and measure some of these changes over a period of years, also to identify and quantify the important trends that are taking place in the tourist-lodging industry (hereinafter referred to as the "T–L industry"), which is in a state of rapid transition.

The methods used are similar to those employed in an earlier study entitled "The Resort Industry of Wisconsin." (Wis. Acad. Transactions, Vol. 53/Part A/ 79–94, 1964.)

In order to obtain comprehensive inventories of Wisconsin's T–L business, State Board of Health inspection records and mailing lists for the years 1961 through 1968 were used. The appropriate data were coded for each establishment, transferred to IBM cards, and the results compiled by data-processing techniques. Four major categories were used in classifying T–L businesses: (1) Hotel type; (2) Motel type; (3) Resort type; (4) Other. The establishment's name was used to categorize each business, and each category was then studied in detail as to the distribution, number, size, and seasonality of the establishments it contained.

An Eleven-Year Look

Thanks to an earlier study of the tourist-overnight accommodations in Wisconsin,* we can go back to the year 1958 for some limited data on the total number of establishments, their seasonality and bedroom unit (B.U.) capacity. This enables us to trace a few of the major trends over an 11-year period (1958–68).

The number of T–L establishments has declined markedly, but the total capacity for housing visitors has held its own. In 1958 there were 7,842 firms offering about 79,000 B.U. to the traveling public. By 1968, the number of businesses had dropped to 6,823—a decline of 1,019 establishments—but the total B.U. capacity remained near 80,000 units. (Note Tables 1-a and 1-b.)

A seasonal establishment is one which operates less than 9 months during a given year. Of the one thousand T–L establishments that have disappeared since 1958, over two-thirds were seasonal in nature and predominantly resort-type businesses, as we shall see later. It is noteworthy that the greater part of this decline, both in total establishments and in seasonal businesses, has occurred since 1965. This suggests that certain trends, at least, have accelerated during the past few years.

Tables 1-a and 1-b show not only the big losses in T–L establishments—673 seasonal and 346 year-round—over the 11 years, but also a substantial drop of almost 5,000 in seasonal B.U.

* By Fine and Tuttle, School of Business, University of Wisconsin.

Table 1-a. Overall Summary: Changes in the Total Number and Seasonality of Wisconsin Tourist-Lodging Establishments during the Period 1958–1968.

Year Studied	Seasonal Establishments	Year-round Establishments	Total No. Establishments	% Seasonal Businesses
1958	5,668	2,174	7,842	72.3
1961	5,733	1,983	7,716	74.3
1965	5,638	1,827	7,465	75.5
1968	4,995	1,828	6,823	73.2
Change (1958–68)	(−673)	(−346)	(−1,019)	

TABLE 1-b. OVERALL SUMMARY: CHANGES IN THE TOTAL NUMBER AND SEASONALITY OF BEDROOM UNITS (B.U.) AVAILABLE AT WISCONSIN TOURIST-LODGING ESTABLISHMENTS DURING THE PERIOD 1958–1968.

YEAR STUDIED	SEASONAL B.U.	YEAR-ROUND B.U.	TOTAL NO. B.U.	SEASONAL B.U. (AS % OF TOTAL)
1958	47,577	31,533	79,110	60.1
1961	47,608	32,690	80,298	59.3
1965	47,085	34,719	81,804	57.6
1968	42,611	37,087	79,698	53.5
Change (1958–68)	(−4,966)	+5,554	+588	

AN EIGHT-YEAR STUDY

We now depart from an 11-year comparison and concentrate on a more detailed 8-year analysis of T–L establishments. Except for the above-mentioned tables, all of the remaining statistical material—including figures and discussion—relates to the period 1961–68 inclusive. Generally speaking, data for the years between 1961 and 1968 are not included herein, since most of the changes and trends observed are quite consistent throughout the period studied. Thus, virtually all of the data used here relate only to the years 1961 and 1968.

Despite changes in the number, type and distribution of T–L establishments, the total visitor-housing capacity has remained near 80,000 B.U. and has not varied as much as 3% since 1958. However, the number of year-round B.U. has increased about 5,000 since 1961, reaching a high of 37,087 in 1968. A comparable decline in seasonal B.U., from 47,600 to 42,600, has tended to offset this gain. In other words, 60% of all B.U. were provided by seasonal establishments in 1961 as compared to only 53% in 1968. It is interesting to note, however, that about 73% of all establishments, statewide, were classed as seasonal in both years.

Table 2 involves the main categories of T–L establishments and includes the total B.U. capacities and number of firms under each category for the years 1961 and 1968. A few definitions may be in order at this point.

SOME DEFINITIONS

A *hotel* is defined as a lodging house, usually more than two stories high, having five or more bedroom units and (usually) a public lounge or lobby plus food service. Most Wisconsin hotels were built prior to World War II.

TABLE 2. OVERALL SUMMARY: CHANGES IN THE TYPE AND B.U. CAPACITY OF WISCONSIN TOURIST-LODGING ESTABLISHMENTS BETWEEN 1961 AND 1968.

Type of Establishment	1961		1968		1961–68 Changes	
	No.	B.U.	No.	B.U.	No.	B.U.
Hotels	583	19,567	457	15,971	(−126)	(−3,596)
Motels	915	12,600	1,056	19,505	+141	+6,905
Resorts	4,761	40,465	4,101	36,255	(−660)	(−4,210)
Other	1,457	7,666	1,209	7,967	(−248)	+301
Totals	7,716	80,298	6,823	79,698	(−893)	(−600)

A *motel* is a T–L establishment, usually on one level and seldom with over two floors, having five or more bedroom units and a convenient auto-parking space on the premises at no extra charge to the guests. The distinction between hotels and motels is usually quite clear for the small establishments with fewer than 20 B.U. However, there is almost no definable difference between medium-sized and larger hotels and motels (usually called motor hotels), except for structural age. Virtually all of the latter are less than 20 years old, whereas very few hotels of the traditional type have been built since 1950. In any case, our motel category includes the newer motor hotels.

A *resort* is defined as a T–L business situated in or near a scenic and/or recreational environment. In Wisconsin a resort-type establishment is usually on or near the water, either a lake or river, but not always.

Our fourth category of establishments, designated as "Other", includes all types of T–L businesses that cannot be identified under the three classifications listed above.

As Table 2 shows, there have been some significant changes in the types of T–L establishments between 1961 and 1968. Hotels and resorts have diminished in number. The hotel total dropped from 583 to 457 during the 8 years, a decline of over 20%. Motels, on the other hand, increased by 15% and showed a gain in capacity of almost 7,000 B.U. The totals for resort-type establishments show a loss of 660 firms and a drop of about 4,200 B.U. since 1961. The "Other" (miscellaneous) category of T–L establishments had a significant loss in the number of businesses, but it gained about 300 B.U. during the 8 years. This group is predominately tourist homes and rooming houses, but youth camps, guest farms, dude ranches, and many other kinds of housing facilities are included among its 1,209 establishments.

In 1961 resort-type establishments comprised 61.7% of all T–L businesses in Wisconsin; in 1968 they still made up 60.1% of the total. Meanwhile, the motel category increased from 11.8% to 15.5% of the total in just 8 years, and the hotel group declined from 7.6% to only 6.7%.

Size of Establishments

As Table 3 indicates, there were some noteworthy changes in the size of housing establishments during the 1961–68 period.

In 1961, for example, the average size of T–L establishments was about 10.4 B.U.—ranging from 8.3 B.U. for seasonal properties to 16.5 for year-round businesses. By 1968 the over-all average had increased to almost 12 B.U. per establishment, with the seasonal businesses showing only a slight increase to 8.5 B.U. and the year-round operations rising sharply to 20.3 B.U. in average size.

The number of small establishments has been dropping rapidly, especially since 1965. Those with less than 10 bedrooms comprised 64.7% of all lodging places in 1961, but they declined to 61.3% of the total by 1968. In 1961 there were 4,995 such businesses offering a total of 23,046 B.U. to the public. Eight years later there were 4,181 establishments and 19,229 B.U. in this 1-to-9 size class, which reflects a loss of 814 establishments and 3,800 B.U. between 1961 and 1968. This drop, the largest in any size group studied, was especially noticeable in the 5-to-9 B.U. range.

The intermediate group of establishments with 10 to 19 B.U. also declined in number, dropping from 1,937 to 1,806 properties and showing a loss of almost 1,500 B.U. during the 8 years. This group, however, still makes up a substantial segment of the industry. It included 25.1% of all Wisconsin T–L businesses in 1961 and 26.5% in 1968, providing about 30% of the State's 80,000 B.U. in the latter year.

Table 3. Overall Summary: Changes in the Size Classification of Wisconsin Tourist-Lodging Establishments between 1961 and 1968.

Size Class of Establishment	1961		1968		1961–68 Changes	
	No.	B.U.	No.	B.U.	No.	B.U.
1-to- 4 B.U.	2,682	7,353	2,325	6,467	(−358)	(−886)
5-to- 9 B.U.	2,313	15,693	1,857	12,762	(−456)	(−2,931)
10-to-19 B.U.	1,937	25,366	1,806	23,888	(−131)	(−1,478)
20-to-29 B.U.	458	10,610	461	10,662	+3	+52
30-to-99 B.U.	277	12,643	308	14,352	+31	+1,709
100 and over	49	8,633	66	11,567	+17	+2,934
Totals	7,716	80,298	6,823	79,698	(−893)	(−600)

It is probably significant that all size categories under 20 B.U. per establishment showed substantial declines in capacity, with a total loss of 945 businesses and 5,295 bedroom units between 1961 and 1968.

Meanwhile, those properties with 20 or more B.U. increased from 10.2% of all T–L businesses in 1961 to 12.2% of the 1968 total. There were 784 such firms with a total of 31,886 B.U. in 1961; by 1968 this group included 835 businesses with 36,581 units. This 20-plus category provided 39.7% of the State's B.U. total in 1961 and 45.9% of it in 1968.

There was a most substantial gain of over 4,600 units in the group of larger establishments with 30 or more B.U. per business, which comprised 5.5% of the T–L firms in 1968. However, the one category showing the largest increases of all—both percentage-wise and in B.U. capacity—was the 100-plus group which gained nearly 3,000 units from 17 additional establishments. Here we observe a 34% increase in the number of businesses and a 35% gain in B.U. in only 8 years, 1961–68.

Table 4 shows the 1961–68 comparisons of Wisconsin T–L establishments as to type, seasonality, number, and bedroom (B.U.) capacity. It also indicates the average size of establishment under each classification, both seasonal and year-round, and under the combined totals for each year.

FEWER BUT LARGER

These data clearly illustrate the fact that, in general, Wisconsin's T–L establishments are getting fewer in number but larger in size. But they also reflect some significant variations among the major categories of establishments. For example, the impact of the newer motels and motor hotels on the traditional hotel-type operation is quite apparent from these figures.

The general decline in resort-type establishments is also evident in Table 4, where we note a loss of 660 businesses and 4,200 B.U. since 1961. Our data indicate that the greater portion of this resort loss has occurred since 1964, when the rate of decline for these establishments accelerated to about 4% per year.

The only group of T–L businesses which has increased steadily in both number of establishments and in B.U. capacity over the 8-year period is the motel category. This group has also shown the largest gain in average size of business (B.U. per establishment).

The remainder of this report will consider in more detail the major changes taking place, as well as apparent trends, within each of the four main categories of T–L businesses. The geographic nature of these changes, especially the regional trends and patterns involved, will also be presented and discussed.

TABLE 4. TYPE, SEASONALITY, AND AVERAGE SIZE OF WISCONSIN TOURIST-LODGING ESTABLISHMENTS, COMPARING 1961 AND 1968.

TYPE OF ESTABLISHMENT	1968 DATA			1961 DATA		
	Seasonal Businesses	Year-round Businesses	Total Establishments	Seasonal Businesses	Year-round Businesses	Total Establishments
HOTELS						
No. of Establishments	72	385	457	112	471	583
No. of Bedroom Units	1,409	14,562	15,971	2,414	17,153	19,567
Average Size (B.U.)	(19.6)	(37.8)	(34.9)	(21.6)	(36.4)	(33.6)
MOTELS						
No. of Establishments	283	773	1,056	261	654	915
No. of Bedroom Units	3,648	15,857	19,505	3,028	9,572	12,600
Average Size (B.U.)	(12.9)	(20.5)	(18.5)	(11.6)	(14.6)	(13.8)
RESORTS						
No. of Establishments	3,824	277	4,101	4,439	322	4,761
No. of Bedroom Units	32,835	3,420	36,255	37,262	3,203	40,465
Average Size (B.U.)	(8.6)	(12.3)	(8.8)	(8.4)	(9.9)	(8.5)
OTHER						
No. of Establishments	816	393	1,209	921	536	1,457
No. of Bedroom Units	4,719	3,248	7,967	4,904	2,762	7,666
Average Size (B.U.)	(5.8)	(8.3)	(6.6)	(5.3)	(5.2)	(5.3)
TOTALS						
No. Establishments	4,995	1,828	6,823	5,733	1,983	7,716
No. Bedroom Units	42,611	37,087	79,698	47,608	32,690	80,298
Average Size (B.U.)	(8.5)	(20.3)	(11.7)	(8.3)	(16.5)	(10.4)

Geographic Distribution

Thus far, we have concentrated on statewide totals, summaries, breakdowns, and changes in the T–L industry. It might be appropriate, at this point in the study, to examine the geographic distribution of T–L establishments in Wisconsin on a county-by-county basis. Figure 1 does this for the years 1961 and 1968 (upper figure is '68), including all types of lodging businesses.

It is noteworthy that only 12 of the 72 counties did not show a decline in the number of T–L establishments, and only 6 counties

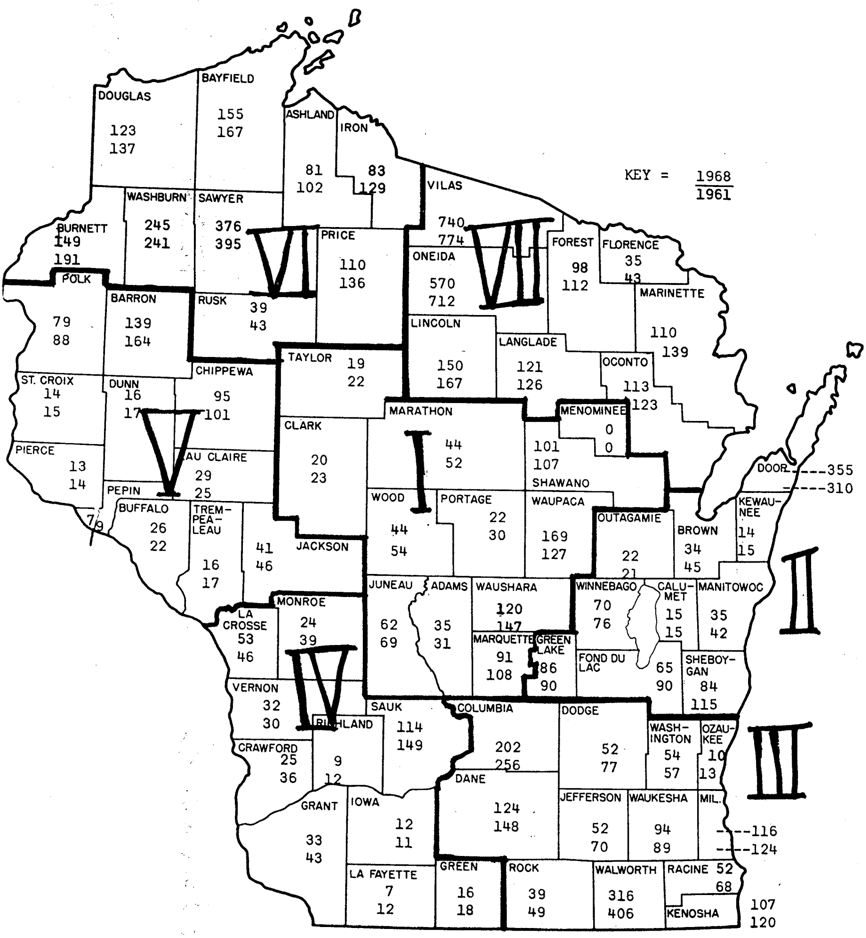

FIGURE 1. The Distribution of Wisconsin Tourist-Lodging Establishments in 1961 and 1968, showing the totals for each county. The upper figure is the 1968 count; the lower is for 1961. These totals include all types and sizes of lodging businesses.

had an increase of 10% or more. Numerically, however, only two counties could claim substantial gains in their total of T–L establishments: Door gained 45; Waupaca gained 42; and La Crosse ranked a poor third with a gain of 7 over the 8-year period. All of the northern counties except Washburn showed substantial declines since 1961, with Oneida's loss of 142 topping the entire state. Percentagewise, Iron County was the "leader" with a drop of 35.7% in its T–L businesses.

It is also interesting to note, on a comparative basis, some of the regional patterns involved in the significant changes and trends affecting the T–L industry since 1961. This will be done by a series of state maps, each showing selected data by geographic regions, comparing 1961 and 1968 figures.

The seven regions used in this analysis are the so-called "state planning regions", which group the 72 Wisconsin counties as follows:

I. Central	*II. East Central*	*III. Southeast*	*IV. Southwest*
Adams	Brown	Columbia	Crawford
Clark	Calumet	Dane	Grant
Juneau	Door	Dodge	Green
Marathon	Fond du Lac	Jefferson	Iowa
Marquette	Green Lake	Kenosha	La Crosse
Menominee	Kewaunee	Milwaukee	Lafayette
Portage	Manitowoc	Ozaukee	Monroe
Shawano	Outagamie	Racine	Richland
Taylor	Sheboygan	Rock	Sauk
Waupaca	Winnebago	Walworth	Vernon
Waushara		Washington	
Wood		Waukesha	

V. West Central	*VI. Northwest*	*VII. Northeast*
Barron	Ashland	Florence
Buffalo	Bayfield	Forest
Chippewa	Burnett	Langlade
Dunn	Douglas	Lincoln
Eau Claire	Iron	Marinette
Jackson	Price	Oconto
Pepin	Rusk	Oneida
Pierce	Sawyer	Vilas
Polk	Washburn	
St. Croix		
Trempealeau		

These county groupings, or regions, are delineated in Figure 1.

The regional totals of both T–L establishments and their bedroom units are shown in Figure 2 for the years 1961 and 1968. The average size of establishment (in B.U.) is also shown for each of the regions. Although all of the regions had an increase in size of business (B.U. per establishment), this gain varied from 0.2 B.U. for the Central Region to a high of 4.6 B.U. in the Southeast Region. All of the regions except for II (East Central) and III (Southeast) showed losses in B.U. capacity, with the largest drops recorded in Region VII (—1,746) and in Region VI (—826). Both of these regions are in northern Wisconsin. They had a combined loss of 439 T–L establishments during the 8 years, almost exactly half of the total loss (—893) registered by the entire state!

The other region showing a relatively large loss of T–L businesses since 1961 is the Southeast (Region III), which had 259 fewer firms in 1968. Altogether, these three regions (III, VI, VII) accounted for 78% (698 firms) of the statewide loss of T–L establishments during the period.

Figure 3 gives similar 1961–68 information, also on a regional basis, for the *seasonal* T–L establishments in Wisconsin. This group includes almost 75% of all T–L businesses. Again, we note that the two northern regions (VI and VII) had a combined loss of slightly over 400 establishments and almost 3,100 B.U.—mostly resort-type accommodations—over the 8-year period.

The average size of establishment (figures in parentheses) varies to only a small degree—from region to region—with these seasonal T–L businesses. It ranged from 6.2 B.U. to 8.9 B.U. in 1961, and from 5.6 B.U. to 9.9 B.U. to 1968, with a state-wide average of

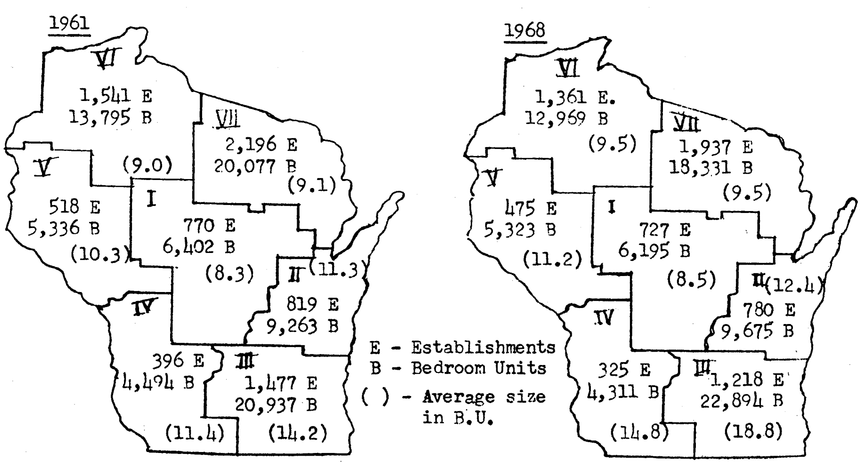

FIGURE 2. The Regional Distribution of Tourist-Lodging Establishments (all types) in Wisconsin for 1961 and 1968.

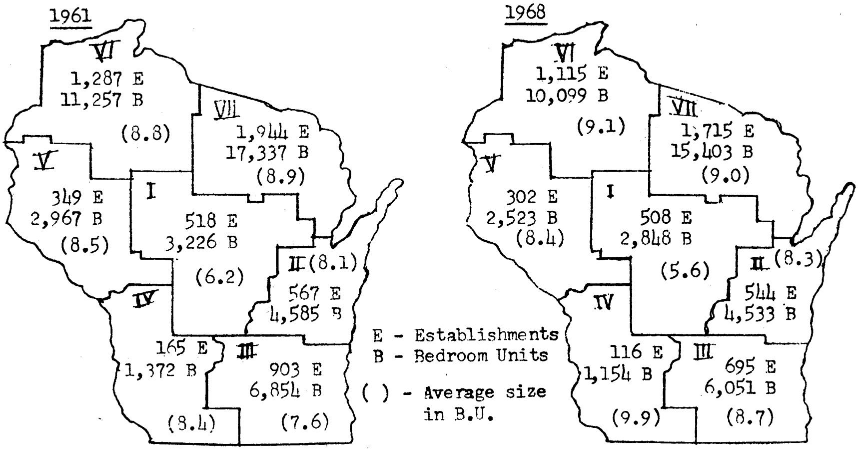

FIGURE 3. The Regional Distribution of Seasonal Tourist-Lodging Establishments (all types) in Wisconsin for 1961 and 1968.

about 8.5 B.U. There was a much greater fluctuation in the average size of year-round establishments, which ranged from 10.0 B.U. to 32.4 B.U. among the various regions during the years studied.

HOTEL-MOTEL TRENDS

The analysis of hotel establishments as to number, size, seasonality, and B.U. capacity is shown in Table 5 for the years 1961 and 1968. The regional distribution and inventory of Wisconsin hotels (all types and sizes) for 1961–68 appears in Figure 4.

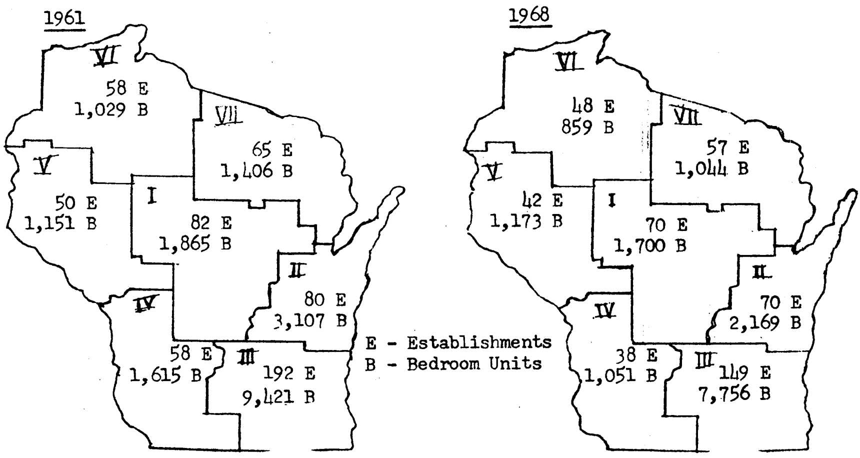

FIGURE 4. The Regional Distribution of Hotel-type Establishments (all sizes) in Wisconsin for 1961 and 1968.

TABLE 5. THE NUMBER, SIZE CLASSIFICATION, SEASONALITY, AND B.U. CAPACITY OF WISCONSIN HOTEL ESTABLISHMENTS IN 1961 AND 1968.

SIZE CLASS IN BEDROOM UNITS	SEASONAL		YEAR-ROUND		TOTAL	
	No. Hotels	No. of B.U.	No. Hotels	No. of B.U.	No. Hotels	No. of B.U.
			Hotels—1968 Data			
Small—5 to 19 B.U.	43	421	194	2,105	237	2,526
Medium—20 to 99 B.U.	28	888	158	6,218	186	7,106
Large—100+ B.U.	1	100	33	6,239	34	6,339
1968 Totals	72	1,409	385	14,562	457	15,971
			Hotels—1961 Data			
Small—5 to 19 B.U.	66	689	245	2,465	311	3,146
Medium—20 to 99 B.U.	43	1,408	188	7,584	231	8,992
Large—100+ B.U.	3	317	38	7,104	41	7,421
1961 Totals	112	2,414	471	17,153	583	19,567
Changes (8 years)	(−40)	(−1,005)	(−86)	(−2,591)	(−126)	(−3,596)

For the purposes of this study, both hotels and motels are classified into three size groups as follows:

Size Group	*B.U. Range*	*1968 Hotels*	*1968 Motels*
Small	5 to 19 B.U.	237	805
Medium	20 to 99 B.U.	186	232
Large	100 plus B.U.	34	19

Approximately one-fourth of the small-size hotels and one-fifth of the medium-size group were lost during this 8-year period, according to Table 5, with heaviest losses in the seasonal ranks. These two size groups alone showed a net loss of 119 establishments and 2,500 B.U. Large hotels (100 B.U. or more) also dropped downward, from 41 to 34 establishments, causing the loss of another 1,100 B.U.—or 3,600 in all for the hotel universe.

Table 6 gives essentially the same kind of information for motels and motor inns as Table 5 provides for hotels.

Although the number of hotels dropped by 126, mostly in the small and medium-size classes, the number of motels increased by 141 establishments. Most of the additional motel enterprises were in the year-round category, and in the medium-size and large-size groups. It is interesting to note, however, that the motel-type businesses increased numerically in every size class, both in the seasonal and in the year-round categories. In fact, motels were the only type of seasonal T–L operation to show any significant increase in number during the 1961–68 period.

The 8-year increase in total motel capacity exceeded 6,900 B.U., and thus it has more than offset the total loss of hotels and hotel rooms since 1960. Hotels provided 24.4% of all B.U. in Wisconsin in 1961, but this percentage dropped to 20.0 by 1968. Meanwhile the motel-type enterprises, which increased from 11.8% to 15.5% of all T–L businesses, provided 15.7% of all B.U. during 1961 and 24.5% of the State's total in 1968.

Besides increasing in number, Wisconsin's motels have increased quite markedly in their average size. In 1961 only 16% of our motel establishments were 20 B.U. or larger in size; and this medium-to-large group provided a total of 4,650 B.U.—only about half of what the small (5-to-19 B.U.) group offered. By 1968 the "20-plus" group comprised 24% of all motels and was providing 10,950 B.U., exceeding the small-size group by 2,400 B.U. In 1961, 28.5% of the 915 motels were classed as seasonal establishments; this percentage dropped to 26.8% for the 1,056 motels in 1968, although the actual number of seasonal motels rose from 261 to 283.

Figure 5 shows the regional distribution of Wisconsin motel establishments in 1961 and 1968. The growth in number of motel

TABLE 6. THE NUMBER, SIZE CLASSIFICATION, SEASONALITY, AND B.U. CAPACITY OF WISCONSIN MOTEL ESTABLISHMENTS IN 1961 AND 1968.

SIZE CLASS IN BEDROOM UNITS	SEASONAL		YEAR-ROUND		TOTAL	
	No. Motels	No. of B.U.	No. Motels	No. of B.U.	No. Motels	No. of B.U.
Motels—1968 Data						
Small—5 to 19 B.U.	238	2,353	567	6,216	805	8,569
Medium—20 to 99 B.U.	45	1,295	187	6,596	232	7,891
Large—100+ B.U.	—	—	19	3,045	19	3,045
1968 Totals	283	3,648	773	15,857	1,056	19,505
Motels—1961 Data						
Small—5 to 19 B.U.	229	2,228	539	5,717	768	7,945
Medium—20 to 99 B.U.	32	800	113	3,525	145	4,325
Large—100+ B.U.	—	—	2	330	2	330
1961 Totals	261	3,028	654	9,572	915	12,600
Gains in 8 years	+22	+620	+119	+6,285	+141	+6,905

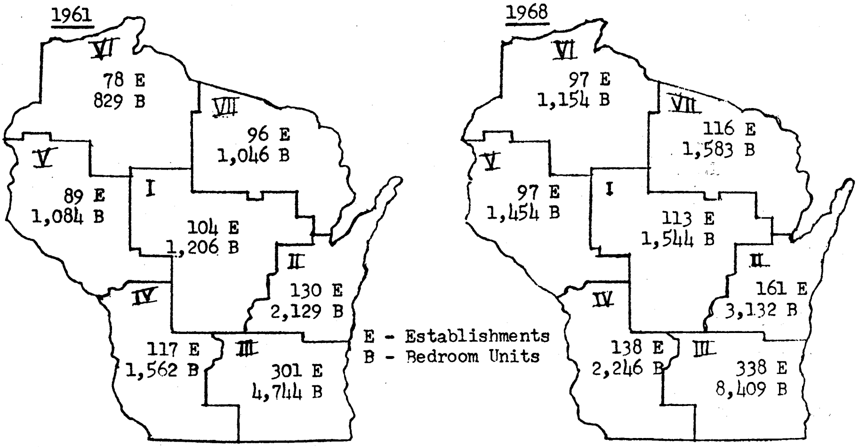

FIGURE 5. The Regional Distribution of Motel-type Establishments (all sizes) in Wisconsin for 1961 and 1968.

establishments has been fairly uniform among the seven regions. However, the increased motel capacities in 1968 (see regional B.U. totals) clearly indicate that the largest gains were in Regions II and III (East Central and Southeast), where over two-thirds of the 6,900 additional B.U. were located.

The three southernmost regions (II, III, and IV) contained well over half of the hotel and motel establishments in Wisconsin, and about two-thirds of the hotel-motel B.U. as well, in 1968. These same regions also showed the greatest gains in motels and the largest losses in hotels during the 8-year period.

RESORT-TYPE ESTABLISHMENTS

Resorts, despite a substantial decline in numbers, continued to make up 60.1% of all T–L establishments in 1968 compared to 61.7% 8 years earlier. In 1961, 83.0% of all *seasonal* T–L businesses were of the resort type; by 1968 this percentage was still 82.1%.

In 1961 resorts provided 50.4% of all B.U. in the State, compared to 45.5% eight years later. However, the great bulk of these were seasonal units—32,800 out of 36,200 B.U.—90.6% in 1968 compared to 92.1% in 1961.

Resort-type establishments continue to be highly seasonal in Wisconsin, despite many promotional efforts and overtures—largely by state and regional tourist organizations and agencies—to encourage and expand year-round housing for visitors. In 1961 seasonal resorts comprised 93.2% of all resort establishments, and the percentage was exactly the same in 1968. Thus, less than 7% of all resort-type businesses are open for 9 months or longer each year, and these are generally located at or near winter-sports facilities.

Because resort-type businesses are considerably smaller than hotel-motel establishments, on the average, a different size classification is used in this study to show what has taken place. This breakdown (together with the 1961 and 1968 totals) is as follows:

Size Class	*B.U. Range*	*1961 Totals*	*1968 Totals*
Small	1 to 9 B.U.	3,202	2,708
Medium	10 to 29 B.U.	1,468	1,301
Large	30 or more B.U.	91	92

Although these categories show the general trend in resort-type establishments between 1961 and 1968, they may not give an adequate picture of what is taking place within the so-called "resort industry" in recent years. Thus, a more detailed size breakdown for resorts is given in Tables 7-a and 7-b.

Small Resorts Are Declining

When we separate the "small" resort group into the 1-to-4 B.U. size—which we term non-commercial establishments—and the 5-to-9 B.U. size, some important differences are readily seen. They are depicted in Tables 7-a and 7-b, which classify the Wisconsin resort inventory by size and seasonality for 1961 and 1968, including a breakdown of the B.U. provided by these establishments and the appropriate totals. For the small-resort category as a whole, there was a loss of 2,473 bedrooms—a drop of 16.5% in capacity—during the 8-year period. However, whereas the 1-to-4 class lost only 10% or 455 B.U., the 5-to-9 group dropped nearly 20% or 2,017 B.U. Similarly, the non-commercial group declined only 11% in number of businesses, while the 5-to-9 class dropped slightly over 20%. In some areas the 1-to-4 class of establishment actually increased in numbers, and it is reasonable to assume that many of these "businesses" are actually recently-built, private cottages or summer houses that are rented out during the prime vacation months of July and August.

Of the 4,639 B.U. lost by small- and medium-size resorts—those with less than 30 B.U. per firm—3,886 or 83% were from establishments in the 5 to 19 B.U. range. Apparently the resorts in this size bracket are closing down more rapidly than those in either the 1-to-4 class or the 20-plus group, possibly because they have the least to offer in the way of economic returns. Yet the percentage of Wisconsin resort establishments in the 1-to-19 B.U. range has

TABLE 7-a. CLASSIFICATION OF WISCONSIN RESORT-TYPE ESTABLISHMENTS AS TO SIZE, SEASONALITY, AND B.U. CAPACITIES FOR 1968.

Size Class	B.U. Range	Seasonal		Year-round		Totals	
		No. Resorts	Total B.U.	No. Resorts	Total B.U.	No. Resorts	Total B.U.
Small	1 to 4	1,408	3,875	78	224	1,486	4,099
	5 to 9	1,142	7,817	80	563	1,222	8,380
Medium	10 to 19	996	13,203	82	1,128	1,078	14,331
	20 to 29	202	4,613	21	476	223	5,089
Large	30 to 99	74	3,076	13	560	87	3,636
	100 and over	2	251	3	469	5	720
Totals		3,824	32,835	277	3,420	4,101	36,255

TABLE 7-b. CLASSIFICATION OF WISCONSIN RESORT-TYPE ESTABLISHMENTS AS TO SIZE, SEASONALITY, AND B.U. CAPACITIES FOR 1961.

Size Class	B.U. Range	Seasonal		Year-round		Totals	
		No. Resorts	Total B.U.	No. Resorts	Total B.U.	No. Resorts	Total B.U.
Small	1 to 4	1,554	4,246	116	309	1,670	4,555
	5 to 9	1,423	9,660	109	737	1,532	10,397
Medium	10 to 19	1,169	15,385	63	815	1,232	16,200
	20 to 29	218	4,983	18	403	236	5,386
Large	30 to 99	74	2,862	14	674	88	3,536
	100 and over	1	126	2	265	3	391
Totals		4,439	37,262	322	3,203	4,761	40,465

declined but little—from 93.1% to 92.3%—since 1961. In terms of total B.U. at resorts, this group still provided nearly 74% of our resort capacity in 1968.

Unfortunately, there has been no significant increase in either the medium-size or the large-size categories of resort-type businesses to offset the decline in small establishments. Thus, the loss in small firms and their B.U. capacities tends to approximate the total loss for the resort industry as a whole.

Resort Distribution

Figure 6 shows the regional distribution of all Wisconsin resort establishments in 1961 and 1968. In both years, over 60% of the resort enterprises and about two-thirds of the total resort B.U. were located in the two northern regions. In fact, Region VII (the Northeast) alone has long had well over one-third of Wisconsin's resorts and almost 40% of the total resort B.U. capacity in the entire state.

Figure 6-a shows the geographic distribution of all resort-type businesses which operate on a year-round basis (open 9 months or longer each year). The number of establishments in this group has not increased in recent years. In fact, the total of these "all year" resorts has dropped from 322 to 276 since 1961. However, the total B.U. capacity of these enterprises has increased about 6.0%—from 3,203 B.U. to 3,402 B.U. over the 8 years.

Figure 6-b depicts the 1961-68 regional distribution of small resorts with less than 10 B.U., which comprise about two-thirds of

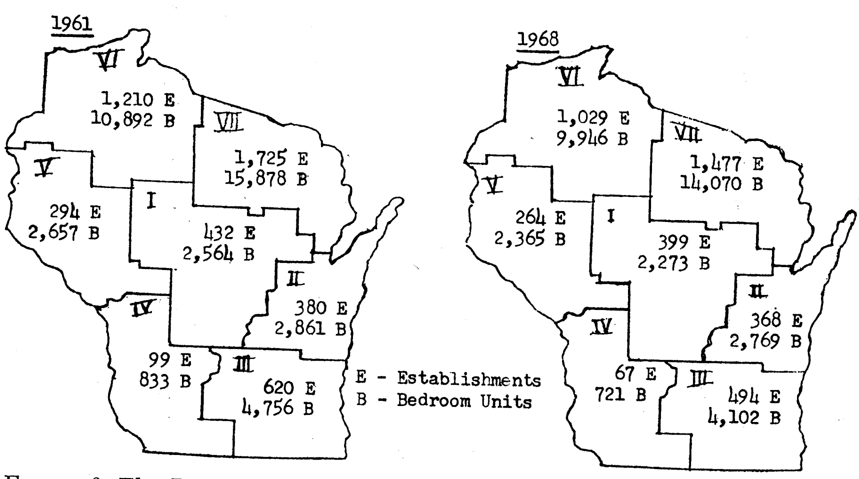

FIGURE 6. The Regional Distribution of Resort-type Establishments (all types and sizes) in Wisconsin for 1961 and 1968.

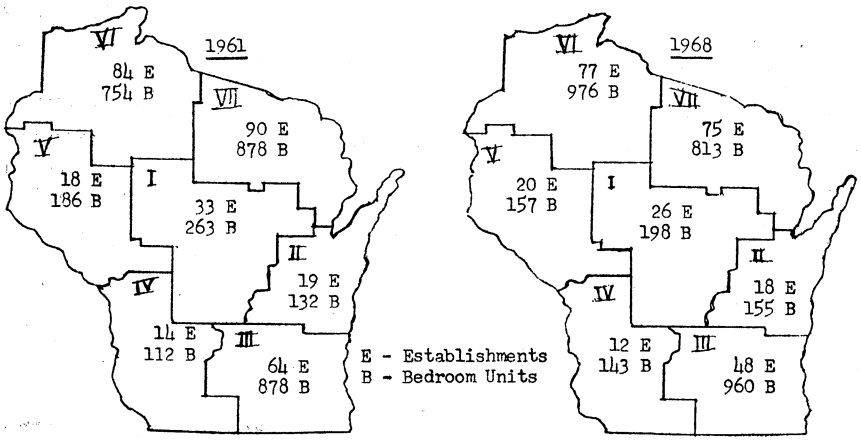

FIGURE 6-a. The Regional Distribution of Year-round, Resort-type Establishments (all sizes) in Wisconsin for 1961 and 1968.

all resort-type establishments in Wisconsin. Both the number of businesses and the total B.U. are shown for each of the seven regions. It is noteworthy that in both years, over 55% of the small resorts and over 60% of the units they provide are located in Regions VI and VII of Northern Wisconsin. These are also the regions in which the greatest losses of small resorts have occurred.

Figure 6-c details the regional distribution of medium-size (10 to 29 B.U. class) resorts in Wisconsin for the years 1961–68. Over 70% of these establishments were located in the two northern re-

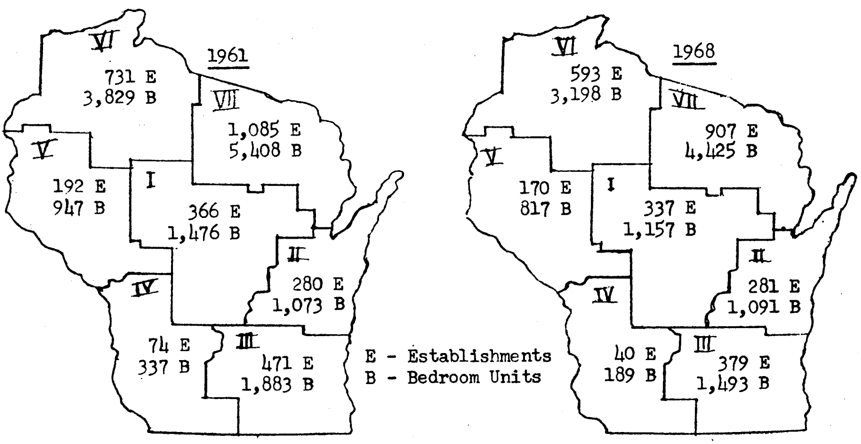

FIGURE 6-b. The Regional Distribution of Small Resort-type Establishments (less than 10 B.U.) in Wisconsin for 1961 and 1968.

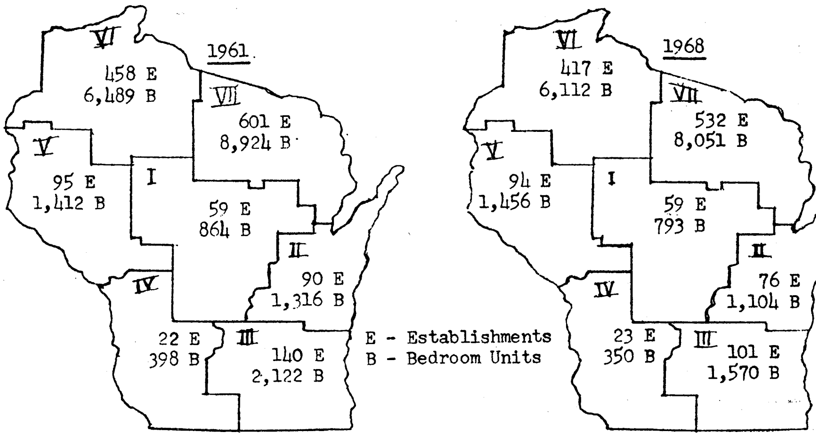

FIGURE 6-c. The Regional Distribution of Medium-size, Resort-type Establishments (10 B.U. to 29 B.U.) in Wisconsin for the years 1961 and 1968.

gions during both 1961 and 1968. The heaviest losses in medium-size resorts occurred in these two regions and in Region III (Southeast) during the 8-year period.

Figure 6-d reflects the distribution of Wisconsin's largest resorts (those with 30 or more B.U.) in 1961 and 1968. As can readily be noted, both the number of establishments and the B.U. capacities are relatively small. Except for some changes among the regions, there have been no major gains or losses during the 8 years studied. Perhaps the most significant change has been in the average size of

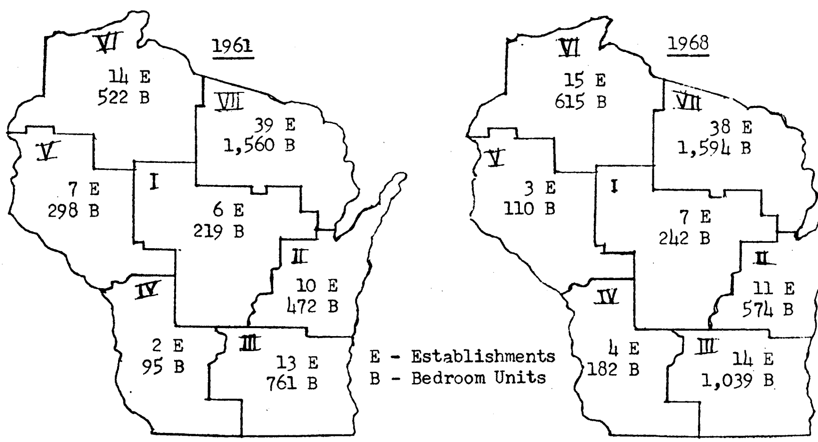

FIGURE 6-d. The Regional Distribution of Large Resort-type Establishments (30 B.U. and over) in Wisconsin for 1961 and 1968.

establishment, which has gone up about 4.5 B.U. per firm. Over one-half of these larger resort-type establishments and about 50% of the total B.U. capacity they provide are situated in the two northern regions. However, the major increase in room capacity since 1961 has occurred in Region III (SE).

Other T–L Establishments

All other types of T–L establishments, particularly those not tallied as hotels, motels or resorts, are categorized and totalled in Table 8 for the years 1961 and 1968. This catch-all group is classified as to size, seasonality, and B.U. capacity. Since the average size of establishment is relatively small, the size classification used is identical with that used for resort-type establishments. This "Other" category includes such diverse types as tourist homes, rooming houses, seasonal dormitories (often called "camps"), dude ranches, vacation farms, clubs, taverns, truck stops, and a variety of other lodgings. Over two-thirds of them have less than 5 B.U., and the bulk of these very small ones are private homes with one or more rental bedrooms.

Table 8 shows a loss of 249 "other" T–L establishments between 1961 and 1968, and well over 90% of these were in the small (1 to 9 B.U.) category. Taken together, these businesses represented a loss of 888 B.U. However, this was more than offset by a gain of 1,189 B.U. from additional establishments in the large category.

Figure 7 shows the regional distribution of Other T–L establishments in Wisconsin for 1961 and 1968, including the number of

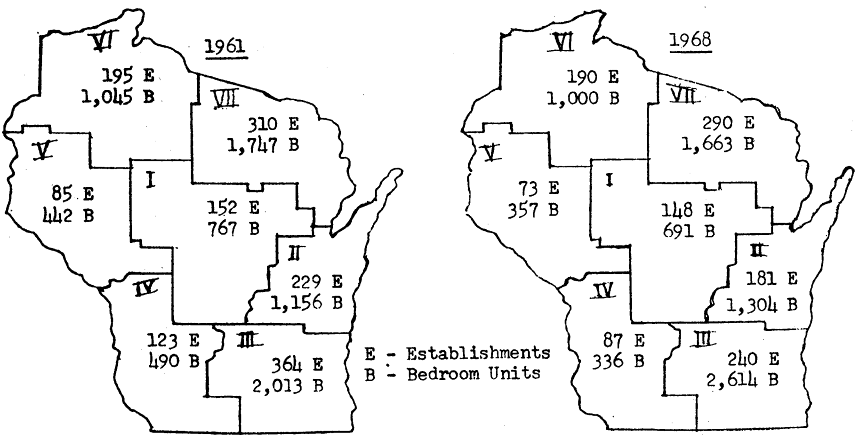

FIGURE 7. The Regional Distribution of Other Types of T–L Establishments (all sizes) in Wisconsin for 1961 and 1968.

TABLE 8. CLASSIFICATION OF OTHER TOURIST-LODGING ESTABLISHMENTS IN WISCONSIN AS TO SIZE, SEASONALITY AND B.U. CAPACITY IN 1961 AND 1968.

Size Class	B.U. Range	Seasonal		Year-round		Totals	
		No. Estab.	Total B.U.	No. Estab.	Total B.U.	No. Estab.	Total B.U.
		1968 Data—Other Establishments					
Small	1 to 4 B.U.	562	1,539	276	829	838	2,368
	5 to 9 B.U.	154	1,015	56	377	210	1,392
Medium	10 to 29 B.U.	91	1,416	46	645	137	2,061
Large	30 B.U. and over	9	749	14	1,397	23	2,146
1968 Totals		816	4,719	392	3,248	1,208	7,967
		1961 Data—Other Establishments					
Small	1 to 4 B.U.	603	1,606	409	1,192	1,012	2,798
	5 to 9 B.U.	198	1,282	87	542	285	1,824
Medium	10 to 29 B.U.	110	1,590	36	497	146	2,087
Large	30 B.U. and over	10	426	4	531	14	957
1961 Totals		921	4,904	536	2,762	1,457	7,666
Changes 1961–68		(−105)	(−185)	(−144)	+486	(−249)	+301

businesses and the total B.U. capacities for each of the seven regions. Although this group represents about 17.7% of the State's T–L establishments—almost two out of every ten—it accounts for only 10% of the total B.U. capacity. This indicates the relatively small size of the average establishment in this category, which would be even further reduced if several of the large seasonal dormitories were excluded from it.

Because such a high percentage—over two-thirds in 1968—of the other establishments are in the seasonal category, it is likely that a substantial number of them are of the resort type, possibly 100 or more. However, since the firm name does not provide us with a positive identification, we will leave them where they now repose in the unclassified "other" group. In any case, it is unlikely that they would add more than 3 or 4 percent to the present resort inventory.

Summary and Observations

Many questions have been raised concerning facts and trends in the travel-recreation industry of Wisconsin, mainly because there has been no regular compilation or analysis of year-to-year data concerning the various businesses involved. Such a "data bank" is essential if we are to identify and measure the changes or trends in this industry or any other field of economic activity.

This study was undertaken in an effort to shed some light on what has taken place in the tourist-lodging business over a period of years (1958–68). Special emphasis is given to changes in the number, size, type, distribution, and seasonality of lodging establishments between 1961 and 1968. However, an earlier study provides us with some data on T–L establishments in 1958, which enables us to observe a few 11-year trends.

In 1958 there were 7,842 T–L businesses in Wisconsin, which provided a total of 79,100 B.U. for the traveling public. By 1968 the number of establishments had dropped to 6,823—a decline of 1,019 firms—but the total capacity remained at 79,700, or essentially the same as it was 11 years earlier. About 70% of the drop in establishments involved seasonal-type businesses, including 660 resort operations.

How serious is this situation? Are we in danger of losing an important segment of our travel-recreation industry in Wisconsin? Some touristry-business leaders have said "yes" as they point to the drop in the number of enterprises. However despite the drop of 12% in the inventory of T–L businesses, the State's total capacity to house vacationers and other visitors has not decreased. It is true that we have lost many of the smaller seasonal establishments —especially cabin courts and cottage resorts—and that certain areas have lost more heavily than other parts of the State. But the number and size of other types of facilities have increased substantially, tending to offset these losses. Campgrounds, for example, are not considered in this report but have increased six-fold since 1958.

These and certain other trends, as noted in this report, do not necessarily spell hardship for the lodging industry or disaster for any group of operators within it. More than likely, these changes simply reflect the shifts and internal adjustments of an industry in transition. And there has apparently been no great economic loss in either business income or in the overall value of T–L facilities. However, certain geographic areas lost more heavily than others in terms of number of businesses and in their total capacity to house visitors. (The two northern regions, for example, dropped substantially in seasonal B.U. capacity.) In addition, some types of T–L businesses appear to be at more of a disadvantage than others in competing for the tourist's dollar.

The smallest establishments showed the largest decreases in number. Those with fewer than 10 B.U. showed a net loss of 814 businesses and over 3,800 B.U. since 1961—a drop of 16%. This category continues to be a fairly large one, however, since it still provided 19,300 B.U. in 1968 (almost 25% of the State's total). Meanwhile, the number of large T–L enterprises with 30 B.U. or more increased from 326 to 374—about 17%—with a gain of almost 5,000 B.U.

As mentioned previously, seasonal establishments have suffered the largest numerical losses since 1961. But contrary to a widely-held notion, the number of lodging businesses that are open to the traveling public on a year-round basis has not increased in recent years. The number of seasonal establishments declined by 13% (from 5,733 to 4,995) during the 1961–68 period, while the year-round firms dropped about 8% from 1,983 to 1,828. However, the total number of year-round bedrooms did increase, going up about 4,400 B.U. since 1961 and almost offsetting the loss of 5,000 seasonal B.U. during the same 8 years. While there is undoubtedly less demand for certain types of seasonal accommodations, the primary reasons for the sharp dip in summer-only establishments in Wisconsin since 1961 appear to be economic ones. First, they have not been able to generate sufficient income to cover the increased costs of operation during the 1960s. Also, the booming market and soaring prices for recreational real estate (especially good lake and river shoreline) have encouraged many unprofitable lodging businesses to sell their property at a handsome price over and above their total investment. A recent study of Northeast Wisconsin by Staniforth and others reported that resort sales in that area were bringing prices equal to about twice the owner's total investment, on the average. When they are sold, practically all of these properties pass out of the lodging business and go over to another use, usually residential.

As to type-of-establishment trends, the biggest declines were noted in the hotel-type and the resort-type businesses. Hotel numbers declined 21%, from 583 to 457, while the number of establishments classified as resorts dropped about 14%—from 4,761 in 1961 to 4,101 in 1968. Despite this substantial decline in resort numbers, the percentage of Wisconsin T–L businesses that can be identified as resort-type establishments dropped only a little (from 62% to 60%) during the 8-year period.

Motels, on the other hand, increased about 15% to a 1968 total of 1,031 establishments and 19,500 B.U., certainly a noteworthy gain in only 8 years. In general, Wisconsin's T–L establishments are getting fewer but larger, while the State's total capacity for housing guests—travelers of all types—has remained fairly constant at about 80,000 B.U. since 1958.

Trend of the Times?

At first glance, the disappearance of over 1,000 T–L establishments in just a few short years seems almost a tragedy. But it is probably in keeping with the general trends of our fast-moving age. These include the trends toward: (1) bigger business places; (2) greater efficiency; (3) more one-stop services; (4) more full-time or round-the-clock operations. Farm businesses have been getting fewer but larger since before World War II. We have seen what has already happened to many small businesses, including neighborhood groceries and small gasoline stations. The same trend seems to be taking place in our Wisconsin T–L industry. The small, inefficient, part-time operations are gradually disappearing. Meanwhile the more-successful businesses are getting bigger, or more specialized, with a greater array of services and conveniences for their guests and other customers.

It has been said that time is the greatest innovator of all in our type of economy. Most of us tend to stall until the change is forced upon us. Time is particularly relentless when people and businesses are slow in adapting to new demands, changes, and opportunities. The obsolete facility, the inefficient business, and the apathetic operator usually drop out of the game. This is undoubtedly a major factor in the substantial decline of hotels and resort-type establishments in Wisconsin.

In most areas, the traditional hotel is fast becoming an antique, particularly the smaller ones in our smaller cities. Many of the older hotels were built on a downtown, railroad-oriented site that is no longer convenient to modern-day travelers. Today we find some of them being converted to apartments, offices, shops, and other uses. Still others have just "hung on", hoping for better days as they watch their business volume dwindle. In any case, these older hotels are gradually being replaced or superseded by modern motels and motor hotels, which provide better accommodations, more and better services, and greater convenience in location, parking, and highway access.

Not only are motel establishments displacing hotels in most communities, but they are also moving into new areas, attracting new business, and expanding their initial plants and facilities at a fairly rapid rate. They are the only type of T–L enterprise in Wisconsin to show a sizeable growth in both number of establishments and total bedroom units. They have increased in all size classes, both seasonal and year round.

An explanation for the large decline in resort-type establishments, most noticeable in the 5-to-19 B.U. range, is not so easy to develop. Despite a rising population, an affluent society, increased urbanization, and more leisure time, there appear to be fewer customers for the traditional type of cottage-resort facilities—particularly those with no food service and limited opportunities for family recreation. Even with longer vacations and greater travel expenditures, the clientele for most of the older resort establishments—those who depend on the long-term (full week or longer) vacationers' trade—has not increased. The reasons are not entirely clear, but there are several major trends in vacation-travel preferences and leisure-time pursuits that may have some bearing on this question.

One of these has been the great increase in the number of camping enthusiasts since 1961, when the Athletic Institute and the American Camping association reported 5,500,000 participants. By the year 1966 there were 37,000,000 participants—an amazing gain of 670% in only 6 years—according to these organizations.

A closely-related factor is the *cottage-on-wheels* movement, which includes the owners and users of all types of recreational vehicles —campers, travel trailers, pick-up coaches, motorized homes, and so on. This group numbers approximately 10 million at present, including almost 2 million American families who wish to transport their own housing while on vacation trips. These citizens have become "campers deluxe" who wish to travel first-class and visit a lot of country, seldom staying at a single site more than 2 or 3 days. For this reason, we might call them "recreational nomads."

We have witnessed an amazing increase in recreational vehicles since 1960. About 83,000 were manufactured in 1961, compared to

395,000 in 1968. The total number in use is expected to exceed two million by 1970, according to the Recreational Vehicle Institute, which is the industry's trade association. This new development has undoubtedly had a considerable impact already on the tourist-lodging business in most parts of the country.

There is another important factor that probably has affected the demand for resort accommodations in recent years. This is reflected in the great and growing demand for second homes and other types of recreational real estate here in Wisconsin.

More and more families want to have their own little "resort" in the form of a vacation cottage, a summer home, a farm, or a little retreat back in the woods. Some want solitude, but others want to be where the action is. In either case, and regardless of what they seek, these people want to nestle down on a private plot and have their own lodging in or near their favorite recreation center. They find it imperative to have a recreational territory that they can hold, either as owners or under long-term leasing. Their numbers are increasing every year in Wisconsin, as well as other states. Because of their habits and their importance to the economy of many communities, we identify this group of people as the "recreational nestlers"—or seasonal residents.

In 1960 there were approximately 55,000 seasonal dwellings in Wisconsin, compared to over 96,000 in 1966. They ranged from hunters' cabins to large, elaborate summer homes that cost well over $25,000 to build. Every family that buys or builds its own recreational nest in Wisconsin ceases to rent vacation accommodations from our T–L businesses. Furthermore, these private seasonal dwellings are also used frequently by relatives, friends and business associates of the owners. Quite a few of them are rented out regularly during the summer period and, since they are subject to inspection by the Board of Health, a considerable number of them are included in the 1-to-4 B.U. category of resorts and "other" establishments. This may explain why this size class of T–L businesses has maintained its total numbers better than the 5-to-9 and 10-to-19 B.U. classes, which have shown greater losses. Since there were fewer than 30,000 rental cottages throughout the state in 1968, including some obsolete units, the importance of private-cottage rentals (and complimentary usage) cannot be ignored as a market factor that affects both the demand for rental cottages and their prices.

With the tremendous increase in the number of both *nomads* and *nestlers* in our recreational landscape, especially during the past 2 years, we can expect even greater changes in our tourist-lodging industry of the future. These are not the only two groups affecting the picture, of course. But, they are of prime importance in determining what happens to our 5,000 seasonal establishments, which still represent about three-fourths of all lodging businesses in Wisconsin.

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TOPOGRAPHIC INFLUENCE ON TORNADO TRACKS AND FREQUENCIES IN WISCONSIN AND ARKANSAS[1]

Robert G. Gallimore, Jr., and Heinz H. Lettau

INTRODUCTION

It has been known for some time that tornadoes appear less frequently in mountainous terrain. Furthermore, spatial variations in tornado formation might also be related to surface temperature, as indicated by Kuhn, Darkow and Suomi (1958).

This study concerns a possible relationship between tornado frequency and topography, as well as the thermal structure of the earth/air interface. Specifically, the distribution of tornadoes in Wisconsin and Arkansas was studied to test the assumption that topography is a significant factor. Detailed information on tornado frequencies can be found in the literature (Flora, 1953). The overriding conclusion is that the annual variation of tornado outbreaks depends primarily on the progression of the seasonal storm track. A reduction of frequencies in northern Arkansas and Missouri may indicate suppression by the Ozark, Boston and Ouachita Mountains. Corresponding relationships can be detected by considering detailed tornado maps like those prepared for Wisconsin by Burley and Waite (1965).

One difficulty with such comparisons, however, must be considered. Since tornadoes are reported by people, the lower population in mountain regions may offer partial explanation for a relatively small number of reported tornadoes. Reduced horizontal visibility and less efficient communication in forested, mountainous or hilly areas are additional factors. Nevertheless, tornadoes leave their marks on the ground for a number of years and many of these will eventually be detected. In this study it is assumed that topography has a real influence which overrides that of a low population density.

PART I: Arkansas Investigation

Regional and Seasonal Variations of Tornadoes in Arkansas

Since Arkansas has interesting regional variations in tornado development, it was chosen for a preliminary study of possible ter-

[1] Part of this research has been sponsored by the United States Army Electronics Command, Atmospheric Sciences Laboratory, Fort Huachuca, Arizona, under Grant No. DA–AMC–28–043–66–G24.

rain effects. Maps published by Asp (1956) and reproduced in Lettau (1967) suggest two distinct tornado "alleys" and two belts with considerably lower frequencies which will be referred to as "shunted" regions. The southern alley lies in the flat Gulf coastal plain while the north–central alley lies in the Arkansas River Valley. The two shunted belts are the Ozark and Boston Ranges, located north of the Arkansas River valley, and the Ouachita Mountains, located in the west central area.

Method of Investigation—Terrain Spectra

The main problem of this study was to obtain a quantitative measure of the difference between alleys and shunted belts. Five longitudinal sections were chosen in the prevailing direction (or close to it) of the tornado paths. Three of these strips covered the main tornado alleys and the two others the shunted regions; they varied in length from 120 to 200 miles. On a topographic map of Arkansas (1 to 500,000), with 250-foot contour intervals, terrain heights were read along these strips at one mile intervals. Portions of three of the resulting terrain profiles are illustrated in Figs. 1 and 2.

The single most significant statistical parameter is the total variance of terrain heights for each strip. More resolution is pro-

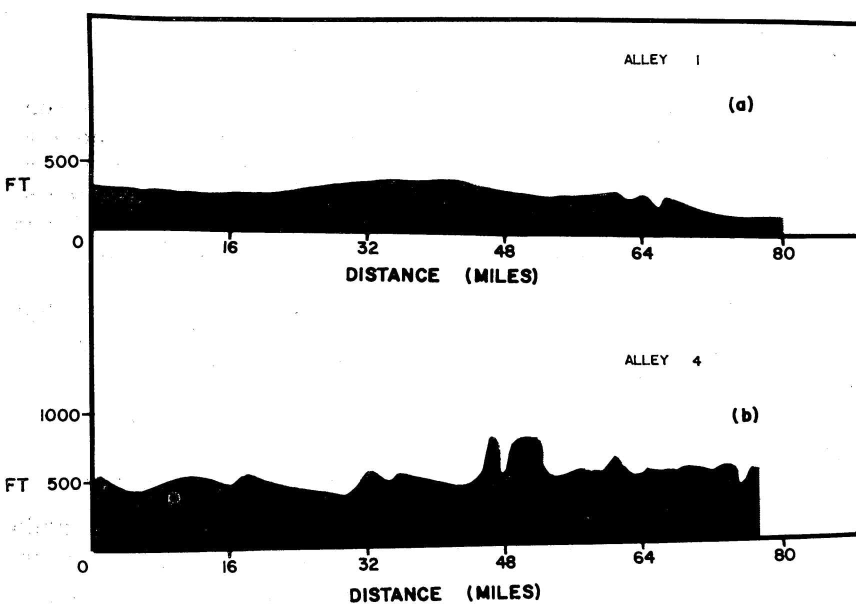


FIGURE 1. Terrain profile in Arkansas tornado alleys. Top profile in Gulf Coastal Plain and bottom profile in Arkansas River Valley.

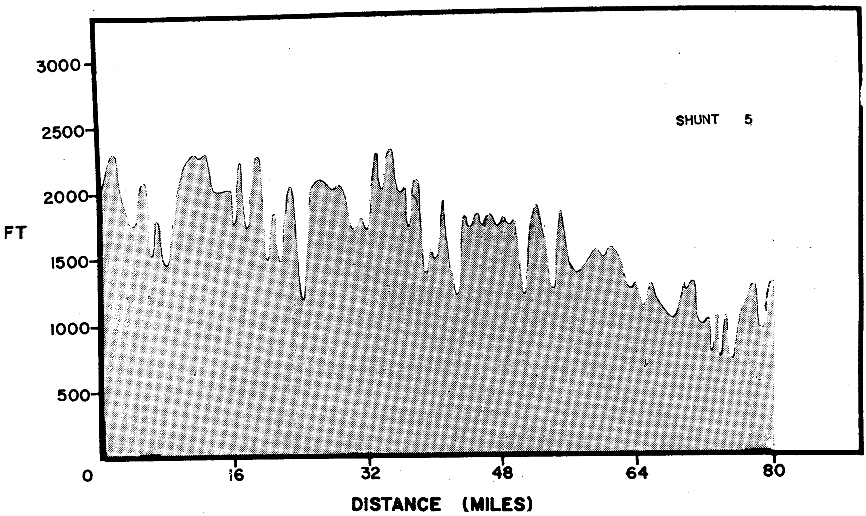


FIGURE 2. Terrain profile in Arkansas "shunt region," located north of Arkansas River Valley in the Ozark and Boston Ranges.

vided by spectral analyses of the height-data, showing relative contributions of different wavelengths or wavenumbers to the total variance. In order to compare the spectral densities of each strip, estimates were normalized. The range of wavelengths covered in this treatment was 2 to 34 miles (corresponding to wavenumbers from 0.5 to 0.029 cy/mile). A total of 17 lags was used. Aliasing was not a problem in the short wavelengths since height values were smoothed by interpolation between the generously spaced contour intervals. In fact, too much smoothing may have resulted since resolution was not optimum, particularly in the coastal plain.

The results of this spectral analysis will be labeled "Zones 1 to 5" from south to north. Zones 1, 2 and 4 are tornado alleys and Zones 3 and 5 the shunted belts. Figures 1 and 2 illustrate the terrain profiles of Zones 1, 4 and 5, respectively.

Results and Conclusions of Spectral Analysis

The results were plotted on a log–log diagram, with the ordinate being the spectral density (p) and the abscissa being the wavenumber (k) or correspondingly the wavelength (1/k). In Fig. 3, the spectral densities for tornado alleys can be compared with that for shunted belts. The averages were computed by an arithmetical mean of the logarithm of the estimates. The individual and averaged variances corresponding to Fig. 3 are summarized in Table 1.

A significant characteristic of a spectrum is the exponent: $n = d(\log p)/d(\log k)$. Its overall numerical value in Zone 4 (tornado

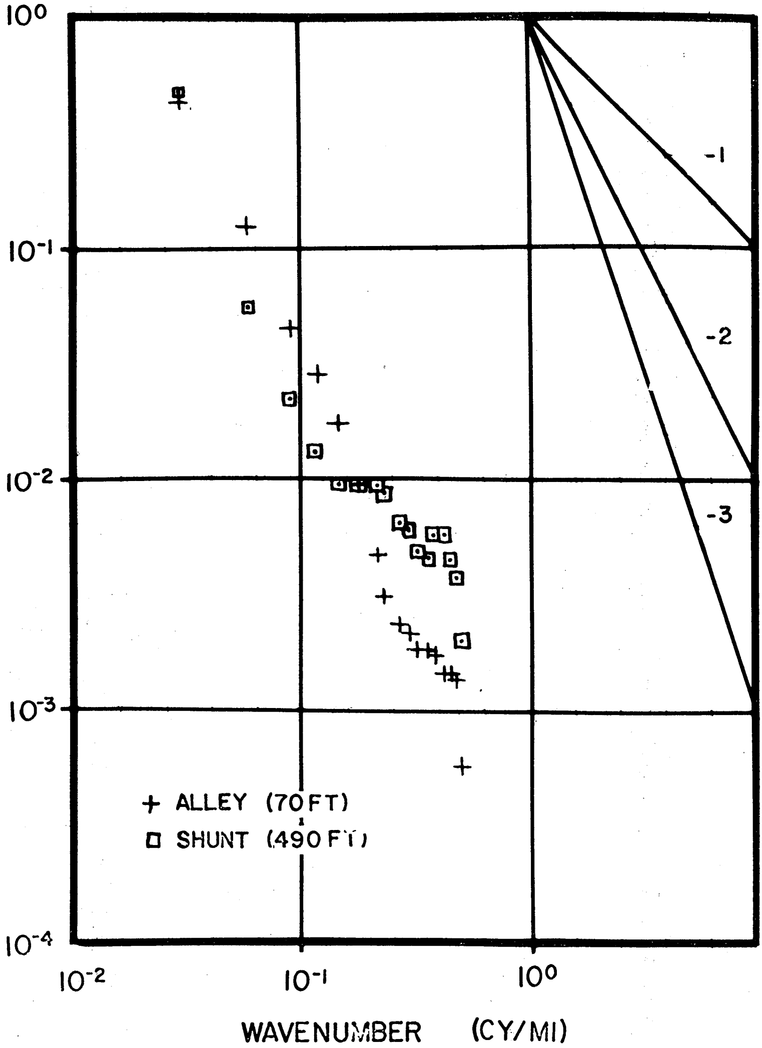


FIGURE 3. Normalized spectral plots of Arkansas terrain separately averaged for "tornado alleys" and "shunt regions." Comparative slope lines for several indicated values of the exponent n are indicated in upper right corner. Averaged standard deviations are given in legend. (Averages were computed by averaging the log of the spectral estimates.)

alley) is near —2 while for Zone 5 (shunt zone) it is close to —1 for large wavenumbers and near —3 for small wavenumbers. Zone 1 has a very pronounced value of n = —3 in medium and small wavenumbers. It is apparent that similar tornado alleys may have

TABLE 1. VARIANCE AND ARITHMETICAL MEAN OF TERRAIN HEIGHTS IN ARKANSAS FOR TORNADO ALLEYS AND SHUNTED ZONES. VARIANCE AVERAGES WERE COMPUTED LOGARITHMICALLY.

ZONE	VARIANCE (FT.)^2	MEAN (FT.)
Alley 1	1,714	208
Alley 2	3,046	257
Shunt 3	152,932	660
Alley 4	23,645	489
Shunt 5	386,910	1,387
Averaged Zones		
1, 2, 4—Alleys	4,930	318
3, 5—Shunts	240,000	1,024

different terrain characteristics; reference can also be made to the discussion in Lettau (1967, p. 5 to 7).

The general differences are best evidenced in Fig. 3; the terrain spectra for tornado alleys "fall off" nearly at n = —3 for all wavenumbers, while the shunted belts show n = —3 only for small wavenumbers and possibly for the largest wavenumbers. At about 10 mile wavelength the two plots diverge with n = —1 prevailing for the shunted belts. It is apparent that the terrain in tornado alleys is smoother, or more "wave like," than in shunt regions. A value of n = —3 indicates that within a large family of terrain features of different sizes, the individual heights of the "obstacles" are proportional to their base–lengths. In other words, n = —3 indicates the same slope angles, or hill–steepness, regardless of base–length or wavenumber. However, the value of n = —1 indicates that the smaller the base-length the steeper the slope. Thus, Figure 3 suggests a "critical" baselength (or wavelength) of about 10 miles, since the shunted belts are distinguished by a change from n = —3 to n = —1 at and beyond wavenumbers of about 0.1 cy/mile. It could be surmised that tornadoes, when encountering a terrain type with n about equal to —1, at wavelengths smaller than about 10 miles, will be inhibited from either sustaining themselves or possibly even deevloping. In the intermediate case of n = —2 (as in tornado alley 4) the terrain may not appear rough enough or still too close to being wave-like to affect tornadoes.

PART II: Wisconsin Investigation

Tornado Statistics

Quite distinct from that of Arkansas, main tornado activity in Wisconsin occurs from March to September with peak intensity in May and June, and a secondary peak in September. The most destructive and longest tracked tornadoes appear in the months of April, May and June. Out of 52 severe tornadoes (according to criteria of Burley and Waite, 1965), 42 occurred during September and the spring months. About 83% of all Wisconsin tornadoes arrive from azimuths between west and south. In July and August, however, many of these storms arrive from the northwest, probably in connection with the frequent northwesterly flow aloft during middle summer. Since the overall synoptic pattern is weak during the summer, the resulting tornadoes are less intense and usually have short tracks. This study will consider tornadoes which are outstanding with respect to both path-lengths and intensity. Some bias may have resulted from the fact that the number of reported tornadoes has nearly doubled in the last 10 years of a 50 year record.

In Wisconsin neither topographical features nor the relations between terrain and tornado frequency are as clear-cut as in Arkansas. Fig. 4 shows the number of tornadoes by county from 1916–1964. Tornadoes are relatively frequent in most west–central counties, but no distinct north–south variation exists. In some summer situations, extreme eastern counties may be "saved" by cool air off Lake Michigan. Tornado frequency increases towards the west to a maximum in central Iowa. The typically flat or gently rolling, unforested farmland of central and western Iowa, which is essentially open, plowed fields in the spring, offers a relatively smooth and heat-absorbing surface probably favorable for tornado formation, while eastern Iowa and southwestern Wisconsin, with forested hills, bluffs and deep river valleys as well as occasional flat ridges, seem to reduce tornado activity.

The distribution of outstanding Wisconsin tornadoes, particularly the long tracked ones, suggests two "alleys"—the rather pronounced "west central alley" and the secondary "southern alley." The west central alley is an extension of the region of large frequency of tornadoes in south central Minnesota. The incidence of tornadoes may be less affected by Wisconsin's unglaciated area than is the ability of these storms to sustain themselves over long distances. Between the two "alleys" there is less reduction of tornado incidence than in the shunted regions of Arkansas.

The two alleys of Wisconsin are frequented at different times of the spring season. The majority of the southern–alley tornadoes occur in April and May, while the west–central alley is most often frequented in June, simultaneously with a jump in tornado activity in both southern Minnesota and west central Wisconsin. This region of Minnesota is flat open farmland, much like that of cen-

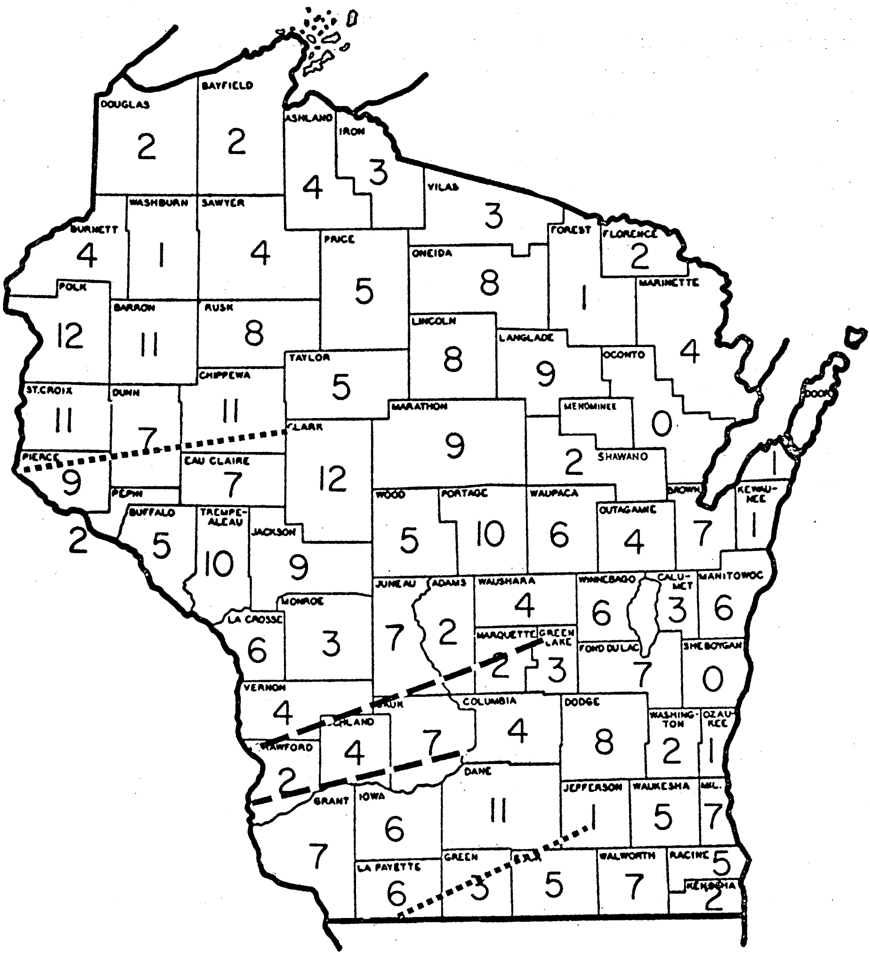


FIGURE 4. Number of reported tornadoes by county, 1916 to 1964 (after Burley and Waite, 1965). Superimposed lines (short-dash for "alleys" A and D, and long-dash for "shunted areas" B and C) indicate paths chosen for investigation.

tral Iowa. July and August tornadoes seem to show no "alleying," and often move in a southeasterly direction, but their rarity prohibits further discussion of topographic effects.

In general east to west trends, population density in Wisconsin is negatively correlated with frequency of tornadoes. However, in Central Wisconsin, just south of the main tornado alley, a sparsely populated area surrounds the forested region including many cranberry bogs east of the hills near the Mississippi River. Consequently, the lower population in areas between the two alleys requires some qualifying of terrain–tornado alley relations based on presently available statistics.

Profiles of Topography and Terrain Slopes

Four topographic profiles were chosen. Two of them followed the tornado alleys and the remaining two were in the region of relatively low tornado frequency. All of these strips extended into adjacent states to the west. The profiles were labeled A, B, C and D from south to north; A and D represent tornado alleys, while C and B correspond loosely to shunted belts. Table 2 gives the geographic locations of these four strips.

Initially it was planned to use a radioaltimeter (type AN/APN-22) in the Cessna 310 twin-engine aircraft employed in previous work at the University of Wisconsin Department of Meteorology (see Lenschow and Dutton, 1964), but the available system was found unworkable. Consequently, the study of terrain profile structure was based on topographic maps. The airplane, however, was useful in measuring profiles of surface temperature along the selected topographical sections. Bolometric sampling of surface temperature was done every second, which corresponds to one sample every 1/20 of a mile. To ensure comparable detail, terrain heights were taken from 7.5 minute (scale 1 to 62,500) Geological Survey Quadrangles. Because these maps are often only planimetric, a portion of Wisconsin's shunted belt could not be analyzed. The contour intervals on the topographic quadrangles proved satisfactory for readings at intervals of 1/20 mile. The actual horizontal increment used was 247 feet, or about 79 meters.

For an illustration of terrain structure, heights were plotted in Figs. 5 and 6 every 4,940 feet. As can be seen from Table 2, the variance of height in the shunt region exceeds that of the tornado alleys, but the difference is less than in Arkansas. Moreover, the

TABLE 2. GEOGRAPHIC STATISTICAL DATA OF TOPOGRAPHIC PROFILES IN WISCONSIN IN CONNECTION WITH TORNADO STATISTICS.

Strip	Endpoints	Length (miles)	Variance (ft.)^2	Mean (ft.)
A (Alley)	Anamosa, Iowa—Fort Atkinson, Wisconsin	138	9,036	899
B (Shunt)	West Union, Iowa—Lake Wisconsin	123	24,785	911
C (Shunt)	Decorah, Iowa—Princeton, Wisconsin	141	44,036	1,010
D (Alley)	Farmington, Minnesota—Stanley, Wisconsin	121	13,197	963

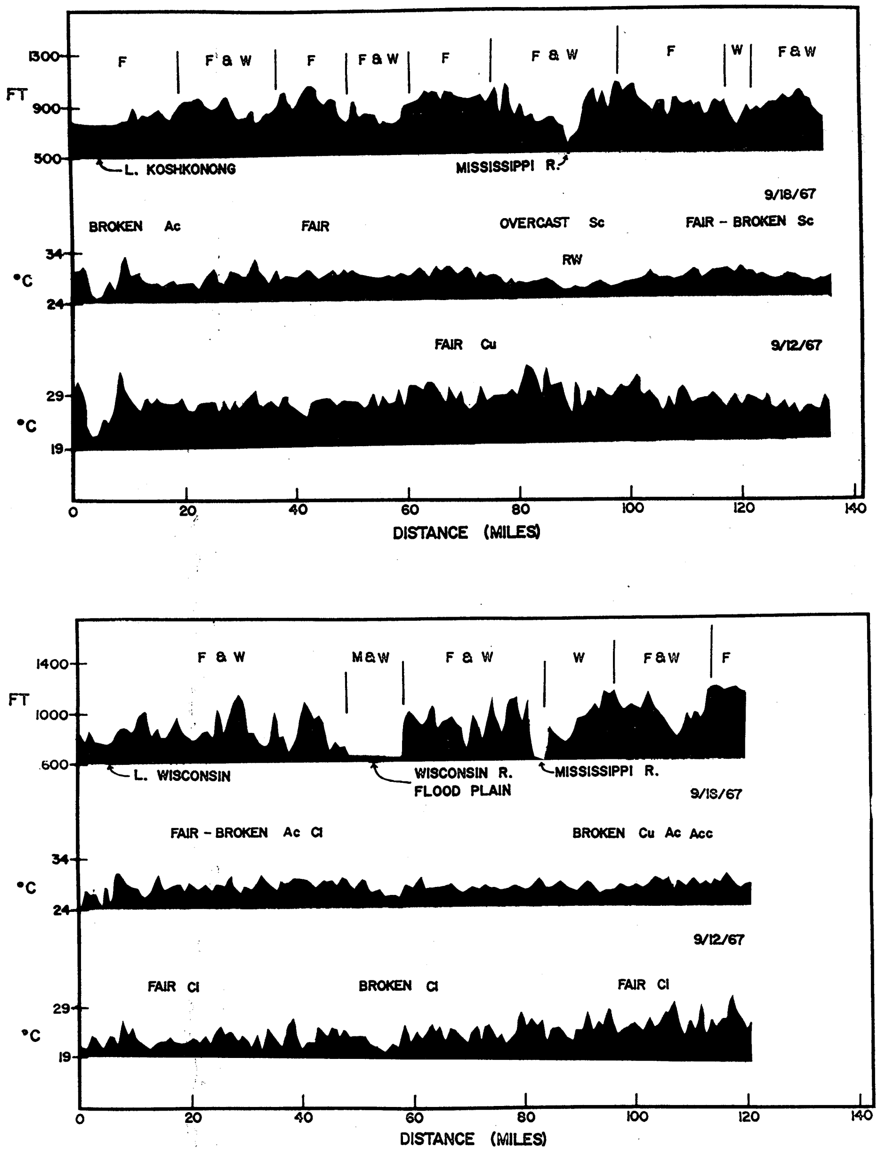
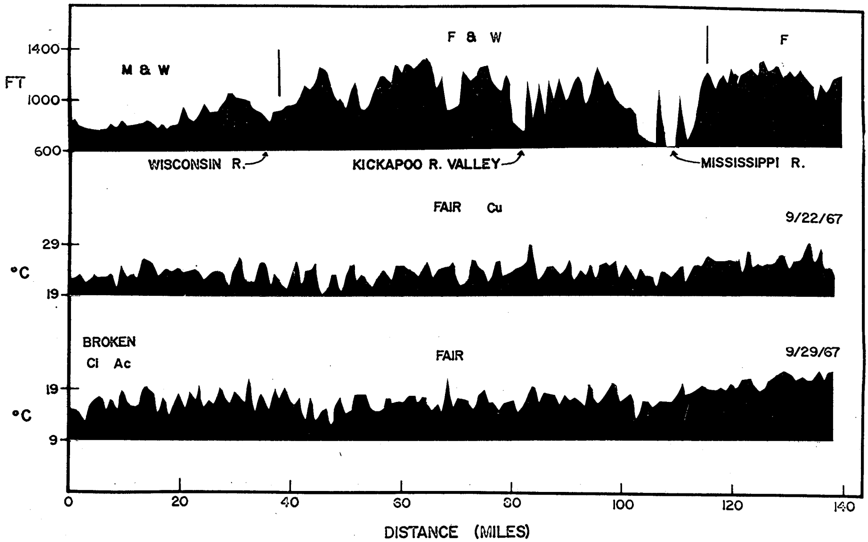


FIGURE 5. Terrain and surface temperature profiles of September 12 and 18, 1967, for Wisconsin Strips A and B (top is A). A new landmarks and a general description of the characteristic surface and sky conditions are also given. (Note: M = marshland, F = open field and farmland, and W = woodland.)



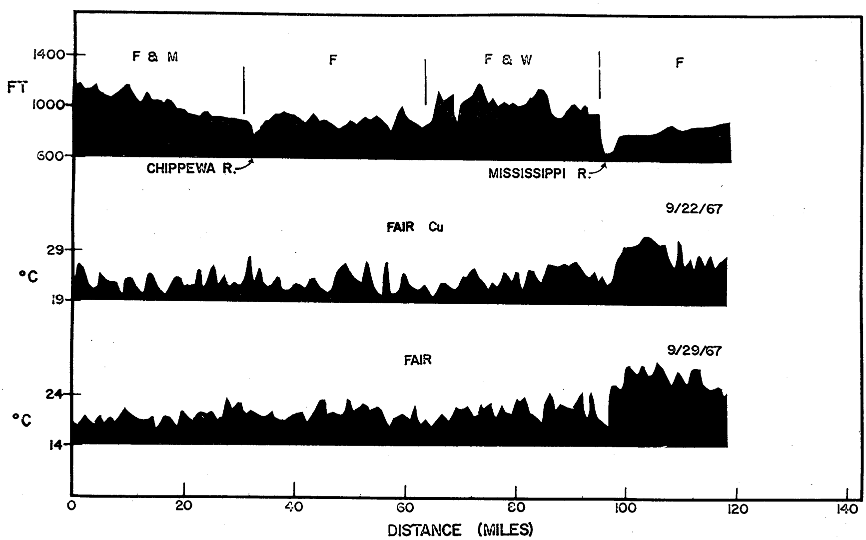


FIGURE 6. Terrain and surface temperature profiles of September 22 and 29, 1967, for Wisconsin strips C and D (Top is C). A few landmarks and a general description of the characteristic surface and sky condition are also given. Note: M = marshland, F = open field and farmland, and W = woodland.

variance along the shunted Strip B in Wisconsin is about the same as that of the Arkansas River tornado alley. If the frequency of tornadoes reported in Wisconsin were equal to that in Arkansas, Strip B might possibly not be considered typical of a shunted belt. The results of spectral analysis (presented later) bear this out to some degree. Strip C appears more representative of Wisconsin's rugged unglaciated area as well as more reliably centered in a shunted belt than Strip B. However, the terrain variation in this shunted zone is far less than in Arkansas. The fact that some active tornadoes do indeed track over this area implies a weaker relation between shunted belts and terrain roughness than is apparent in Arkansas.

The terrain profiles show that unlike the other profiles, D has relatively large variation in very long wavelengths. This implies that "Alley D" is relatively smoother than the other strips at short and medium wavelengths. The flat terrain west of the Wisconsin portion of D coincides with a region of notorious tornado activity during June.

Figure 7 suggests that tornadoes may shy away from varying slopage, i.e., terrain roughness and downslope. The positive relation of tornado frequency with upslopes toward the East may further be enhanced by middle and late afternoon heating.

Tornado frequencies appear to depend on somewhat different mechanisms than other convective phenomena. Hail and heavy rainfall are also known to be dependent on terrain slope, elevation, and roughness as well as distribution of woodlands. Hail intensity not only appears positively related to upslope, but unlike tornadoes it is positively related to downslope, roughness and woodlands (Stout, 1962). Rainfall patterns show a similar relationship except that downslopes likely reduce convective instabilities and hence reduce thunderstorm rainfall.

During spring, thunderstorm cells tend to move northeasterly; considering the previously mentioned topographical relations, this appears to be the main reason for maximum hail and rainfall in the hilly areas west and northwest of Madison and in the Northern highlands generally north of the west central tornado alley. Most of this information can be found in Wisconsin Weather (Wisconsin Statistical Reporting Service, 1967).

Terrain Spectra

Spectral analyses were performed on the terrain profiles defined in Table 2, with a total lag of 200. Figures 8 and 9 show examples of individual spectra for Strip A (alley) and C (shunt). The spectra were plotted by computer versus increasing period. The left vertical line indicates the Nyquist wavelength of the Arkansas

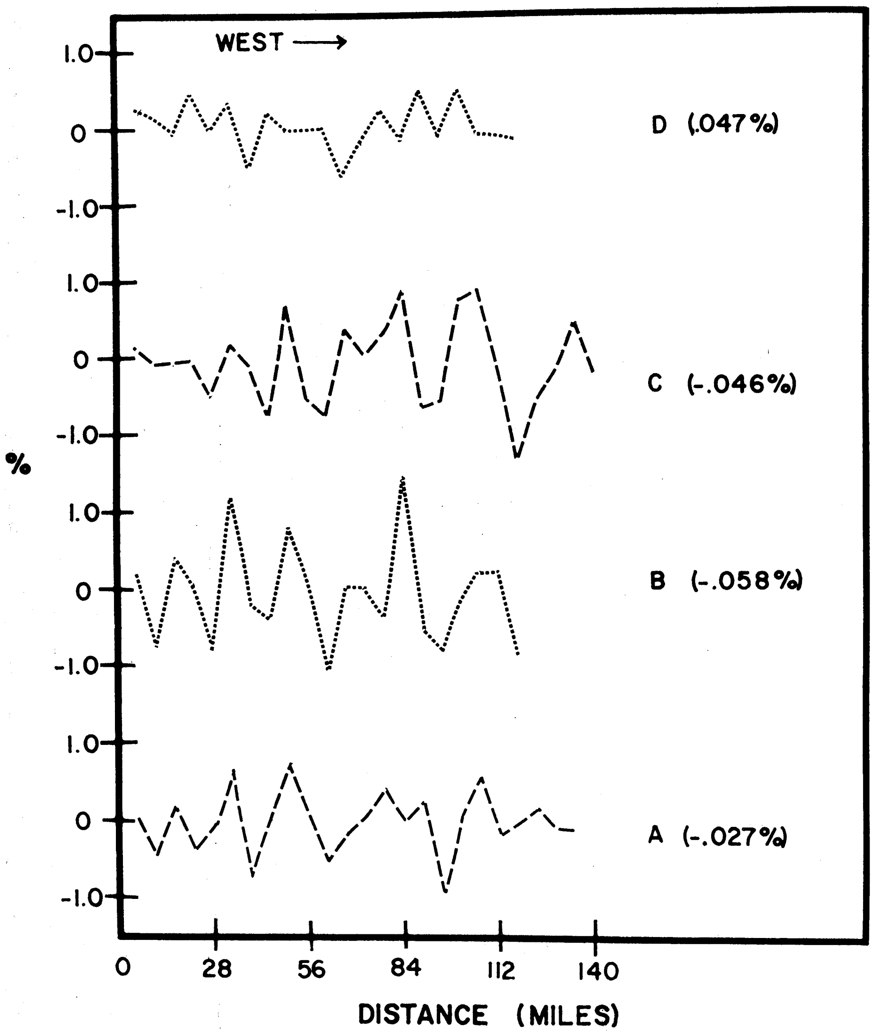


FIGURE 7. Wisconsin terrain slopes for Strips A, B, C and D, given in perctntage (positive for upsloping to the east) over 5.6 miles. The mean slope is indicated to the right of the corresponding strip.

investigation, and the right vertical line the 10-mile wavelength critical for the Arkansas shunted belts.

In view of the different total variance and the structure of the profiles of Figs. 6 and 7, it is not surprising that the spectra are also different. The plots of A, B and D are almost identical with a "critical" wavelength near one kilometer. For longer wavelengths

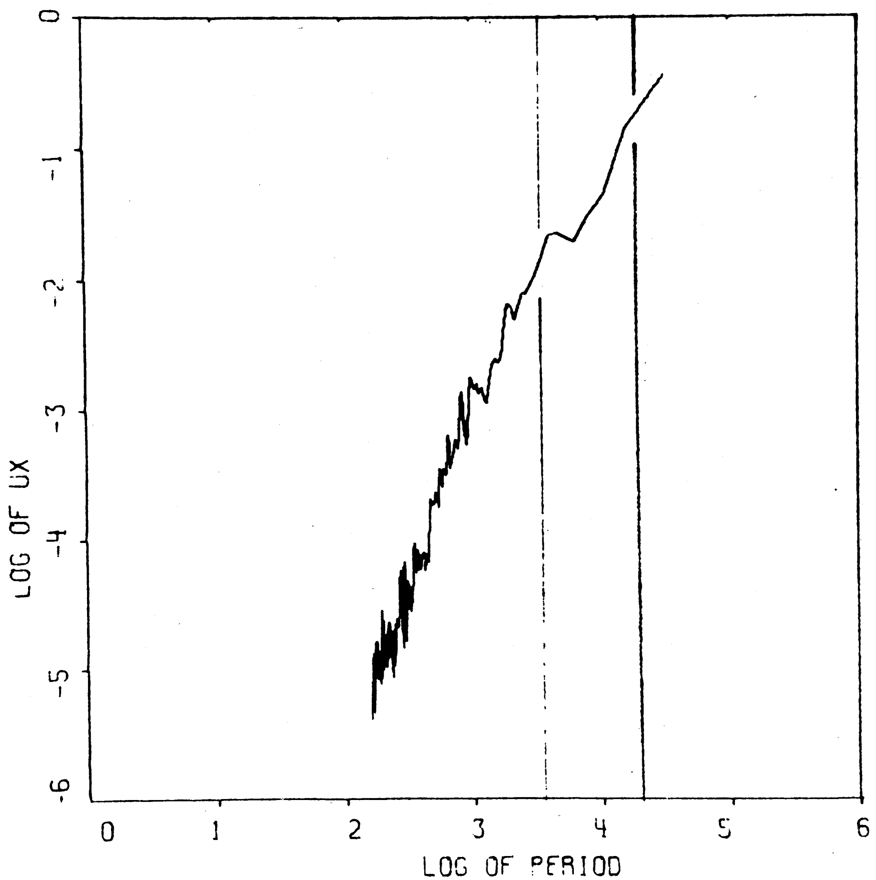


FIGURE 8. Normalized terrain spectrum of Wisconsin, Strip A (tornado alley). Vertical lines represent 2 to 10 mile spectral band covered in Arkansas spectral analysis.

the exponent (n) is near —2 whereas for shorter wavelengths n is close to —3. Strip C differs from this pattern. Here the exponent increases continuously for decreasing wavelengths starting near —2 and gradually changes to zero for wavelengths less than one kilometer. Short wavelengths contribute more variance in the shunted region C than in A, B or D.

In the 2 to 20 mile wavelength band, the spectra for A, B and D are similar to that of the Arkansas River Valley, which has a total variance reasonably close to these 3 strips. The exponent n is about —2. In marked contrast, C has a spectral variance in this band much like the shunted belts of Arkansas. Its total variance, however, is considerably smaller than in any of these belts but larger

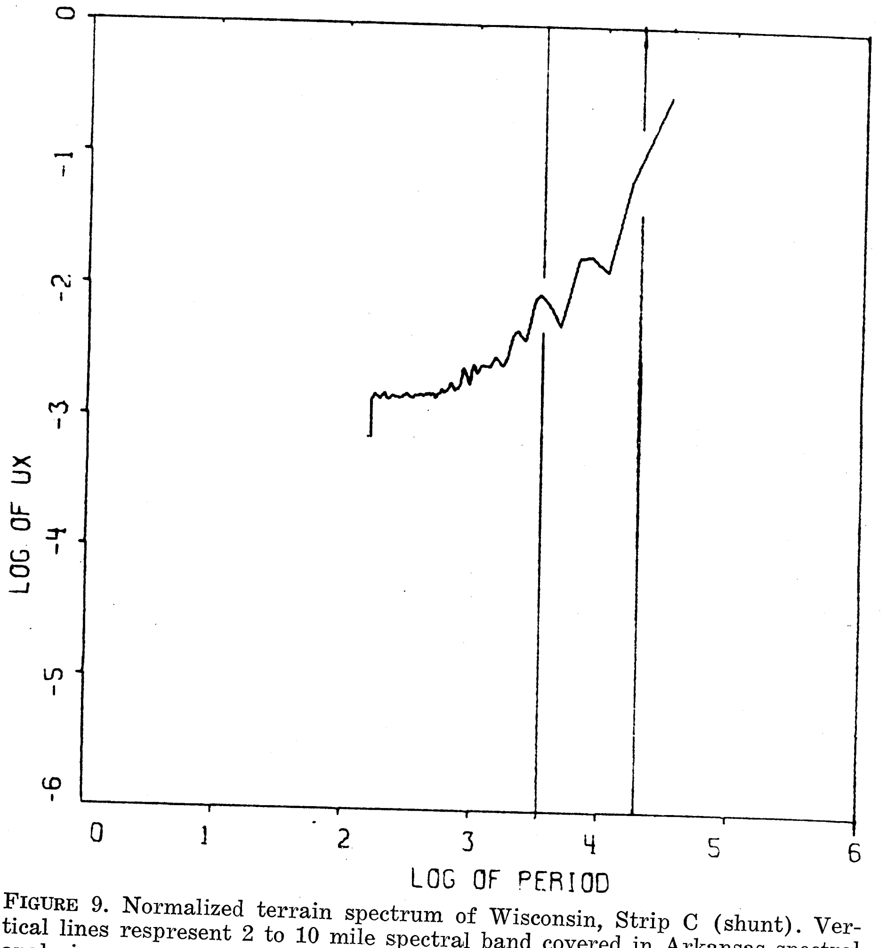


FIGURE 9. Normalized terrain spectrum of Wisconsin, Strip C (shunt). Vertical lines respresent 2 to 10 mile spectral band covered in Arkansas spectral analysis.

than in the other Wisconsin strips. Due to the difference in sampling intervals for the Arkansas and Wisconsin investigations we cannot say at present how realistic this comparison is.

Averaged spectral estimates for the two tornado alleys and the two shunted strips are illustrated in Fig. 10. Since the spectrum of B resembles more that of A than C, combination of B with C may not yield a representative average of the shunted belt of Wisconsin. More representative of a shunted strip would probably have been a profile from La Crosse to northern Juneau and Adams counties, but topographic maps were not available for this region.

A discontinuity in the spectra appeared at a wavelength of

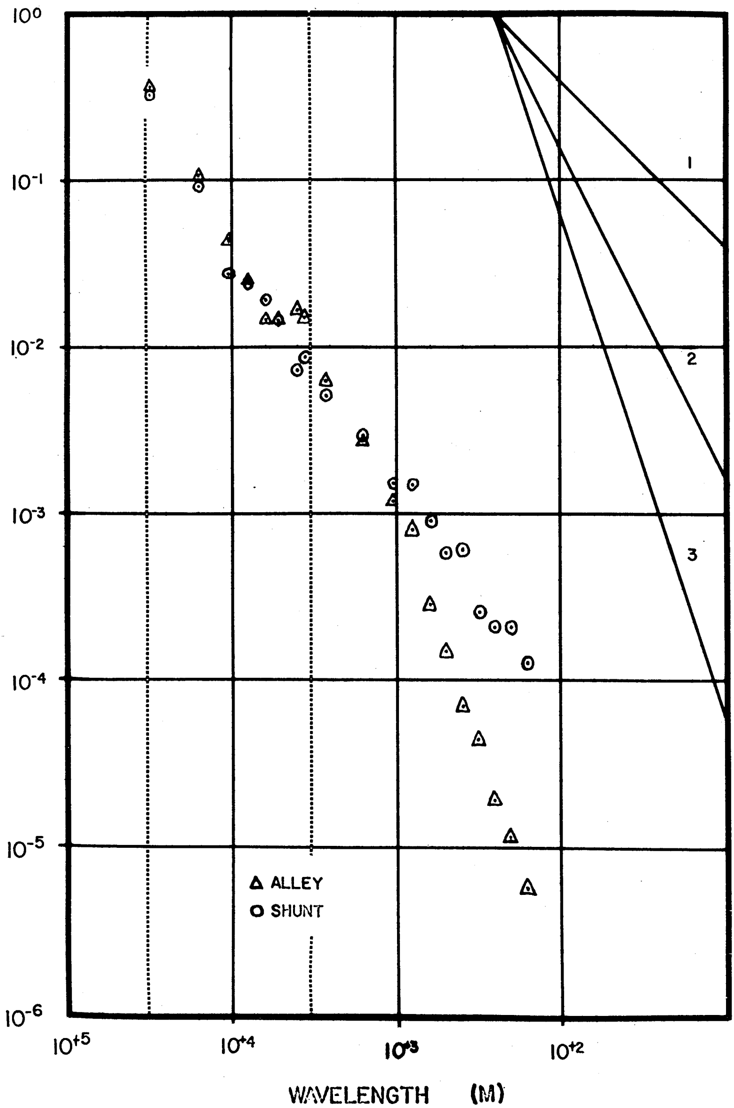


FIGURE 10. Normalized spectral plots of Wisconsin terrain separately averaged for "tornado alleys" and "shunt regions." Comparative slope lines are indicated in upper right corner. The two vertical lines are the 2 to 10 mile wavelength band covered in Arkansas spectral analysis. (Averages were computed by averaging the log of the spectral estimates.)

about one kilometer. The exponent n is near—1 for the shunted belt and near —3 for the alleys. For longer wavelengths, including the 2 to 20 mile wavelength band, both graphs suggest n = —2. The case n = —1 implies increasing hill steepness and fairly uniform hill heights with decreasing wavelength, while n = —3 indicates a uniform hill steepness and, thus, with heights decreasing with decreasing wavelength. The fact that the split appeared near one kilometer instead of around 10 miles (found critical for Arkansas) could be the result of more detailed data collection in Wisconsin.

The near-zero value of the exponent n for short wavelengths (< 1 km) of the shunted region C suggests pronounced steepening of slope with decreasing base length of the hills. It would be interesting to know if this is typical of other shunted areas like those of Arkansas. Furthermore, a critical wavelength around 10 miles corresponds to the "scale" of thunderstorms, while a critical wavelength near one kilometer corresponds to the "scale" of tornadoes. This might suggest that only tornadoes and not thunderstorms are significantly affected by topography in Wisconsin.

Surface Temperature Measurement from an Airplane

Surface temperature was measured, along the terrain profiles shown in Fig. 4, with the aid of a Barnes IT–3 Infrared Thermometer (bolometer) mounted in the baggage section of a Cessna 310 twin engine aircraft. This bolometer has a 3° field of view corresponding to a circle of about 15.7 meter radius on the ground, at 300 meters flight altitude. The technique is described by Lenschow and Dutton (1964).

Before each flight, a pre-check of the system was made with water baths of varying temperatures. Check flights over Lake Mendota were also included on the day of a run, to insure proper functioning of the instruments when airborne. Sometimes the bolometer indicated a spurious rise of about 1° C of the Lake Mendota temperature after considerable time in the air, but such discrepancies were within error tolerance. Although all instruments were shock-mounted, some vibrational noise still occurred, and an electronic filter was used to remove it for spectral analysis of temperatures. The use of this filter, however, introduced some additional problems that will be discussed later.

According to Stefan–Boltzman's law, radiation emitted by a surface depends on both its emissivity and its temperature. Since emissivity (ϵ) varies over different surfaces, errors will be introduced regardless of the accuracy of the calibration. An 8% change in emissivity corresponds to about a 6° C change in measured surface temperature (Lenschow and Dutton, 1964). Except in dry sandy areas, variations as large as 8% in emissivity are not likely in Wisconsin.

Radiation entering a bolometer depends on the radiation emitted by the environment. For the bolometer used, the radiometer filter was an 8 to 14 micron passband, with nearly zero response outside, with insignificant dependency on temperature. For the type of surfaces encountered in Wisconsin, the emissivity was assumed nearly constant for all wavelengths in the band of the filter. Errors resulting from this assumption can be reduced if the surrounding radiation is as small as possible. Tanner and Fuchs (1966) showed that the equivalent black-body temperature departs from the actual surface temperature by less than 1° C for Sudan grass ($\epsilon = 0.976$) and alfalfa ($\epsilon = 0.977$). However, Lorenz (1966) noted that for an emissivity of 0.925, the difference could be as large as 3.5° C. In general, the apparent surface temperature is sufficiently close to the actual radiation surface temperature provided the bolometer is not located far above the ground. Menon (1967) discussed surface temperature corrections for flights over Lake Michigan and Lake Superior. He found that errors of ± 0.5° C can be expected, without corrections, at 300 meter heights.

Table 3 summarizes the results of the calibration flight over Lake Mendota on August 21, 1967; a comparison of bolometric water temperature (T_b) with the lake temperature measured from a boat (T_w) showed a difference of about 0.5° C at 300 meters. The dew point was relatively high. As expected, the measured bolometric temperature decreases with height.

It should be pointed out that the bolometer "sees" an area (for our flights) of about 776 m². It records an average radiation temperature over this area that tends to be slightly higher than the

TABLE 3. RESULTS OF BOLOMETRIC FLIGHT OVER LAKE MENDOTA ON AUGUST 21, 1967. T_a IS THE AIR TEMPERATURE MEASURED FROM AIRPLANE, T_b IS BOLOMETRIC WATER TEMPERATURE, T_w IS WATER TEMPERATURE MEASURED FROM A BOAT. SIMULTANEOUS RECORDINGS AT TRUAX FIELD SHOWED A DRY-BULB TEMPERATURE OF 21° C AND A DEW POINT OF 15° C.

HEIGHT (FT.)	T_w	T_b	T_a
0	21	—	—
500	—	22	23
1,000	—	21.5	22
1,500	—	21	20.5

true area mean surface temperature. Lenschow and Dutton (1964) discussed this problem and found such errors to be less than 1° C, which was considered tolerable for this investigation.

Data Collection and Effect of Weather

The temperature trace on the "Visicorder" was read (for the same number of points as the terrain height data) by a specially designed chart reader, and data automatically punched on cards, then transformed into surface temperature with the aid of a computer-program and a linear equation.

Of a total of 14 flights, five (4 near noon and one at dawn) covered strips A and B, two were over strip C near noon, and two were over strip D in the early afternoon. Table 4 lists the resulting means and variances as well as the time and date of each flight. It should be noted that the effect of the 5-sec filter is to reduce the variance but not to alter the mean of the actual surface temperature series. Temperature profiles were included in Figs. 5 and 6 together with the general characteristics of the terrain "landmarks" and sky conditions.

The day-to-day variation in surface temperature is due to changes in insolation (which depends on cloudiness, season, latitude, etc.), albedo, emissivity, wind (speed and prevailing direction), thermal admittance of the soil, and air temperature and moisture gradients. Significant daily variations in some of these parameters occur even when the same air mass prevails over a region for several days. The days chosen to measure the surface

TABLE 4. MEAN SURFACE TEMPERATURE AND STANDARD DEVIATION (DEG C) FROM BOLOMETRIC FLIGHT OVER THE FOUR "STRIPS" IN WISCONSIN INDICATED IN FIG. 4.

Date 1967	Tornado Alleys			Shunt Regions		
	Strip	Hours	Temp.	Strip	Hours	Temp.
Sept. 11	A	10:50-11:38	23.1 ± 3.9			
12	A	12:47-13:35	27.8 ± 3.9	B	10:40-11:25	24.7 ± 5.4
18	A	13:14-14:03	27.3 ± 2.0	B	14:27-15:11	27.6 ± 1.1
21				B	11:34-12:13	25.3 ± 0.9
22	D	14:43-15:25	24.3 ± 8.7	C	11:44-12:34	23.6 ± 3.3
29	D	14:12-14:52	22.3 ± 10.6	C	11:41-12:32	17.3 ± 4.5
Oct. 2				B	12:28-13:14	27.3 ± 3.3
3				B	6:36- 7:26	15.7 ± 1.9
5	A	6:30- 7:10	13.1 ± 2.2			
5	A	12:24-13:11	22.8 ± 1.9			

TABLE 5. AVERAGE MAXIMUM AIR TEMPERATURE (IN °C) FOR TRIPLETS OF WEATHER BUREAU CLIMATOLOGICAL STATIONS LOCATED NEAR RESPECTIVE STRIPS. VALUES WITH ASTERISKS ARE AVERAGED MINIMUM AIR TEMPERATURE.

DATE—1967	STRIP A	STRIP B	STRIP C	STRIP D
Sept. 11	21.3			
12	24.3	24.8		
18	26.7	26.7		
21		23.0		
22			20.2	19.4
			12.6	15.6
Oct. 2		27.9		
3		13.0*		
5	9.6*			
5	27.1			

temperature were selected with the intent to isolate some of the dominant parameters. Tables 5 and 6 provide information on air temperature, wind and total isolation for the days and regions.

The difference between moist and dry surface conditions is illustrated by comparing the profiles of September 12 and 18 for Strips A and B. Due to preceding rainy days, the overall variation on the 18th is relatively small. Reduced insolation due to overcast cloudiness also significantly damps out temperature variability. In general, flights were scheduled only when cloudiness was expected to be light, but, unfortunately, in view of the approach of autumn,

TABLE 6. PARTIAL SUMMARIES OF WEATHER AND CLIMATOLOGICAL DATA PERTINENT TO BOLOMETRIC FLIGHTS. VALUES IN PARENTHESES ARE MAXIMUM WIND SPEEDS DURING THE DAY.

DATE 1967	AVERAGE RESULTANT WIND				INSOLATION (LY/DAY)	
	Madison		Minneapolis		Madison	La Crosse
	Direction	MPH	Direction	MPH		
Sept. 11	140	7.3 (15)			464.6	514.0
12	170	5.7 (16)			461.0	436.5
18	120	2.6 (14)			344.1	294.9
21	320	9.6 (22)			398.3	444.0
22	030	3.9 (9)	180	8.2 (17)	465.1	450.0
29	330	8.8 (15)	170	1.7 (7)	249.0	440.4
Oct. 2	200	9.9 (20)			414.9	397.3
3	200	5.6 (9)			347.0	342.6
5	020	7.8 (14)			398.4	389.9

this requirement was often relaxed. The flight of September 18 over Strip A was under heavy cloudiness and showed reduced standard deviation of surface temperature. Several examples—notably October 5 of Strip A, September 12 of Strip B and September 18 of Strip A—illustrate how periods of overcast cloudiness can induce long "trending" in the surface temperature record.

On a given day when the soil was wet, the mean surface temperature was relatively close to the average maximum air temperature of the nearest climatic stations. The mean surface temperature was found generally higher than the air temperature for fair skies and relatively dry soils. The two dawn flights (October 3 and 5) show mean surface temperatures higher than the average minimum station temperature. The variance was also found fairly high indicating that warmer ground inversions were probably being measured as part of the effective radiative surface. Temperature trends under variable conditions appear to substantiate Lambert's investigation of thermal response of a Sumac canopy (1967) to cloud shadows.

Table 6 shows lowest average windspeeds on the 18th (Madison) and 29th (Minneapolis) of September. The large surface temperature variations on the 29th in comparison with the 22nd probably resulted from drier soils and low wind speeds. The 18th and 21st appear to have sufficiently identical soil and sky conditions that the significant difference in average wind speed appears to be the cause of the lower variance of the latter. It should be noted that the times of these two flights differed by about 3 hours. Obviously, the available information was insufficient to determine the full effect of air motion on surface temperature.

Influence of Land Use and Surface Types

Figures 5 and 6 provide a general description of the distribution of surface types along the strips. Farmland and irregular spaced forests will respond differently to solar heating. The selected interval (4940 ft.) for plotting the temperature profiles suppresses these effects because rain and cloudiness affected most of the samples taken along Strips A and B; hence this discussion will be primarily concerned with Strips C and D.

The relatively high surface temperatures west of the Mississippi River over Strips C and D coincide with areas of extended, harvested fields of brown color. High readings also occurred in other regions of dominantly open farmland. Lowest mid-day temperatures generally appeared in the marshy and scrubby vegetated areas. Mixed areas both flat or hilly showed considerable variation but have on the average a mean temperature between that of farmland and marshy land. The relatively high surface temperatures observed near the Mississippi River along Strip A are over a region with some hills but less forested than either B or C. In essence, these findings agree with the results reported by Lenschow and Dutton (1964) for central and southern Wisconsin.

The total sample of surface data was unfortunately too small to establish conclusively differences between tornado alleys and shunted strips. Several factors can be mentioned: First, the period studied did not coincide with the maximum tornado season, while the surface structure, both in open and forested areas, varies seasonally; for example, deciduous forests are leafless during April and early May, cornfields are bare in spring but not in late summer and fall, whereas for hay and wheatfields the reverse is true. A relatively warm band of nearly 20 miles (Fig. 6) in Minnesota is interesting and invites further study, because of high tornado incidence in June in this region. The high variance of strip D (Table 4) is probably also connected with this farm area. Second, warm regions of smaller scale (several miles or less) appear rather frequently and may contribute to randomness of convection phenomena. Third, a portion of the variances of several of the days were influenced significantly by cloudiness and soil moisture. More information is needed on surface temperature response under varying weather conditions before inferences on relationships between temperature structure and tornadoes may be reached.

Variance Spectra of Surface Temperature Profiles

Spectral analysis was performed on the surface temperature data in the same manner as for topography. Smoothing of the terrain data was a direct result of the interpolation on topographic maps. The effect of filtering on the measured surface temperature had to be considered in more detail. The bolometric averaging over a circular area of 15.7 meter radius may tend to increase the exponent n at the high frequency end of the spectrum. These forms of smoothing of temperature and terrain data probably eliminated some aliasing problems. Also, a 5-sec filter was used to help prevent aliasing, but because it damped out important amplitude variations in intermediate wavelengths, the unfiltered spectral estimates had to be recovered, following a method described by Dutton (1962).

A test was conducted to compare a "red noise" spectrum against the actual spectra. (For a detailed discussion of "red noise spectra" see Gilman, et al., 1963.) In particular, for a "null" hypothesis the "red noise" was considered the underlying continuum or actual population from which the direct estimates were just random samples. A plot of the "red noise" estimates corresponding to September 22 of Strip C is given in Fig. 11. Conditions for the other

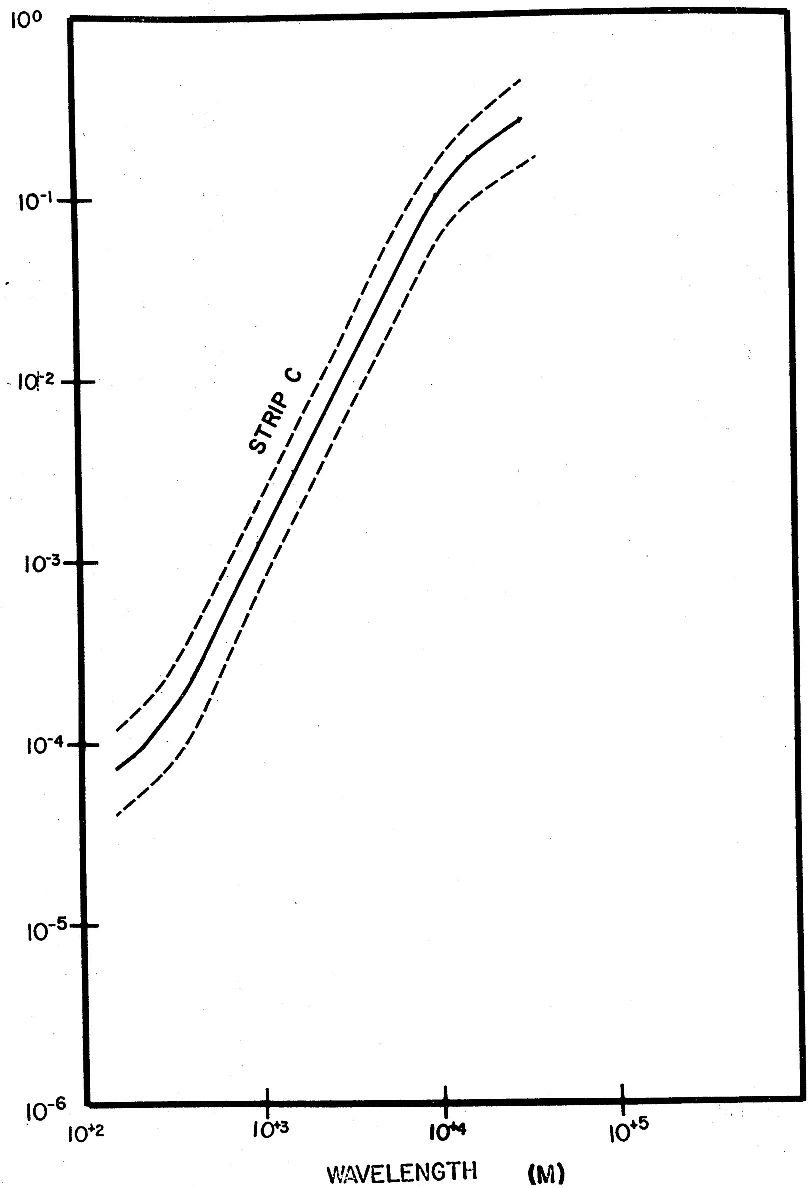


FIGURE 11. Red noise spectrum of surface temperature corresponding to September 22, 1967, of Wisconsin Strip C ("shunted strip"). Estimates based on a sample one-lag autocorrelation coefficient equal to 0.9697. Chi-square confidence lines are given in dashed curves.

dates were similar. For a testing, it is assumed that the ratio of the sample estimate to the continuum estimate is a chi-square variable divided by the number of degrees of freedom. In this way, a confidence (acceptance) region can be specified about each continuum value, according to Tukey. The estimates of September 22 differed significantly from the red noise continuum at the 5% level of significance. The sample curve appears to follow simple persistence in short (<600 meters) and long wavelengths, while intermediate wavelengths suggest a "white noise" shift. Many of the other spectral graphs also show this tendency.

For further tests, fitting lines were placed by sight through the short and intermediate period regimes. Figure 12 illustrates a pair of such lines as well as the confidence limits pertinent to Strip A of September 11. The regimes of simple persistence and "near-white-noise" are well contained inside these confidence limits. Numerous spikes and overall noisiness in the direct spectra appear to be statistically insignificant. However, more data would be needed to verify the validity of this statement. Recurring maxima or "spikes" might indeed prove physically real for an individual terrain profile.

The results above indicate that by and large, the intermediate "waves" of 0.5 to 5 km are made up of a random distribution of temperature oscillations. This may correspond to the fact that the arrangements of forests, lakes, towns, variable crop fields, and pastureland are of the order of intermediate wavelengths and tend to be fairly irregular. They include the dominant homogeneous features introduced by man. As dominating features get smaller, the temperature response decreases rather strongly.

One important exception was found on September 18 over Strip B, where the spectral density suggested an exponent n of less than 1. The wet soil and extensive cloudiness present on this day could have resulted in the damping of major randomness in intermediate wavelengths.

For the terrain spectra previously discussed, a comparison was made with the red noise spectrum. Figure 13 illustrates the red noise spectrum corresponding to Strips A and C. The topographies of A, B and D all have a high degree of simple persistence, while "white noise" in smaller wavelengths of C causes substantial deviation from red noise, although some persistence in long wavelengths may prevail.

Concluding Remarks

The results of this study seem to pose more questions than answers. The fact that "alleys" and "shunted regions" exist suggests the qualitative picture of tornadoes shying from "rough" ter-

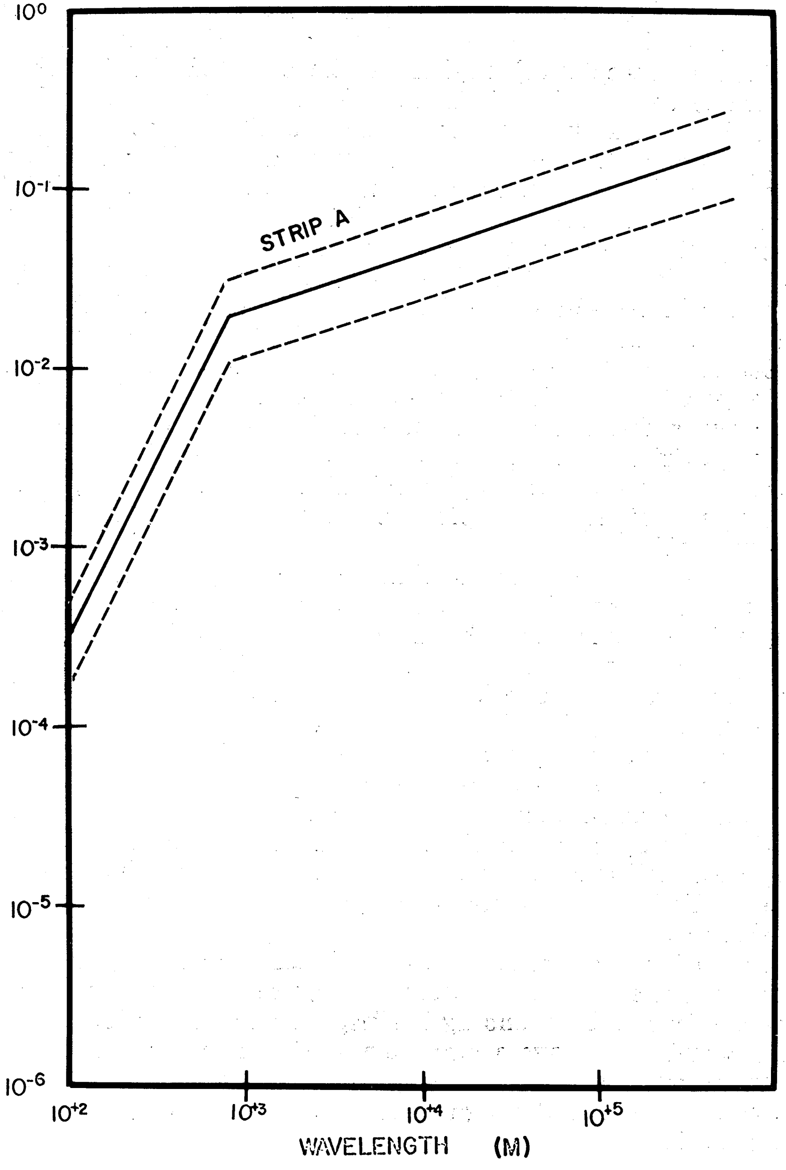


FIGURE 12. Lines (placed by sight) fitting spectral curve of surface temperature for September 11, 1967, of Wisconsin Strip A ("tornado alley"). Confidence lines are also indicated.

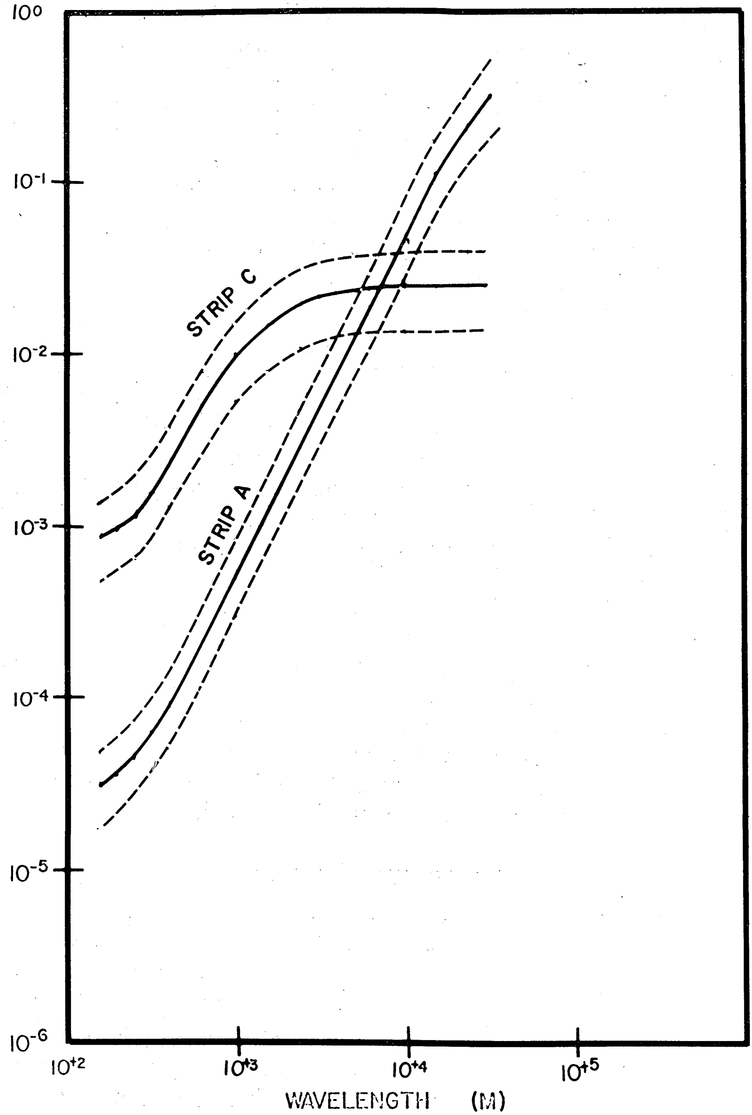


FIGURE 13. Red noise spectra corresponding to terrain of Wisconsin Strips A ("tornado alley") and C ("shunt strip"). Estimates were based on one-lag autocorrelation coefficients 0.9874 and 0.7078 respectively for Strips A and C. Chi-square confidence lines are also given.

rain. We tried to understand roughness on a quantitative scale in order to explain how terrain may affect these storms. This has been attempted through the use of spectral analysis for selected one-dimensional terrain profiles. In order to measure roughness which is representative of a region, a two-dimensionly approach will be needed to determine the full variability of surface structure.

Surface temperature is one measure of how a surface type responds to the supply of solar energy, but variations in the many factors governing thermal response make it difficult to specify tornado-suppressing and tornado-supporting trends. One possible approach would be to parameterize conditions for each "mosaic" element of a complex land/air interface like that in Wisconsin and develop a theoretical model of thermal response to radiative forcing functions, as that of "climatonomy" proposed by Lettau (to be published). Full parameterization of surface conditions must include a measure of aerodynamic roughness, of albedo and emissivity, of moisture availability, and the thermal admittance of the submedium. This study provided new information on surface roughness and its effect on surface temperature variability. One important result could be that features smaller than about 600 meters appear to have little significance for surface temperature variations. With the establishment of such limiting criteria the task may not be overwhelming.

Very little is known about how local supplies of sensible and latent heat are utilized in severe convective storms. Mesoscale meteorology has not had the benefits of intensive research that larger scale studies have. Even less is known on the generation of hail and tornadoes. Further research on the basic dynamics and energetics of the mesoscale is certainly needed.

Acknowledgments

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THE OTTER IN EARLY WISCONSIN

A. W. Schorger

The otter *(Lutra canadensis)* was one of the most valuable furs sought by trappers. During the period 1835–1848, the Northern Outfit of the American Fur Company, located on Madeline Island, collected annually an average of 1555 pelts. Based on trapping records the otter was about as plentiful as the beaver. It was much easier, however, to discover the presence of beaver than the wandering otter, so that most trappers devoted their attention to this mammal. The otter has a popular appeal from the ease with which the young can be tamed, a marked contrast to the viciousness of the other mustelids, the skunk excepted. The young in Wisconsin are born mainly in April and May (Knudsen, 1956).

SIZE

Reference books vary widely on the size and weight of otters. Coues (1877) wrote that there was great variation. The average was 4 to 4.5 feet in length, though some individuals attained 5 feet. According to Jackson (1961:383) the total length of adults is 35.4 to 48 inches, and the weight 15 to 20 pounds, rarely to 30 pounds in males. Hamilton (1943) gives a length of 35.4 to 43.3 inches, and a weight of 12 to 15 pounds, the latter being seldom exceeded. Otters in Main weighed from 18 to 20 pounds, 25 being exceptionally heavy (Hardy, 1911:331). Heavy weights have been recorded. On February 17, 1771, George Cartwright (1911:50) shot an otter weighing 33 pounds. A Carolina old male was 4 feet long and weighed 23 pounds; and a specimen from Texas was 4 feet and one inch in length and weighed 20 pounds (Audubon and Bachman, 1851). An adult female *(Lutra c. sonora)* collected at Montezuma Well, Arizona, was 51.2 inches in length and weighed 19.5 pounds (Bailey, 1931); and an adult female from Idaho was 45.3 inches in length and weighed 19 pounds (Merriam, 1891).

I do not know of any data on the dimensions and weights of entire Wisconsin otters given by fully trustworthy observers. George Knudsen of the Wisconsin Department of Natural Resources has examined a large number of carcasses obtained from trappers. Quite fresh carcasses of adult males weighed 19 to 22 pounds; length from tip of nose to tip of tail vertebrae 46 to 48 inches. The green skin with adhering fat would add an additional 3 to 4 pounds. The carcasses of adult females weighed 15 to 18 pounds, and the lengths were 44 to 45 inches (Unpublished).

Food

The food of the otter consists primarily of fish and crayfish, with some mussels, amphibians, insects, and birds. In 1680 Hennepin (1903) appropriated a paddlefish *(Polyodon spathula)* which an otter was eating along the Wisconsin section of the Mississippi. Along the banks of the Fox and Wisconsin rivers Featherstonhaugh (1836) found great quantities of mussel shells left by otters and muskrats. D. Cartwright (1875:60) found a bushel of the heads of bass, supposedly rejected by the otter, in the Lake Superior region. One trapper reported to Knudsen (1957:61, 62) that he watched otters catch five northern pike and eat only the heads; while another stated that he saw a "lot of bass heads" on the ice. For some unknown reason the heads of bass appear to be undesirable. Jackson (1961:388) observed in Bayfield County an otter eating a chub, beginning at the head. At Great Bear Lake, Mackenzie District, otters usually took the heads of the fish caught in nets and left the bodies (Richardson, 1829). It has been stated that all but the tail of a fish is eaten, and that when plentiful the otter may take only a bite or so from the head of each fish captured (Godwin, 1935). Apparently the head is the most desirable part of most species of fish. A study by Knudsen (1957:53) of the food habits of otters that had been trapped revealed the following frequency of occurrence: fish 90 percent, crayfish 50 percent, insects 20 percent, and debris 30 percent. In frequency of occurrence of fish, game fish were 30 perent and rough fish 80 percent.

Otters will dive deeply to secure food. Ben Gustavson, a commercial fisherman of Bayfield, Wisconsin, on February 24, 1939, found a drowned otter on one of his baited set lines. The bait was in 42 feet of water and 500 feet from the shore of Bass Island, one of the Apostle group (Waskow, 1939; Scott, 1939).

The teeth become worn with age and kind of food. An old male in Carolina had teeth much worn (Audubon and Backman, 1851). An otter trapper near Sturgeon Bay was believed to be old since "his teeth were nearly all gone," that is worn (Sturgeon Bay, 1896). The teeth of sea otters *(Enhydra lutra)* approximately 4 to 5 years old show marked wear, induced apparently by the preferred diet of the individual (Barabash-Nikiforov, 1962). The teeth of some of the Wisconsin otters examined by George Knudsen were "worn to the bone.

TRAILS

Otters are great travelers and seldom stay long in one place. They will take to land to cross from one stream or lake to another and make cutoff trails at the bends of streams. Cartwright (1875: 60, 61) states that he has known them to cross from the head of one stream to another, a distance of two miles. He termed the trails portages. The winter of 1837–38 Kingston (1879) and companion explored the Lemonweir River for pine timber. Concerning their return down the river he wrote. "Following the otter trails or slides cutting the bends of the river, we found the distance greatly shortened."

TRAPPING

There is no clear description of the method by which the Indians took otter prior to the availability of the steel trap. Hennepin (1903:517) stated merely that the Indians caught otters in traps and killed them with arrows or shot. Lahontan (1905) wrote: "These Traps are made of five* Stakes plac'd in the form of an oblong Quadrangle, so as to make a little Chamber, the Door of which is kept up, and supported by a Stake. To the middle of this stake they tye a string which passes thro' a little fork, and has a Trout well fastened to the end of it. Now, when the otter comes on shoar, and sees this bait, he puts above half his Body into that fatal Cage, in order to swallow the Fish; but he no sooner touches, than the string to which 'tis made fast pulls away the Stake that supports the Door, upon which an heavy and loaded Door falls upon his Reins and quashes him." This was a deadfall.

The deadfall could be used only on land while the steel trap could be set on land and in the water. Cartwright (1875:62) opposed a set on land. He favored setting the trap in about four inches of water where a slide entered and on the side of it. The reason for this is that the otter's fore feet are short and wide apart so that if the trap were placed in the middle of the slide the feet were unlikely to touch the pan of the trap. Regarding trapping at the slide, Newhouse (1874) states: "Spencer J. Clarke, . . . who formerly trapped in Wisconsin, recommends setting the trap where the Otter comes out of the water in the following position: The Otter swims to the shore, and as soon as his fore feet strike the ground his hind feet sink to the bottom and he walks out erect. Find the point where the Otter's hind feet strike the bottom, and set the trap there." The otter is frequently abroad in the daytime so that formerly many were captured by shooting.

* "Five" should read "small". It is *petits* in the original (Lahontan. 1703. Nouveaux voyages . . . dans l'Amerique Septentrionale. Le Haye. p. 85).

Utilization

The Indians used the skin for medicine bags and ceremonial purposes. Carver (1784) was at a dance in western Wisconsin when: "I could not help laughing at a singular childish custom I observed they introduced into this dance . . . Most of the members carried in their hands an otter or martin's skin, which being taken whole from the body and filled with wind, on being compressed made a squeaking noise through a piece of wood organically formed and fixed in its mouth. When this instrument was presented to the face of any of the company, and the sound emitted, the person receiving it fell down to appearance dead."

The fur is very durable and equalled only by that of the wolverine, On the basis of 100 for otter, the wearing quality of other aquatic mammals such as beaver is 90 percent and muskrat 45 percent (Innis, 1927). The skins are used for collars, trim, and ladies coats.

Trappers were frequently forced to eat the animals they caught. On February 17, 1771, George Cartwright (1911:66) wrote in his journal that otters are "hard and strong eating."

Prices

The largest market for otter fur was China. This fact is expressed frequently in the correspondence of the American Fur Company. On November 30, 1821, R. Crooks wrote to J. J. Astor that the otters will go to China (Am. Fur Co.). H. H. Sibley of Fort Snelling was informed on April 7, 1840, that the only hope for otters was resumption of trade with China; and on December 25, Pierre Chouteau and Company of St. Louis was told that there was only a limited demand for the furs for caps. A letter of April 4, 1843, to Joseph Rogers, Toronto, stated that the supply of pelts exceeded the demand of the market in Canton.

Considerable value was placed on otter in 1760 in Milwaukee by an English trader who refused payment for supplies except with otter and the finest fox skins (Western Hist. Co., 1881). The prices of the pelts varied with the demand and quality. In August, 1820, the American Fur Company credited Porlier and Rouse of Green Bay with 50 otters at $3.53 each. R. Crooks wrote on April 23, 1822, to J. J. Astor that $3.75 would be paid for Lake Superior otter, and $3.25 for those from the St. Peter (Minnesota) River. Four days later he wrote to S. Abbott at Mackinac to pay only $3.00 for otter since there were on hand the entire collections for 1820 and 1821. In June, 1827, 13 otters from La Bulle (Wausau) were invoiced at $2.50 each.

The pelts received in 1835 from Solomon Juneau of Milwaukee were graded and priced as follows: No. 1, $7.00; No. 2, $4.50; No.

3, $2.25; and cubs $0.75. Juneau in 1840 made several purchases at prices ranging from $5.00 to $7.00. Myrick and Weld (1843), merchants at La Crosse, in 1843 purchased pelts at the very low price of 20 shillings ($2.50). In November, 1847, the prices paid at Prairie du Chien were: No. 1, $4.00; No. 2, $3.00; No. 3, $2.00; and No. 1 cub, $0.50–$0.75. The winter of 1856–57, in Buffalo County, Cooke (1940) was pleased to receive $2.00 for an otter pelt. Low prices prevailed in 1859 at Eau Claire (Eau Claire, 1859), the range being $0.75 to $3.00. In 1880, in Waukesha County, the pelts were said to be worth $9.00 to $20.00 (Western Hist. Co., 1880).

Abundance

In the first half of the 19th century, the otter appears to have been somewhat more abundant than the beaver in the Great Lakes region. Compilation of 159 inventories at various posts of the American Fur Company gave 51,067 beavers and 65,781 otters, a ratio of 1 beaver : 1.29 otters. There are insufficient data to determine the number of otters collected in Wisconsin in any one year. It has been possible from the papers of the American Fur Company possessed by the Wisconsin Historical Society to compile for a number of years the collections made by the Northern Outfit at La Pointe, Madeline Island (Table 1). Essentially all of the pelts were taken in northern Wisconsin. The principal subposts were at Lac du Flambeau and Lac Court Oreilles. The year 1835, e.g., represents the pelts taken during the winter of 1834–35.

The table shows a steady decline in the number of otters taken. Fur statistics show fluctuations in numbers, but there does not appear to be any cyclic phenomenon for the otter (Hewitt, 1921). During the 1968 season, 1007 otters, with an average value of $21.50, were taken in Wisconsin, so that the present status of the species is gratifying.

TABLE 1. OTTERS COLLECTED AT LA POINTE

Year	No. of Pelts	Year	No. of Pelts
1835	4,831	1842	1,072
1836	1,842	1843	1,005
1837	2,997	1844	512
1838	1,270	1845	478
1839	2,384	1846	1,140
1840	1,574	1847	559
1841	1,791	1848	321

DISTRIBUTION

The otter is generally found on rivers, large creeks, and interior lakes. Large lakes such as Michigan are less attractive; however, when Fonda (1868) was carrying mail between Green Bay and Chicago the winter of 1827–28, an otter or a fisher would glide from the ice-fields to a retreat in the bank of the lake. The otter has been recorded for nearly every county in the state. More recent records and specimens examined are to be found on the map by Jackson (1961:384). According to Strong (1883) it was to be found occasionally in the northern half of the state. Subsequently Cory (1912) gave it an increased range, "the greater portion of Wisconsin." That the otter still has a wide distribution is to be seen in Fig. 1

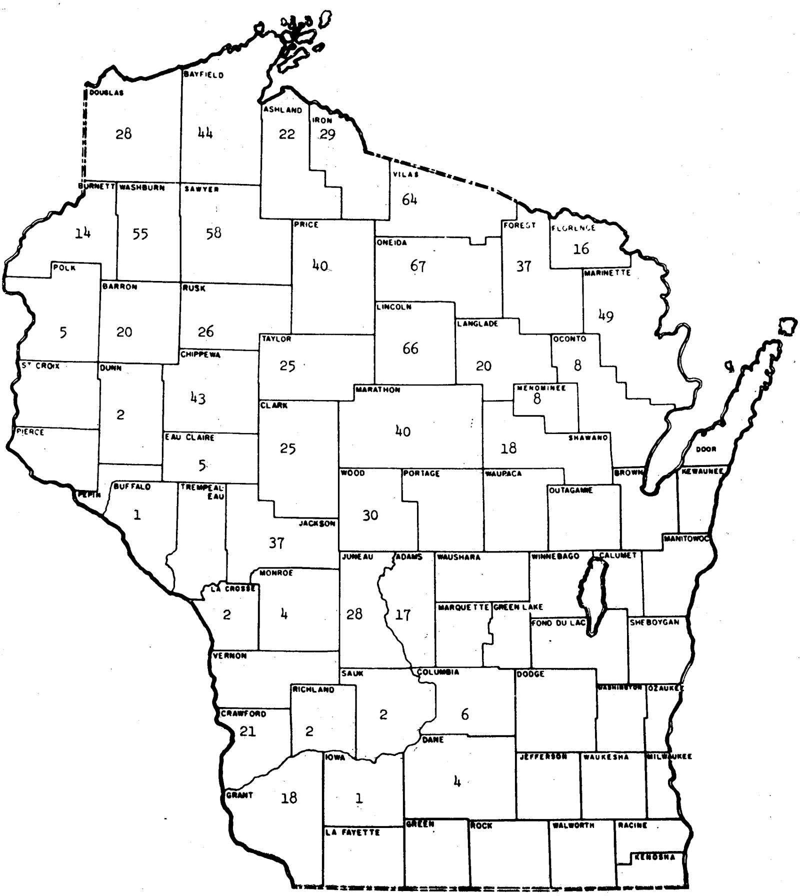

FIGURE 1. Otter Harvest by Counties in 1968.

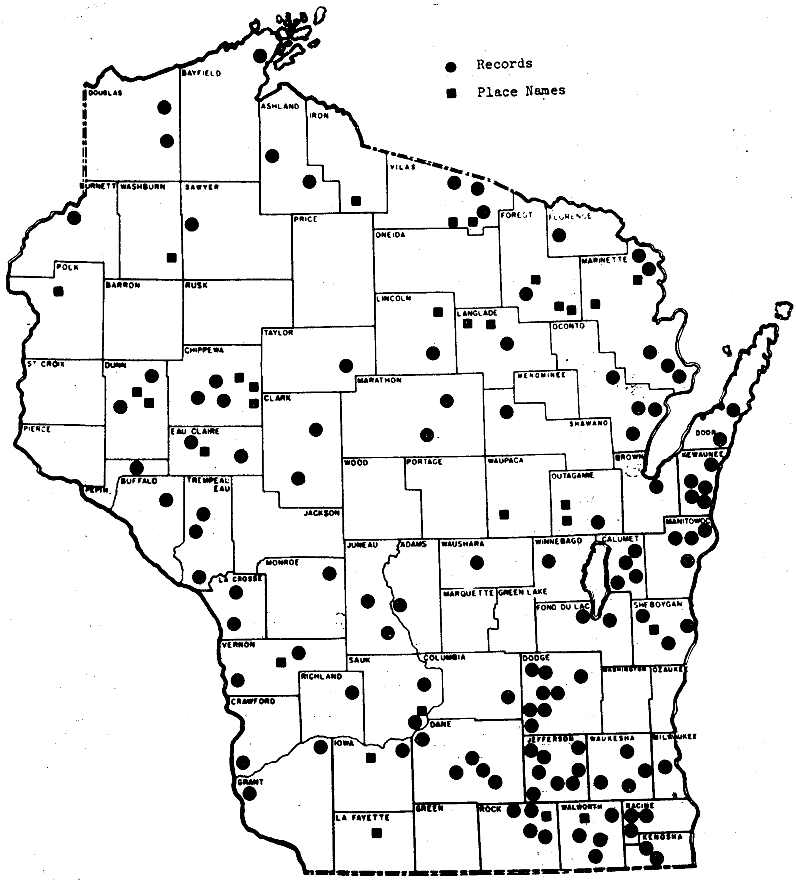

FIGURE 2. Early Distribution of the Otter in Wisconsin.

where the harvest in 1968 is shown by counties. The early records and place names are shown in Fig.2. The Sea Lion and Seal lakes of northern Wisconsin, not plotted, presumably were named from the otter through erroneous identication. A swimming otter resembles a seal.

Adams.—It was stated in 1919 that the otter no longer occurred (Cole and Smythe, 1919). This statement must have been made from lack of sufficient information as it is still quite common along the Wisconsin.

Ashland.—In the spring of 1885 E. B. Gordon and H. A. Mallory had a fine lot of otter and other furs taken near Glidden (Glidden, 1885). In the early months of 1885, George and Frank Bell trapped on the headwaters of the Bad River, said to be 15 miles west of

Penokee, and caught a number of otters (Ashland, 1885). The farthest west tributaries of Bad River are in the town of Marengo, about 10 miles from Penokee.

Otter Island is one of the Apostle group.

Bayfield.—A Mr. Hayward of Bayfield had a fine lot of otter pelts (Bayfield, 1877). Jackson (1908) and Cory (1912) examined specimens from the county. At present it is one of the best otter counties.

Brown.—The otter killed by a farmer with a heavy whip (Green Bay, 1895) was very probably traveling on land.

Buffalo.—The family of Cooke (1940) settled within five miles of Gilmanton in the fall of 1856. His father did much hunting and trapping, and otter was among the furs marketed.

Burnett.—Curot (1911) was in charge of a post on the Yellow River the winter of 1803–04. His entries show that he purchased 16 otters.

Calumet.—An otter was shot near Chilton (Chilton, 1880). Two were killed by N. Cheseboro near Clinton in 1887 at which time otters were rarely seen (Chilton, 1887). One was killed near Brothertown in April, 1897 (Chilton, 1897); and another was trapped at Forest Junction, town of Brillion, in March, 1899 (Chilton, 1899).

Chippewa.—Cartwright (1875:245), the winter of 1857–58, trapped otters on O'Neil Creek, town of Eagle Point. In the spring of 1865, otters were being caught in large numbers (Chippewa Falls, 1865). A large shipment of furs made by Mairet, Allen and Company of Chippewa Falls contained many otters (Chippewa Falls, 1871);

Otter Lake, town of Colburn, is drained by Otter Creek which flows north then west into Yellow River. Lttle Otter Creek rises in the town of Thorpe, Clark County, flows south by west and enters the Wolf River in the town of Delmar, Chippewa County.

Clark.—The winter of 1844–45, Manly (1927:56) and companion while trapping on the Black River above Neillsville found two otters coming towards them on the ice. One was killed, the other escaped. At the time of settlement of Neillsville, 1844, otter and other mammals were plentiful (Neillsville, 1873; French, 1875; Curtiss-Wedge, 1918).

Columbia.—The American Fur Company received from the Portage post 6 otters in 1827, and 17 in 1840. Wayne B. Dyer came to the present site of Columbus in 1843 and trapped many otters along the Crawfish (Butterfield, 1880). A few otters had been observed during the past year in the Wisconsin River between Kilbourn (Wisconsin Dells) and Portage (Cole, 1918).

Crawford.—In the early days H. L. Dousman had at Prairie du Chien a tame otter that would catch fish for him "at his bidding" (Bunnell, 1897).

Otter Creek, town of Kickapoo, flows east into the Kickapoo.

Dane.—When Stoner (Madison, 1899) came to Madison in 1838. the surrounding marshes and streams were full of otters and other game. The first settlers who arrived at Mazomanie in 1843 found otters and other fur bearers common (Kittle, 1900). A large otter was trapped on the north shore of Lake Mendota on April 18, 1854 (Madison, 1854). One was captured by D. A. Waterman, of the town of Rutland, in the Yahara near Lake Kegonsa in March, 1891 (Madison, 1891; Carr, 1891). According to Brown (1915) it occurred formerly at Lake Wingra.

Dodge.—Two otters were taken at Fox Lake in December, 1858 (Fox Lake, 1858). One weighing 16.5 pounds was killed by L. Rushlow at Beaver Dam Lake in April, 1860 (Beaver Dam, 1860). Another was caught at Fox Lake in January, 1867 (Fox Lake, 1867). A large otter was trapped in 1877 in the town of Elba by E. Sweet (Portage, 1877). A trapper caught two in the Horicon Marsh in November 1884 (Delevan, 1884). The winter of 1887–88 one was trapped in the town of Portland (Waterloo, 1888). According to Snyder (1902) the otter was common at the time of settlement. In the early 1890's Adam Ergotz, a former professional trapper, found a slide on Beaver Dam Lake but could not catch the otter. One was captured since 1890.

Door.—An otter, then rare, was caught by R. Haash at Forestville in the spring of 1887 (Sturgeon Bay, 1887). One weighing 20 pounds was trapped at Lilly Bay in March, 1896 (Sturgeon Bay, 1896). Lilly Bay is on the Lake Michigan shore near Clark Lake.

Douglas.—In the spring of 1766 while Henry (1921) was at Chequamegon Bay, the Chippewa went to war with the Sioux. A battle was fought at a river which was undoubtedly the Brule, as it was the traditional battle place for the two tribes. They returned with a rich cargo of furs and Henry purchased from them and other Indians 150 packs of beaver and 25 packs of otter and marten skins. The Brule was a noted stream for trapping. When Allen (1834) was at La Pointe in 1832 he was informed that the trading posts on this river took in primarily muskrats, bears, and otters. Cram (1841) reported that at the proper season the Indians resorted to the Brule to trap otter and beaver which occurred throughout its length; however, their numbers had been greatly reduced. Cory (1912) examined specimens from the county.

Dunn.—The winter of 1857–58, Cartwright (1875) and companions caught otters on Pine Creek, town of Sand Creek, and on Gilbert Creek, town of Lucas. Altogether the party of three caught 50 otters, most of them in the county.

Otter Creek, the two branches of which rise in the town of Wilson, flows south into Hay River, town of Otter Creek. Little Otter Creek rises in the later town and flows west into Otter Creek.

Eau Claire.—In the fall of 1883 "several more" otters were caught in Seven Mile Creek, town of Seymour (Eau Claire, 1883). Charles Martin, the famous hunter, caught an otter near Augusta in October, 1897 (Augusta, 1897).

Otter Creek rises in the town of Otter Creek, flows northwest and empties into the Eau Claire, town of Seymour.

Florence.—C. Hanson while hunting along Pine Creek, town of Long Lake, in October, 1884, saw seven otters and killed three of them (Florence, 1884).

Fond du Lac.—In 1852, a few miles east of Fond du Lac, otter and other game were "too numerous to attract much attention" (Titus, 1936). In 1881 the capture of an otter on the west side of Lake Winnebago by Jacob H. Horn resulted in the comment that it was the first taken in many years (Fond du Lac, 1881).

Forest.—Two males were killed two miles west of Crandon on February 12, 1908 (Jackson, 1910). Cory (1912) examined specimens from the county.

Otter Creek rises in Otter Springs, town of Lincoln, and flows northeast into the Peshtigo. A second Otter Creek, town of Wabeno, flows southeast into Otter Lake.

Grant.—The fall and winter of 1845–46, Robert and William McCloud, at Muscoda, purchased otter and other furs from the Indians (Butterfield and Ogle, 1884). In the spring of 1858, Austin Birge captured a large otter in the bluffs along the Mississippi (Prairie du Chien, 1858).

Iowa.—Cory (1912) examined specimens from Arena.

Otter Creek rises in the town of Dodgeville and flows north into the Wisconsin.

Iron.—Otter Lake is in the northern end of the town of Oma.

Jefferson.—The Coe (1908) family settled on the west bank of Rock River, town of Ixonia, in 1839. The following winter Indians camped on the opposite bank and caught otter and other fur bearers. In 1855, while going down Bark River, Cartwright (1875: 161) shot an otter. Within two weeks he and a companion captured sixteen. In the spring of 1879, an otter was shot in the town of Hebron (Fort Atkinson, 1879). Six large otters were taken at Waterloo early in 1881 (Waterloo, 1881). According to Hawkins

(1940) the otter was never common at Faville Grove, and it disappeared from the Crawfish River about 1883. About 1882 an otter was trapped at Faville Grove and another at Mud Lake, town of Lake Mills. In April, 1887, Frank Tooker shot one on Bark River at Ft. Atkinson (Ft. Atkinson, 1887). A very large otter weighing 25 pounds was killed on Bark River by Roy Chase the spring of 1890 (Ft. Atkinson, 1890). In July, 1901, there was an otter slide at Lake Koshkonong, section 34, town of Summer (Jackson, 1908).

Juneau.—The winter of 1837–38, Kingston (1879) and companion traveled down the Lemonweir, following the otter trails. In December, 1890, George Dillon of Lemonweir, town of Lemonweir, trapped an otter 44 inches in length (Mauston, 1890).

Kenosha.—In a letter dated November 7, 1837, Quarles (1933) wrote from Southport (Kenosha) that otters were very plentiful on his contemplated farm on Fox River, and sought information on trapping them. In autumn Indians came from the north to the town of Salem and camped on the Fox River. Here deer, otter, and some other fur bearers were abundant (Lyman, 1916).

Kewaunee.—The otter was reported scarce when one was taken late in 1886 a few miles west of Kewaunee (Kewaunee, 1886). An otter, the first in many years, was seen in April, 1893, in East Twin River, town of Carlton (Kewaunee, 1893). One was caught in the town of Ahnapee in October, 1894 (Ahnapee, 1894). In October, 1896, quite a number were shot along the Kewaunee River (Kewaunee, 1896). M. Vesseley trapped a large otter in the town of West Kewaunee in January, 1897 (Kewaunee, 1897).

LaCrosse.—At the time of settlement there were otters in Lewis Valley through which flows Fleming Creek (Sisson, 1955). There were brought to La Crosse the pelts of four otters which were trapped a few miles from the city the winter of 1880–81 (La Crosse, 1881).

Lafayette.—Jesse Shull came to the present site of Shullsburg in 1818 and established a post to trade for furs (Gregory, 1932). In so sparsely wooded a county, it is probable that otter and an occasional beaver were the only valuable furs obtainable.

Otter Creek rises in the town of Mineral Point, Iowa County, and flows south into the Pecatonica.

Langlade.—Otters were among the fur bearers taken (Dessureau, 1922). Cory (1912) examined specimens from the county.

Otter Lake is in the town of Elcho. There is also a small Otter Lake in the northwest corner of the town of Parrish.

Lincoln.—Two otters were trapped in May, 1884, on Pine River, town of Pine River (Merrill, 1884).

Otter Lake is in the town of Skanawan.

Manitowoc.—August Sprecht, in January, 1894, complained of the ravages of otters at his carp pond at Mishicot (Manitowoc, 1894). In the fall of 1895, Joseph Stangel caught in the town of Two Creeks an otter weighing 27 pounds (Kewaunee, 1895). Another was shot by Peter Zinn in the fall of 1896 (Two Rivers, 1896). The winter of 1897–98, trappers at Neshoto (Shoto), town of Two Rivers, captured five otters (Two Rivers, 1898).

Marathon.—In the early days Michael De Jardin, a Chippewa, assisted his father at Mosinee in trapping otter and other fur bearers which were plentiful (Ladu, 1907). The small post of the American Fur Company at La Bulle (Wausau) shipped 13 otters in 1827.

Marinette.—Stanislaus Shappus reported that he had on hand June 27, 1834, at the American Fur Company post on the Menominee River, only one pack of furs in which were some otters. On June 5, 1835, he had 80 otters. A black otter was trapped on the Peshtigo in December, 1875 (Marinette and Peshtigo, 1875). In November, 1889, two otters were killed near the village of Peshtigo (Marinette, 1889). The fall of 1895, Gus Wendt caught two otters up the Peshtigo (Peshtigo, 1895). One was shot in November, 1898 (Peshtigo, 1898). At that time the capture of the fourth otter near the village of Peshtigo was reported (Marinette, 1898). The same fall Tom Bone trapped two otters six miles up the Menominee (Marinette, 1898.1).

Otter Lake is in the town of Pembine. Otter Creek, town of Silver Creek, flows east into the Peshtigo.

Marquette.—On December 5, 1824, Jacques Porlier wrote to A. Grignon that he had obtained 12 otter pelts from the Indians at Buffalo Lake (Porlier, 1911). In 1849 there were otters and other fur bearers (Acme, 1890). In July, 1880, a den of young otters was discovered at the foot of Buffalo Lake. They were being raised on a bottle (Montello, 1880). An otter was seen swimming in the mill pond at Westfield, October 1, 1882. It evaded capture (Montello, 1882).

Milwaukee.—The otter was listed by Lapham (1853) as one of the indigenous mammals of the county.

Monroe.—In the late fall of 1844, Manly (1927:52) found sign of otter on the headwaters of the Lemonweir and set traps.

Oconto.—J. I. Bovee caught two otters on the upper Pensaukee in the spring of 1884 (Oconto, 1884). In the fall of 1885 an otter was caught in Leigh (Lee) Lake, town of Bagley, and another was shot within the corporate limits of Oconto (Oconto, 1885). A large otter was killed in December, 1886, a few miles west of Oconto where it was considered rare (Oconto, 1886).

Oneida.—Specimens from the county were examined by Jackson (1908).

Outagamie.—In April, 1873, Louis West shot an otter on the edge of the city of Appleton (Appleton, 1873).

Black Otter Lake is in the town of Hortonia. It is drained by Black Otter Creek which flows north into the Wolf.

Pepin.—On April 16, 1888, Benjamin Dickinson shot an otter on Plumer (Plummer) Lake (Durand, 1888). It was 4 feet in length from tip to tip and weighed 20 pounds. The lake, in sections 30 and 31, town of Durand, has nearly disappeared.

Polk.—According to Surface Water Resources of Polk County (1961), Otter Lake with an area of 8.3 acres is in the town of Milltown.

Racine.—Dr. H. V. Ogden had in his collection a skull from the town of Waterford (Cory, 1912). On December 12, 1879, Charles Graves speared near Waterford an otter weighing 20 pounds (Waterford, 1879). E. Alaxson, in April, 1886, killed one otter and wounded another which escaped (Waterford, 1886).

Richland.—C. C. Derrickson caught a black otter in Willow Creek, in the town of Willow (Richland Center, 1889).

Rock.—Caswell (n.d.) came with his parents to section 7, town of Fulton, in 1837. At that time there were many otters. On February 24, 1839, Ogden (1839) wrote in his diary that he saw two otters in the town of Milton, presumably on Otter Creek. This creek's name was derived from the number of otter slides on its banks when first surveyed (Guernsney, 1856; Smith, 1872). An otter was captured alive on Bass Creek in the town of Rock in January, 1870 (Janesville, 1870). In the spring of 1876 an otter was taken at Otter Creek near Milton (Janesville, 1876). In June, 1902, Jackson (1961:383) saw tracks along Otter Creek, section 5 (probably 3) town of Milton.

Otter Creek rises in the town of Lima, flows west into the town of Milton, then north into Lake Koshkonong.

Sauk.—Canfield (1870:38) stated that the otter was "quite plentiful." In March, 1887, a trapper of North Freedom caught an otter four feet in length in the Baraboo River where there were several others (Wonewoc, 1887). Occasionally seen along the Wisconsin River (Cole, 1922).

Otter Creek rises in the town of Freedom, flows south and enters the Wisconsin 1.5 miles below Sauk City.

Sawyer.—The American Fur Company on July 22, 1822, reported 80 otters among the furs received from Lac Court Oreilles.

Sheboygan.—In 1859 a boy caught two young otters near Sheboygan (Sheboygan, 1859). Otters were present and their skins were purchased by traders (Buchen, 1944). Prior to 1870 the Indians took in the town of Rhine about $800 worth of deer, muskrat, and otter in a season (Gerend, 1920).

Otter Pond, very small, is in the northwest corner of the town of Plymouth.

Taylor.—The summer of 1885, A. Bonneville of Medford was keeping two young otters as pets (Medford, 1885).

Trempealeau.—James Reed, a well known trapper, settled at Trempealeau in 1840 when otter was one of the abundant fur bearers (Pierce, 1915). In the spring of 1850, Grignon (1914) traded with the Indians who had trapped up the Trempealeau and secured a fine lot of furs including otter. Two otters were seen on a slide on the Trempealeau as late as 1880 (Bunnell, 1897). The species disappeared long ago (Curtiss-Wedge, 1917).

Vernon.—The winter of 1839–40 Robert Douglas came upon an otter using a slide on the Bad Axe River (Polleys, 1948). Mather (1896) and his trapping companion caught several otters on the headwaters of the Kickapoo (erroneously called the Bad Axe) the winter of 1855–56.

Otter Creek rises in the town of Webster, flows southeast, and enters the Kickapoo at La Farge.

Vilas.—Perrault (1909–10) in 1791 bought of Dufund Dufault the furs, including one pack of otter, for which he had traded at Lac du Flambeau. The winter of 1804–05 Malhiot (1910) was in charge of a post at this lake. On October 5, 1804, his inventory of furs included 44 otters, and on May 21, 1805, he recorded a return of 20 otters. Cram (1841) stated that the Lac Vieux Desert region was tolerably well provided with otters. In the spring of 1857 H. P. Poler of Eagle Lake arrived in Wausau (1857) with furs including otter. Jackson (1910) had the report that during the winter of 1908–09 otters were quite common at Oak Lake and Mamie Lake, which are at the Michigan boundary.

Otter Lake is in the town of Lincoln, and Otter Rapids on the Wisconsin River about five miles west of the village of Eagle River.

Walworth.—W.H.M. came to the town of East Troy in 1845. Honey Creek was full of fish, and lakes and streams were "alive with muskrat, mink, and otter" (Burlington, 1882). In the early days otters were seen occasionally, the town of Sugar Creek being mentioned specifically (Western Hist. Co., 1882). The Indians hunted otter in the vicinity of Lake Geneva (Simmons, 1875).

Otter (Wandewaga) Lake is in the northeast corner of the town of Sugar Creek.

Washburn.—At present one of the most productive counties for otter.

Waukesha.—A settler who came to Waukesha in the spring of 1841 wrote that an otter would occasionally plunge into the Little Fox (Waukesha, 1890). Two young otters were captured by Rolla Clark at Big Bend, town of Vernon, near the Fox River in April, 1876 (Waukesha, 1876). About a dozen otters were taken in a month's time during the past season (c. 1880) by A. Vieu, who lived near Little Muskego Lake, town of Muskego (Western Hist. Co., 1880). An otter measuring three feet and eleven inches was shot at the head of Eagle (Spring) Lake. It was carrying a trap (Kaukauna, 1889).

Waupaca.—Otter Lake is in the southeastern part of the town of Farmington.

Waushara.—A farmer living a few miles north of Wautoma is said to have trapped a large otter (Chilton, 1889.1).

Winnebago.—At the Menominee payment at Lake Poygan in 1847 the Indians traded a large number of otter and other furs (Anon., 1847).

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VENTIFACTS ASSOCIATED WITH THE CAMBRIAN–PRECAMBRIAN UNCONFORMITY AT NEKOOSA, WISCONSIN

Ronald W. Tank

Technological advances in science and engineering have enabled geologists to approach many of the problems of geology with a high degree of sophistication and precision. Radiometric dating has led to our modern concept of time, geophysical techniques have enabled the exploration geologist to locate new ore bodies, and observations by satellites have improved our understanding of the structure of the earth. However, the nature of the rock record argues against the suggestion that someday technology will enable the geologist to solve all the problems of earth history with similar precision. One reason is that wherever sedimentary rocks are studied there are gaps or unconformities marking interruptions of the stratigraphic record. In 1788 James Hutton first recognized these temporal breaks in the rock record, and later Charles Darwin, in his monumental *Origin of Species,* emphasized the "imperfection of the geologic record". These imperfections have frustrated the efforts of historical geologists for almost two centuries.

In Wisconsin, more of geologic time is probably represented by uncomformities, or temporal breaks, than is represented by the rocks themselves. For example, approximately 600 million years have elapsed since the beginning of Cambrian times (Holmes, 1959). The post-Precambrian rock record of Wisconsin records less than 200 million years of this interval in earth history. There are many small gaps in the stratigraphic record of Wisconsin, but one of the largest and most noteworthy gaps occurs at the contact between the Cambrian and Precambrian rocks (Weidman, 1907, Atwater, 1935, Raasch, 1950, Thwaites, 1957). The Cambrian-Precambrian unconformity is perhaps the most striking and universal break in the succession of rocks covering the earth. The period of world-wide erosion associated with this unconformity was called the Lipalian interval by Walcott (1910), who was intrigued by its possible relationship with the problem of the first appearance of a rich fauna in the rock record. The areal extent of this unconformity in Wisconsin in shown in Figure 1. Although the map pattern of the unconformity traces a sinuous line across the entire state, actual exposures are limited to only a few quarries and river valleys.

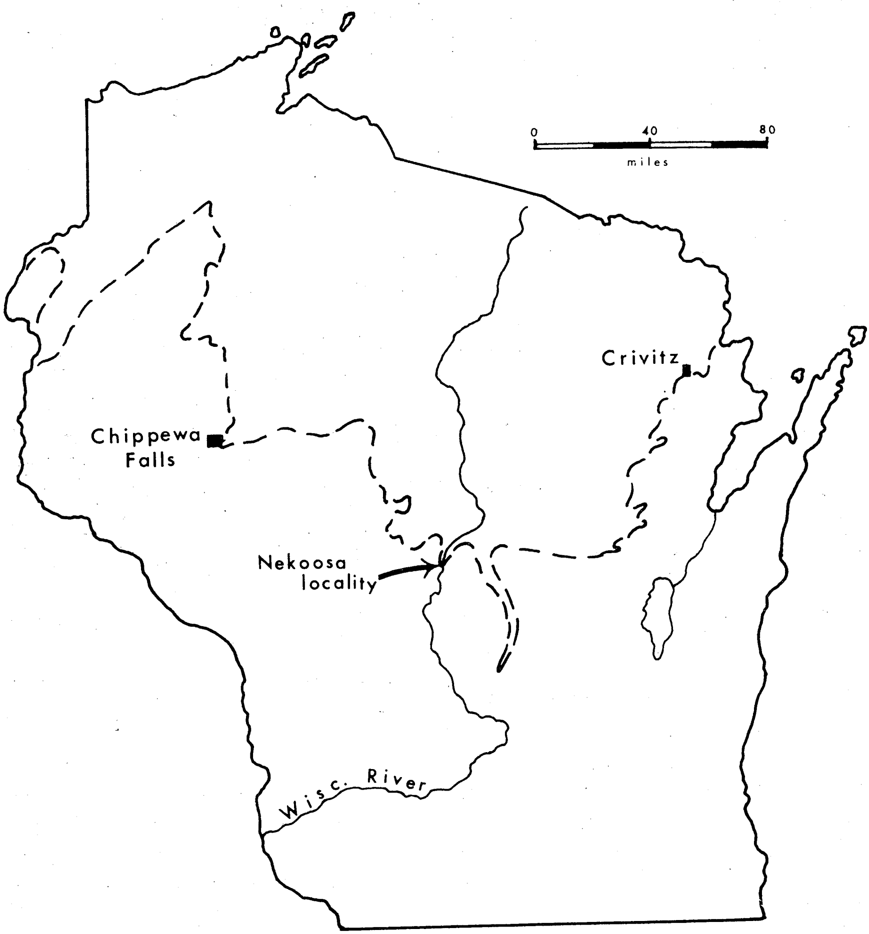

FIGURE 1. Map of Wisconsin showing Nekoosa locality and northern limit of Cambrian-Precambrian contact (dashed line) from geologic map of Wisconsin by Bean (1949).

The purpose of this paper is to report on the occurrence of ventifacts in the exposure of the Cambrian-Precambrian unconformity at Nekoosa, Wisconsin. Ventifacts are stones that have had their surfaces or shape modified by wind-driven sand. Their surface is generally characterized by a high polish and by a variety of facets, ridges and pits. They are rarely found in older rocks but are not uncommon in Recent and Pleistocene materials. Several specimens collected from modern environments are shown in Figure 2. Ventifacts are useful as indicators of prolonged wind erosion commonly associated with the desert, polar or beach en-

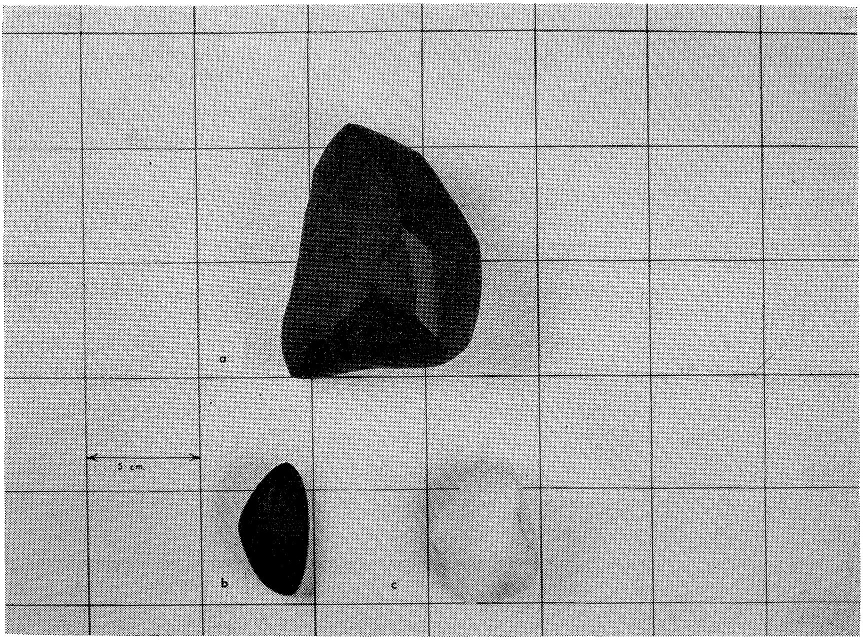

FIGURE 2. Modern ventifacts collected from the Green River Basin, Wyoming (specimen a; sandstone), Terry Andrae State Park, Wisconsin (specimen b; basalt) and Mojave Desert, California (specimen c; vein quartz).

vironment. Although the writer has been unable to find ventifacts at other exposures of the Cambrian-Precambrian unconformity, Parker (1965) reports an occurrence near Crivitz, Wisconsin and Wentworth and Dickey (1935) report an occurrence near Chippewa Falls, Wisconsin.

The Nekoosa exposure is located along the east bank of the Wisconsin River and extends from the foot of the mill dam of the Nekoosa Edwards Paper Company to a point approximately 200 yards downstream (SW ¼, NW ¼, SE ¼, Section 10, T 21 N, R 5 E, Wood County, Wisconsin). Cambrian Dresbach Group sandstones outcrop along the east bank of the river and are in nonconformable contact with Precambrian gneiss and schist near river level. The contact represents an old erosion surface with approximately four feet of relief at this exposure.

Unaltered Precambrian granite gneiss and schist are exposed near the dam. The gneiss and schist are cut by numerous quartz and granite veins, and the entire exposure is interrupted by numerous joints. High water levels during the summer of 1968 prevented a more detailed examination of these rocks, but Weidman (1907) reports northeast strikes and steep dips in the schist plus schistose greenstrone. Above the unaltered gneiss and schist is a zone of altered schist which ranges from a few inches to five feet in thickness. The quartz veins are unaltered in this zone, but textures and banding in the schist are only faintly visible. The altered schist is locally overlain by yellowish-gray, structureless, kaolinitic clay up to 6″ thick. Fine- to medium-grained, cross-bedded, orthoquartzitic sands of the Dresbach Group overlie the clay, or, where the clay is absent, rest directly on altered schist. A thin bed of pebble conglomerate is generally present at the base of the Dresbach sands.

Two vein quartz ventifacts were discovered *in situ* at Nekoosa. Specimens "a" and "b" in Figure 3 were taken from the contact between the pebble conglomerate and the highly-altered clayey schist. Although the ventifacts cannot be correlated to a specific vein, they were most probably derived from nearby quartz veins that cross-cut the gneiss and schist and represent a residual weathering

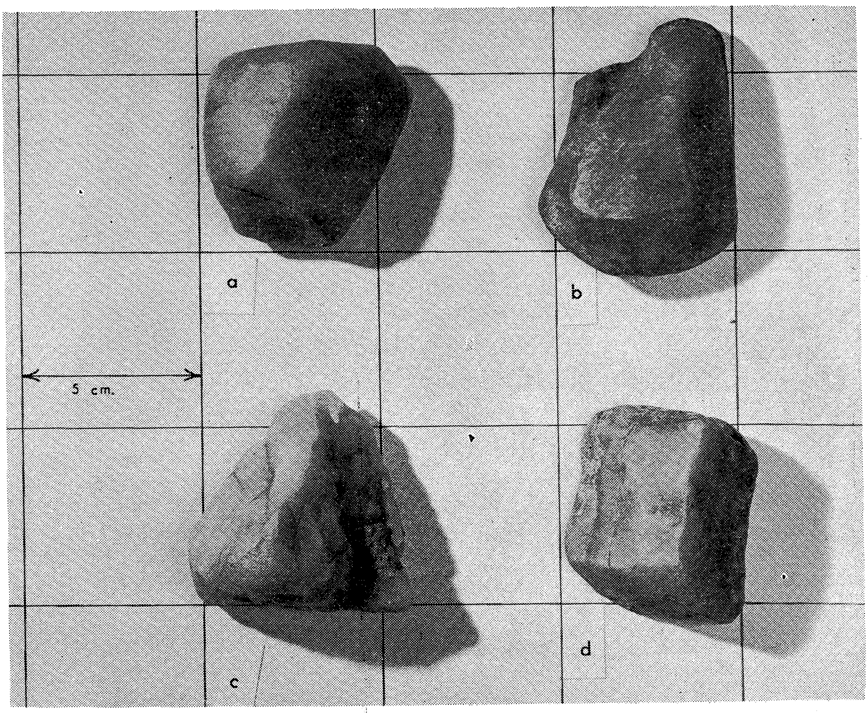

FIGURE 3. Ventifacts (specimens a and b) from Cambrian-Precambrian contact and cobbles of vein quartz (specimens c and d) from bed of Wisconsin River; Nekoosa, Wisconsin.

product. Specimen "a" measures 6.50 x 6.00 x 3.55 cm. and specimen "b" 7.59 x 5.58 x 2.88 cm. The basal surfaces are somewhat pock-marked and several distinctly developed facets are present. The facets are well-worn, smooth and slightly curved and form well-developed ridges where they intersect.

Two cobbles collected from the river bed adjacent to the outcrop are illustrated as specimens "c" and "d" in Figure 3. These specimens are representative of the numerous rough-surfaced cobbles that are present on the river bed. These cobbles were probably released from quartz veins through modern stream erosion and should not be confused with the ventifacts.

The world-wide extent of the Cambrian-Precambrian unconformity indicates a general lowering of sea-level and correspondingly high-continentality. The ultimate cause of the lowering of sea-level in late Precambrian time is unknown. Some geologists have suggested late Precambrian glaciation, while others have suggested epeirogenic movements or even extraterrestrial forces. Whatever the cause, the agents of erosion operating on the exposed continents were certainly as varied then as they are today. The occurrence of ventifacts at the top of the Precambrian erosion surface at Chippewa Falls, Nekoosa and Crivitz indicates that during the late Precambrian wind erosion was an active agent in Wisconsin.

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PALEO-GEOGRAPHIC IMPLICATIONS OF CLAY BALL DEPOSITS UNDER VALDERAN TILL IN EASTERN WISCONSIN

*Barbara Zakrzewska**

The late Valderan glacial deposits of eastern Wisconsin are discussed in the general literature on Pleistocene geomorphology (1) as well as in specific papers (2). There is, however, no mention in this literature of red clay ball deposits found under the Valderan till just north of Two Rivers, Wisconsin, in a north–south trending ridge in Sec. 31, T20 N, R25 E (Fig. 1). In this ridge numerous distinct layers of red clay balls are found in stratified sands and silts which are overlain by 7 to 10 feet of red Valderan till.

The clay balls vary from less than half an inch to four inches in diameter, with one to two inches being the predominant size. Usually the size of the clay balls varies less within a given layer than between layers. The balls have a high degree of sphericity, but some have a flat ring around them suggesting rolling in one direction. They are composed of red blocky clay and contain small pebbles, or occasionally a large pebble as a core, but do not have a conspicuous coating of gravel. The balls occur in layers imbedded in and separated by stratified coarse and fine sands, silts, and very small pebbles (Fig. 2). The overlying red Valderan till usually rests on an undisturbed surface of sand or silt but occasionally is partly interbedded with them or contains sand lenses. (Figs. 3, 4).

The literature reviewed suggests that similar clay balls have been found in other areas, including contemporary beaches. The old but comprehensive paper on "armored mud balls" by Bell (3) deals with clay balls formed on stream bottoms. Leney and Leney (4) discuss clay balls found in outwash in front of a moraine. Kugler and Saunders (5) describe clay balls formed on present beaches backed by unstable marl and clay cliffs providing, through land sliding, lumps of clay which are rolled by waves into round balls. The characteristics of clay balls found near Two Rivers and their stratigraphic and topographic positions suggest that they probably formed under beach-nearshore conditions in front of an ice sheet heavily laden with red clayey till.

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* I would like to acknowledge extensive assistance in data collection and interpretation received during the field stage of this study from Howard Deller, a geography graduate student at the University of Wisconsin–Milwaukee. The idea of curling mud cracks developing into clay balls is predominantly his.

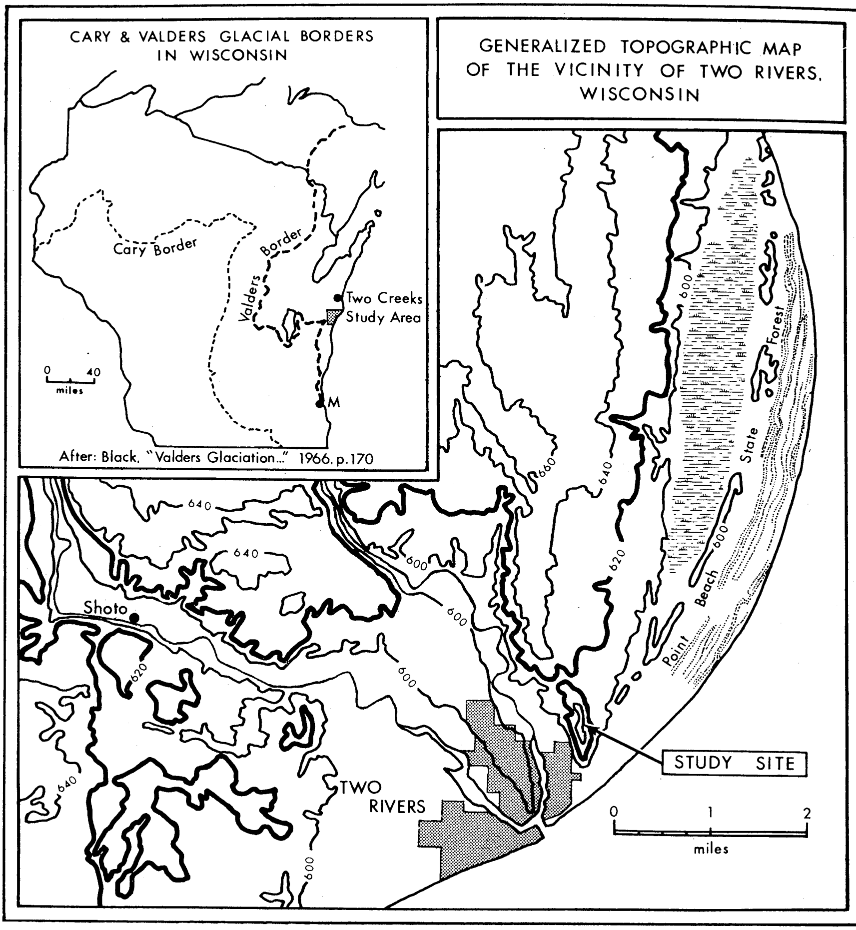

FIGURE 1.

An analysis of the geomorphic history of Eastern Wisconsin and further study of the topographic and geographic positions of the clay ball deposit suggest its significance in the reconstruction of the paleogeography of Eastern Wisconsin.

It is generally accepted that the red Valderan deposits, of which the clay balls seem to be composed, are derived partly from reworked mid-Wisconsin till and partly from red lake sediments transported from Lake Superior (2, Petersen and others, p. 187) during the retreat of the Cary ice through channels established across Upper Michigan and connecting Glacial Lake Keweenaw in the Lake Superior area with Glacial Lake Chicago (2, Murray, p.

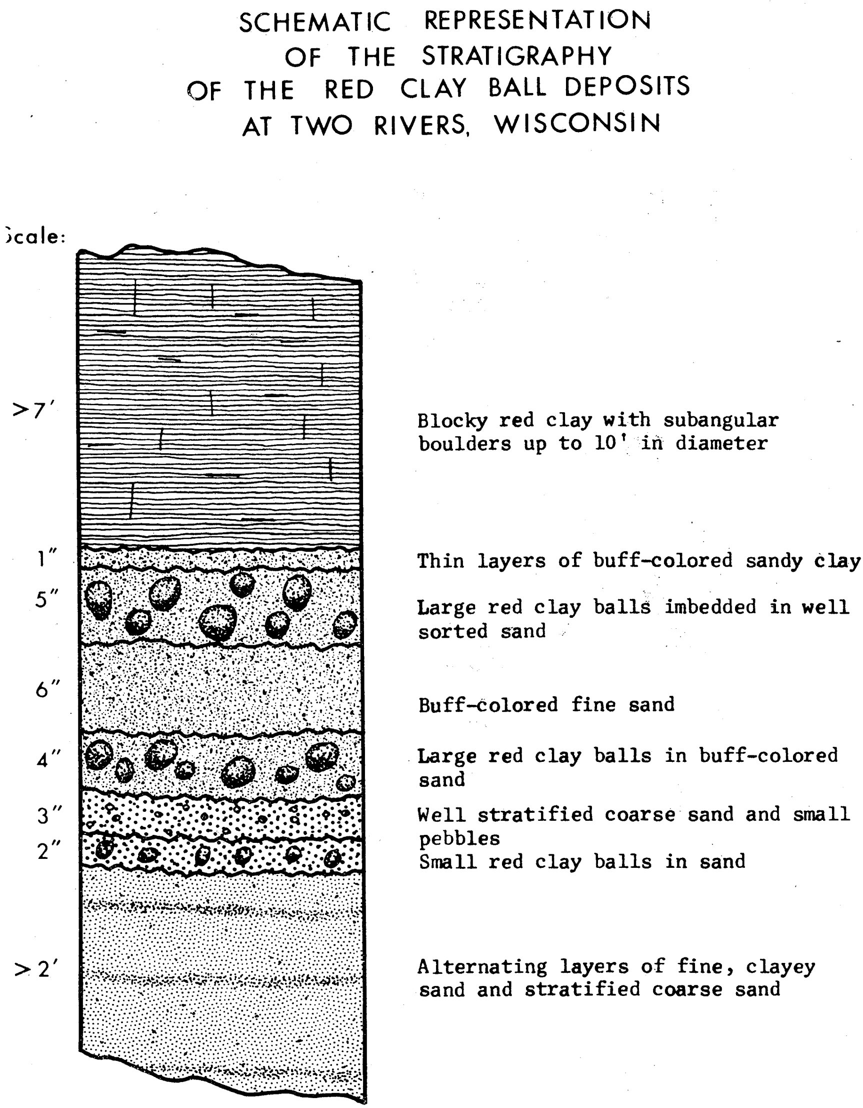

FIGURE 2.

153). The advancing Valderan ice later eroded these red silts and clays, mixed them with the underlying materials, and deposited them as the red clayey till on the uplands of eastern Wisconsin (6). In front of the advancing Valderan ice the lake level of the Lake Calumet stage of Glacial Lake Chicago rose to 620 feet (7). Dur-

FIGURE 3. Clay Balls in Stratified Sands and Silts under Valderan Till, Two Rivers, Wisconsin.

ing the retreat of the Valderan ice, extensive marginal lakes formed in which the red glacio-lacustrine sediments, also found in this area, were laid down (2, Petersen and others, p. 187).

Many of the glacial events of Eastern Wisconsin have been reconstructed through the study of the Two Creeks Forest bed site at Two Creeks, Wisconsin, eleven miles north of the area of this study. Wilson suggested (8) and others confirm (9) that the Two Creeks Forest grew in this area on mid-Wisconsin till and lake deposits during the low stage of Lake Calumet, called Lake Bowmanville (7), which probably stood at the 580 feet level (1, Thwaites and Bertrand, p. 859). Readvance of the ice in the Valderan glacial substage caused the lake to flood the Two Creeks site and bury the forest in stratified clays, silts, and sands. Subsequent

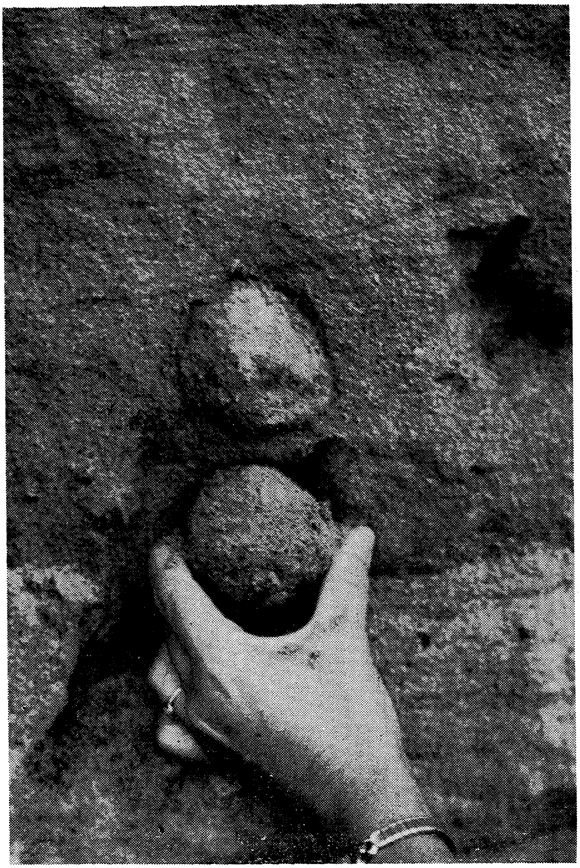

FIGURE 4. Typical Clay Ball in Stratified Sand under Valderan Till, Two Rivers, Wisconsin.

advance of the ice broke the trees and covered the site and the surrounding area with almost 10 feet of red till. According to Thwaites and Bertrand (1) and Hough (9, p. 98), well developed Calumet stage level beaches have not been discovered in Eastern Wisconsin. This paper reports on field evidence of what is probably a buried beach of the Calumet II stage of Glacial Lake Chicago.

As the clay balls found near Two Rivers occur in several layers in generally undisturbed stratigraphic sections underlying Valderan till (in which we found a large tree log probably derived from the nearby Two Creeks Forest bed), it can be suggested that in this locality the advancing Valderan ice was fringed by a shallow marginal lake or a lagoon formed behind offshore sand bars. As a result of wave erosion or melting along the advancing Valderan ice, small chunks of clayey Valderan till were brought to this marginal lake. The high degree of cohesion and compactness of the till, or its frozen state, could have kept the clay chunks from disintegrating. In the shore environment the chunks of till were probably rolled on the beach by successive waves until they acquired a high degree of sphericity. Evidence supporting the suggestion that the clay balls may represent beach environment was found at the nearby Point Beach State Park. Red clay balls are present on the inner part of the beach where red clay (probably from parking lot construction) projects through the sand. These balls must have been formed recently by waves which reached the clay bed, detached segments of it, and rolled them into round balls. Shallow lakes or lagoons with waves of smaller magnitude could have provided a more suitable environment for clay balls to be preserved in successive layers of sands and silts varying in thickness from several inches to a few feet. Intermittently-dry lagoon bottoms could have also provided thick flakes of red clay curling up between dessication cracks, easy to roll into oval clay balls when washed over by small waves. However, while several elongated clay balls composed of layered rather than blocky clay have been found at the site of study, most balls are composed of blocky red clay containing small pebbles.

The present topographic setting of the study site further contributes to the understanding of the paleogeographic conditions in the area during the formation of the red clay balls. The mile-long north–south trending ridge in which the clay balls are found reaches an elevation of about 640 feet above sea level (see Fig. 1) and is located one and a half miles west from the present shore of Lake Michigan. It rises about 30 feet above a gently sloping plain whose eastern edge is marked by a north–south trending 600 feet contour line interpreted to be an abandoned shoreline of Glacial Lake Nipissing (1, Thwaites and Bertrand, Plate 8). Immediately east of this shoreline lies the Point Beach State Park consisting of a broad overgrown lagoon fringed on the east by crescent-shaped, north–south trending, parallel alternating lagoons and sand bars forming a peninsula-like projection into Lake Michigan. These ridges and lagoons are of post-glacial origin and are not covered by glacial till. The north–south trending ridge in which the buried clay balls are found may be a remnant of a beach ridge analogous to the present beach ridges located to the east of it. On the basis of its altitude, the ridge may be interpreted to be a part of the Glacial Lake Calumet II shoreline, whose elevation is estimated at 620 feet (7). The maximum elevation of the ridge is just over 640 feet, and the elevation of the buried beach ridge, overlain in places by as much as 10 feet of Valderan till, is not much over 630 feet.

The clay ball deposits are located below that elevation, or around 620 feet. Since the beach ridge is buried by the Valderan till, the lake whose shoreline it represents must have existed just prior to the maximum extent of the Valderan ice.

Wayne and Zumberge summarize the chronology of glacial lakes in Lake Michigan Basin as shown in Table 1.

Inasmuch as the clay balls are found in the upper strata of water-deposited sands and silts which appear to be of Two Creeks age and are overlain by the red Valderan till, they had to be formed at the end of the Two Creeks period but before the maximum advance of the Valderan ice. It is therefore suggested that they represent a beach ridge of Glacial Lake Calumet II.

A search for other sites containing layers of clay balls which would further help interpret the site described was conducted through a 75 square mile area around Two Rivers (in ten sand and gravel pits), but similar beach-ridge deposits were not found. A distinct layer of red clay balls was found at only one other place:

TABLE 1.

YEARS B. P.	NAME OF LAKE AND ELEVATION IN FEET
	Lake Michigan (580)
2,000	Lake Algoma
3,000	Lake Nipissing
4,000	
	(slow crustal uplift due to glacial unloading)
	Chippewa (230)
9,500	Post Algonquin Main Algonquin Kirkfield
11,000	
Valders Maximum	Tolleston (605)
	Calumet II (620)
Two Creeks	Bowmanville
12,000	
13,000	Calumet I (620)
14,000	Glenwood (640)

Source: W. Wayne and J. Zumberge, *The Quaternary of the United States,* p. 76.

a small sand and gravel pit on a gently rolling upland immediately adjacent to and south of West Twin River valley, just west of Shoto (Sec. 29, T19 N, R24 E). The site is located seven miles from the shore of Lake Michigan at an approximate elevation of 620 feet. The layer of clay balls found here lies below 620 feet and is imbedded predominantly in gravel deposits, overlain by about five feet of well sorted sands, and about two feet of buff-colored till containing ice wedges. A few small clay balls are present in the lowest layers of the sand, but the underlying gravel deposits contain most of the red clay balls, which are of varying sizes up to 7 inches in diameter and have an occasional distinct pebble armor around them. The clay balls in this site are less consistently round; many are oval or cigar-shaped with a flat ring suggesting rolling in one direction. Inasmuch as red till is not present in this area, though the area is mapped as Valderan (6, p. 170), the red clay balls were probably brought into this locality with outwash gravels from an area of red Valderan till and, therefore, differ in origin from the clay balls at Two Rivers. Furthermore, the clay balls at Shoto do not occur in a distinct ridge parallel to the shores of Lake Michigan beach. Therefore, there is little to suggest at present that they represent a beach ridge environment such as that at Two Rivers.

A few scattered red clay balls were also found near Sheboygan, which is located about 35 miles south of Two Rivers, but the topographic and stratigraphic conditions again were different from those at Two Rivers. Horn (2, p. 174) found one clay ball southwest of Omro, west of Lake Winnebago, imbedded in sand under 20 feet of stratified material covered by 6 to 12 feet of red Valderan till. However, distinct clay ball layers, such as those at Two Rivers, were not reported. All these sites, therefore, though containing clay balls, are not comparable to the site at Two Rivers and do not contribute directly to its interpretation. Further search may, however, reveal sites which are comparable to that at Two Rivers.

In summary, the field findings presented in this paper suggest that marginal lakes, probably with fluctuating water level, fringed the advancing Valderan ice near Two Rivers. The clay ball deposit is interpreted to be a beach ridge of Glacial Lake Calumet II, which was present in this area just prior to the maximum advance of the Valderan ice. The deposit appears to be a beach deposit because of the presence of distinct layers of highly spherical clay balls imbedded in stratified sands and silts, similar to clay balls found on nearby modern beaches, and because of the topographic position of the clay balls in a north–south trending ridge roughly parallel to the shores of Lake Michigan basin. The deposit is inferred to represent a beach ridge of Glacial Lake Calumet II on the basis of its geographic position, its specific elevation, and, through its stratigraphic position, its place in the chronology of geomorphic events of this area. This conclusion assumes that the sequence of geomorphic events proposed in the literature reviewed (7) is correct.

Further search around Lake Michigan for sites containing layers of clay balls imbedded in beach deposits under Valderan till may help determine whether the deposit described in this paper represents the shoreline of Glacial Lake Calumet II, and may help map this shoreline. Findings of this nature should help reconstruct the paleogeography of Eastern Wisconsin during the most recent advance of the continental ice into this area (10).

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9. For example: Hough, J. L., "The Prehistoric Great Lakes of North America," *Amer. Scientist* 51, No. 1, 100 (1936); or Wayne, W., and Zumberge, H., *op. cit.*, pp. 73–80; or Thwaites, F. T., and Bertrand, K., *op. cit.*, pp. 859–860.

10. I thank Professors K. Nelson and N. Lasca of the Department of Geology, University of Wisconsin–Milwaukee, for their comments on the ideas contained in the early version of this paper, and Professor J. Flannery and the UWM Cartographic Laboratory for the preparation of illustrations. Figure 4 was provided by Mr. Charles Collins.

NOTES ON THE ECOLOGY OF THE HARVEST MOUSE, *REITHRODONTOMYS MEGALOTIS*, IN SOUTHWESTERN WISCONSIN

Gerald E. Svendsen

Introduction

The harvest mouse, *Reithrodontomys megalotis,* occurs throughout most of the central and western United States and Mexico. It is the most widespread of all species of harvest mice, preferring thick stands of grass (Hall and Kelson, 1959). Local abundance depends on a variety of vegetation that provides food at all seasons. Uncultivated fields and areas having grasses bearing large seeds are favored. In Wisconsin, as far as is known, the distribution of this species is limited to the driftless region, and it favors more or less open, grassy, neglected fields, grassy borders of cultivated fields, and grain fields (Jackson, 1961).

The first specimens of the harvest mouse collected in Wisconsin were taken in La Crosse county in 1930 by Vernon Bailey, and Francis Hammerstrom procured a specimen from Juneau county in 1936 (Jackson, 1961). Subsequent specimens were collected from Columbia and Sauk counties by Hansen (1944a). Personal records include specimens from La Crosse, Wood, and Vernon counties. Hansen (1944a) and Jackson (1961) recognize this harvest mouse to be *Reithrodontomys megalotis pectoralis,* but Hooper (1952) and Hoffmeister and Warnock (1955) find it indistinguishable from *Reithrodontomys megalotis dychei.*

This paper presents some observations on habitats used by this animal, population densities, and a record of some relationships with associated species in southwestern Wisconsin.

Methods and Materials

Population and vegetation analysis were determined in a 9 acre field which has not been under cultivation for 8 years. This neglected field is bordered on the north by a wooded area, on the east by a wet marsh, and on the west and south by a 3 track railroad right-of-way and cultivated fields planted in soybeans and corn. The abandoned field is essentially isolated from any other area of similar vegetational composition. A snap trap grid was arranged in 1 acre plots with traps stationed every 30 feet. The grids were run for six consecutive nights and the population estimates were made from data based on the removal of the animals (Zippen, 1958).

Vegetational analysis was accomplished by randomly selecting five 1 meter plots within the grids and determining species composition. Light intensity was measured with a light meter at noon on a clear sunny day, and expressed as percent of overhead light.

HABITAT PREFERENCE

Trapping efforts in the wooded area, the marsh, the railroad right-of-way, and in the cultivated fields yielded no harvest mice. The only habitat from which the harvest mouse was collected was the abandoned field. This field is in an early stage of succession, with sapling elm, oak, and sumac (½–1 inch d.b.h.) at a density of 3 to 5 per acre. The ground cover is dense, total foliage cover is 90 percent. Light intensity at ground level is 15 to 20 percent of full sunlight. The areas of sparse vegetation are due to places where animals' digging and denning activities have brought up large quantities of sand.

Seventy-two percent of the total species of plants are the grasses *Phleum, Agropyron,* and *Panicum,* and the legumes *Lespedeza* and *Trifolium.* The forbes *Aster, Asclepias, Aplopappas* and *Solidago,* the grasses *Andropogon, Elumus* and *Setaris,* the blackberry *Eubatus,* and the composites *Tragopogon* and *Tarazacum* make up 23 percent of the plants. The remaining 5 percent of the species are woody plants and other grasses and forbes.

Average height of the vegetation varies from 12 to 20 inches, with no ground litter over most of the area. The soil is a sandy loam with very good drainage. The mice live mainly in burrows.

POPULATION DENSITY OF REITHRODONTOMYS

The population density of *Reithrodontomys megalotis* was measured in the falls of 1967 and 1968 in the abandoned field where previous trapping indicated the presence of a substantial population of this species. The fall population, estimated by the removal method, was 18 animals per acre. This represents 0.046 animals per trap night. The spring trapping yielded 0.012 animals per trap night. The fall population based on animals per trap night is almost four times that of the spring population. Hansen (1945) estimated a maximum density of harvest mice in foxtail-smartweed cover type as 2.4 per acre. Birkenholz (1967) estimated a fall population of 17 animals per acre in central Illinois.

Associated Species

The harvest mouse is found in the same area with a variety of other small animals. *Peromyscus maniculatus* is the only species which outnumbers the harvest mouse. The estimated density of *Peromyscus maniculatus* is 72 animals per acre, representing 56 percent of the total population of animals in the old field study area. The percent of the total population represented by the other animals is *Reithrodontomys megalotis* 14 percent, *Blarina brevicauda* 10 percent, *Microtus pennsylvanicus* 7 percent, *Mus musculus* 4 percent, *Peromyscus leucopus* 4 percent, *Zapus hudsonius* 3 percent, *Sorex cinerus* 1 percent, and *Spermophillus tridecemlineatus* 1 percent.

Eleven percent of the total population is composed of two species of predators *Blarina brevicauda* and *Sorex cinerus,* the former being the most common. *Peromyscus leucopus* were all captured not more than 30 feet from the edge of the woods. These individuals were probably wanderers from the woods rather than permanent residents of the field. *Microtus* were trapped mainly in areas of the field where lespedeza and clover were especially thick, and infrequently over the rest of the field. *Mus, Zapus,* and *Peromyscus* were continually trapped with the harvest mouse, especially in areas of the field where the seed-bearing plants were more common. These four species appear to compete directly with one another. *Zapus* hibernates from late October to May and at this time would be removed from competition, and Catlett and Shellhammer (1962) suggest that *Mus* and *Reithrodontomys* form a cospecies social hierarchy and that little competition exists between these species. *Peromyscus maniculatus* appears, therefore, to compete most strongly with the harvest mouse throughout the year in this study area.

Discussion

It can be assumed that clearing of woodlands and establishing grasslands and grainfields has aided the distribution of the harvest mouse. Birkenholz (1967) reports an eastward range extension in Illinois during the past century in response to the clearing of woodlands. The harvest mouse populates new habitats suddenly and attains a high local abundance if the habitat alteration favors its establishment. These habitats are usually transitory resulting in a decrease in abundance if the vegetation composition becomes less favorable.

The harvest mouse can become established in these local and transitory habitats in two ways. Individuals from widely distributed but small and relic populations can populate the new areas, or a saltatorial colonization can occur from isolated, well-populated pockets. Saltatorial colonization by vertebrates is considered unlikely by Smith (1957), although Leopold (1947) reports that outlying individuals are common in species in the process of expanding their range.

Five years of intensive trapping of all types of habitats has yielded only one harvest mouse from an area which could be considered nontypical, and Hansen (1944) reported catching one individual on a juniper bluff. The trapping data would, therefore, favor saltatorial colonization of new areas, due to the lack of individuals, representing a scattered population, in nontypical habitats. It is reasonable that saltatorial colonization can take place if the harvest mouse has a tendency to wander, and if it has a low degree of motivation to return home. Fisler (1966) reported that the homing tendencies of the harvest mouse would be best described as nonrandom throughout the terrain and that the mice lack motivation to return home from unknown areas.

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AN ANNOTATED CHECK LIST OF THE GEOMETRIDAE (LEPIDOPTERA) OF WISCONSIN[1]

Charles V. Covell, Jr.

Upon completing the task of identifying some 1,700 undetermined specimens of Geometridae for the University of Wisconsin Insectarium, I felt that a Wisconsin list of this family of moths would be useful to lepidopterists. To this end I examined additional material: 1,300 more specimens from the University of Wisconsin; 1,800 specimens from William E. Sieker; and over 2,000 specimens taken by Harold Bower. Over 7,000 specimens provided the data in this list, and localities in at least 30 counties are represented.

Previous check lists including Wisconsin Geometridae are those of Rauterberg (1900), Fernekes (1906), and Muttkowski (1907), all of which are restricted to Milwaukee County. I have not included their records here because of subsequent changes in nomenclature of species, and because some of their identifications are dubious (e.g., Fernekes, p. 54, lists *Melanchroia cephise* Cramer, a Florida species). However, most of their records are corroborated here; and other species are recorded from Wisconsin for the first time.

Although this list is based upon specimens I have actually examined, a few records are included which were taken from recent revisionary literature. These cases are so noted in the text, and appropriate references are cited.

The nomenclature and arrangement of taxa follow generally those of McDunnough (1938), since that list has long been the basis for organization of most collections of North American moths. I have used Forbes (1948) and the revisionary works of McDunnough, Rindge, Capps, Rupert, and others as aids in my determinations; consequently some digressions from McDunnough (1938) have been made here. Numerous genera, such as *Semiothisa*, badly need revisionary study. It therefore follows that certain long-standing errors in nomenclature are unfortunately continued in this list. These must wait for future correction.

Most of the specimens studied were collected by the following, each listed with the localities where he made most of his captures: Harold Bower (Lake Katherine in Oneida County, Milwaukee, and

[1] University of Louisville Publications in Biology (New Series) No. 110.

Wausau); Louis Griewisch (Green Bay and other "Brown County" labels); Gary Lachmund (Sauk City); Gary Ross (Florence County); and William E. Sieker (Bailey's Harbor in Door County, other "Door County" labels, and Madison). All of the Bower specimens are in the Los Angeles County Museum, and most of the Sieker and Lachmund material is in my collection; the rest is at the University of Wisconsin.

I am deeply indebted to the following for their contributions to this effort: Dr. Roy D. Shenefelt, Curator of the University of Wisconsin Insectarium, and his project assistants, Lutz J. Bayer and Isabel Arevalo, for providing material and important information; William E. Sieker of Madison and Gary Lachmund of Sauk City for numerous specimens; Lloyd M. Martin, Los Angeles County Museum, for making the Bower collection available; Dr. Frederick H. Rindge, American Museum of Natural History, for nomenclatural advice; and Patricia K. Liles, my curatorial assistant, for compiling data. I am also very grateful to Dr. John A. Dillon, Jr., Dean of the Graduate School, University of Louisville, for making graduate school funds available to me for the visit to the Los Angeles County Museum.

FAMILY GEOMETRIDAE

Subfamily Brephinae

1. *Brephos infans* Möschler — Apr. 10–May 7
   Lake Katherine, Oneida Co.
2. *Leucobrephos brephoides* Walker
   Synonym *hoyi* Grote was described from Wisconsin.

Subfamily Oenochrominae

3. *Alsophila pometaria* Harris — Apr. 18; Oct. 25–Nov. 5
   Crandon; Madison; Wausau, Marathon Co.

Subfamily Geometrinae

4. *Nemoria mimosaria* Guenée — May 14–July 11
   Bailey's Harbor; Florence Co.; Griffith State Nursery, Wood Co.; Lake Katherine; Marinette Co.; Wausau.
5. *Nemoria rubrifrontaria* Packard — May 20–June 27
   Lake Katherine; Sauk City; Vilas Co.
6. *Dichorda iridaria* Guenée — May 31–June 7
   Door Co.; Sauk City.
7. *Synchlora liquoraria* Guenée
   Lake Katherine. This is, according to Ferguson (1969), subspecies *albolineata* Packard.

8. *Synchlora aerata Fabricius* June 11–Aug. 27
Columbia Co.; Lake Katherine; Madison; Trout Lake, Vilas Co.; Sayner; Wausau. These records include *rubrifrontaria* Packard, synonymized by Ferguson (1969).

9. *Chlorochlamys chloroleucaria* Guenée June 4–Sept. 8
Belleville; Columbia Co.; Door Co.; Green Bay; Harrisville; Madison; Rusk Co.; near Sayner, Vilas Co.; Wausau.

10. *Hethemia pistaciaria* Guenée June 11–July 10
Florence Co.; Lake Katherine.

11. *Mesothea incertata* Walker May 10–30
Cranmoor, Wood Co.; Lake Katherine; Marinette Co.

Subfamily Sterrhinae

12. *Metasiopsis balistaria* Guenée May 14–July 22
Boscobel St. Nursery, Grant Co.; Dane Co.; Griffith St. Nursery, Wood Co.; Milwaukee; Sturgeon Bay, Door Co.

13. *Scopula cacuminaria* Morrison June 18–Sept. 13
Lake Katherine; N.E. Price Co.; Wausau.

14. *Scopula quadrilineata* Hulst (probably June–Aug.)
"Wis." on pin label.

15. *Scopula ancellata* Hulst Aug.
Bailey's Harbor.

16. *Scopula junctaria* Walker May 7–July 26
Bailey's Harbor; Crandon; Florence Co.; Lake Katherine.

17. *Scopula limboundata* Haworth June 10–Aug. 16
Bailey's Harbor; Crandon; Dousman; Florence Co.; Lake Katherine; Madison; Marinette Co.; Milwaukee; Sauk City; Trout Lake, Vilas Co. Known widely as *enucleata* Guenée.

18. *Scopula frigidaria* Möschler July 3
Florence Co.

19. *Scopula inductata* Guenée May 30–Sept. 14
Columbia Co.; Door Co.; Gordon Nursery, Douglas Co.; Green Bay; Lake Katherine; Madison; Milwaukee; Sauk City; Waushara Co.

20. *Idaea demissaria* Hübner May 25–July 21
Door Co.; Madison. Fletcher (1966, p. 12) synonymizes the familiar *Sterrha* Hübner to *Idaea* Treitschke.

21. *Haematopis grataria* Fabricius May 31–Oct. 4
Badger Ordnance Works, Sauk City; Boscobel; Brown Co.; Columbia; DeForest; Door Co.; Lake Katherine; Madison; Milwaukee; Rusk Co.; Sauk City; Tower Hill State Park, Iowa Co.; Washburn Co.; Waushara Co.; Wood Co.

22. *Calothysanis amaturaria* Walker July 14–Sept. 14
Columbia Co.; Lake Katherine; Madison.

23. *Pleuroprucha insulsaria* Guenée June 9– Oct. 1
Dane Co.; Door Co.; Lake Katherine; Milwaukee.

24. *Cyclophora pendulinaria* Guenée May 21–Sept. 4
American Legion State Forest, Oneida Co.; Lake Katherine; Rusk Co.; Trout Lake; Wausau.

25. *Cyclophora packardaria* Prout June 16–Aug. 29
Lake Katherine.

Subfamily Larentiinae

26. *Acasis viridata* Packard May 16–31
Lake Katherine.

27. *Nyctobia limitaria* Walker May 1–June 9
Lake Katherine.

28. *Nyctobia anguilineata* Grote and Robinson May 28
Lake Katherine.

29. *Cladara atroliturata* Walker Apr. 15–May 22; Aug. 9
Lake Katherine.

30. *Lobophora nivigerata* Walker May 18–July 12
Brown Co.; Dane Co.; Florence Co.; Green Bay; Lake Katherine; Sauk City; near Sayner, Vilas Co.

31. *Heterophleps refusata* Walker June 20–July 12
Florence Co.; Milwaukee; Wausau.

32. *Heterophleps triguttaria* Herrich-Schäffer June 17–July 11
Madison; Milwaukee; Wausau.

33. *Dyspteris abortivaria* Herrich-Schäffer June 4–Aug. 11
Madison; Selzer Farm near Holy Hill.

34. *Trichodezia albovittata* Guenée May 26–July 23
Kewaunee Co.; Lake Katherine; Madison; Milwaukee.

35. *Oporophtera bruceata* Hulst Oct. 15–Nov. 12
Lake Katherine; Wausau.

36. *Triphosa affirmaria* Walker Apr. 19–Oct. 28
Dane Co.; Florence Co.; Lake Katherine; Wausau. Known widely as *haesitata* Guenée.

37. *Hydria undulata* Linnaeus June 11–Aug. 15
Door Co.; Dousman; Florence Co.; Kenosha Co.; Lake Katherine; Madison; Milwaukee.

38. *Coryphista meadi* Packard May–Sept. 10
Dane Co.; Green Bay.

39. *Eupithecia miserulata* Grote May 30–Oct. 19
Columbia Co.; Dane Co.; Door Co.; Florence Co.; Lake Katherine; Rusk Co.; University of Wisconsin Arboretum, Madison.

40. *Eupithecia castigata* Hübner June 12–26
Lake Katherine.

41. *Eupithecia palpata* Packard June 9
Florence Co.; Vilas Co.

42. *Eupithecia transcanadata* MacKay May 19–June 17
Lake Katherine.

43. *Eupithecia columbiata* Dyar Apr. 30–May 24
Lake Katherine. Determined by Bower as subspecies *erpata* Pearsall.

44. *Eupithecia herefordaria* Cassino and Swett June 9–Sept. 15
Columbia Co.; Florence Co.

45. *Eupithecia carolinensis* Grossbeck June 10
Lake Katherine. Determined by R. Leuschner.

46. *Eupithecia russeliata* Swett May 24–July 27
Lake Katherine.

47. *Eupithecia indistincta* Taylor July 10
Trout Lake, Vilas Co.

48. *Eupithecia coagulata* Guenée July 21–Aug. 22
Lake Katherine; Milwaukee; Wausau.

49. *Eupithecia perfusca* Hulst June 18–July 20
Lake Katherine. Determined by Bower as subspecies *youngata* Taylor.

50. *Eupithecia ravocostaliata* Packard Apr. 26–30
Lake Katherine.

51. *Horisme intestinata* Guenée May 30–Aug. 23
Bailey's Harbor; Brown Co.; Green Bay; Lake Katherine; Milwaukee; Sauk City.

52. *Eustroma semiatrata* Hulst June 10–Aug. 4
Crandon; Lake Katherine near Hazelhurst; N.E. Price Co. Known widely as *E. nubilata* Packard.

53. *Eulithis diversilineata* Hübner June 24–Aug. 30
Brown Co.; Florence Co.; Kenosha Co.; Madison; Milwaukee; Sauk City; Wausau. Fletcher (1966, p. 15) cites *diversilineata* as type of *Eulithis* Hübner [1821] which antedates *Lygris* Hübner [1825].

54. *Eulithis gracilineata* Guenée June 24–Sept. 16
Brown Co.; Griffith State Nursery; Madison.

55. *Eulithis testata* Linnaeus June 14–Sept. 5
Florence Co.; Lake Katherine; Wausau.
56. *Eulithis molliculata* Walker June 14–Aug. 20
Milwaukee; Platteville.
57. *Eulithis destinata* Möschler July 3–Aug. 22
Florence Co.; Lake Katherine.
58. *Eulithis explanata* Walker June 24–Aug. 25
Florence Co.; Lake Katherine.
59. *Eulithis xylina* Hulst July 6–Aug. 2
Lake Katherine.
60. *Diactinia silaceata* Hübner June 14–Sept. 16
Forest Co.; Lake Katherine.
61. *Plemyria georgii* Hulst Aug. 11–18
Lake Katherine.
62. *Dysstroma citrata* Linnaeus June 4–Sept. 1
Florence Co.; Lake Katherine; Trout Lake.
63. *Dysstroma hersiliata* Guenée June 19–Aug. 28
Bailey's Harbor; Crandon; Dodgeville; Door Co.; Florence Co.; Lake Katherine; Washburn Co.; Wausau.
64. *Stamnodes gibbicostata* Walker Aug. 31–Sept. 4
Lake Katherine.
65. *Hydriomena transfigurata* Swett May 11
Dane Co. This is subspecies *manitoba* Barnes and McDunnough.
66. *Hydriomena perfracta* Swett May 6–June 24
Lake Katherine; Vilas Co. near Sayner.
67. *Hydriomena divisaria* Walker May 6–July 16
Lake Katherine; Vilas Co. near Sayner.
68. *Hydriomena renunciata* Walker May 11–Aug. 5
Bailey's Harbor; Dane Co.; Door Co.; Florence Co.; Green Bay; Griffith State Nursery; Lake Katherine; Milwaukee; Summit Lake, Langlade Co.; Trout Lake; Waterloo; Wausau.
69. *Xanthorhoe lacustrata* Guenée May 29–Aug. 10
Door Co.; Florence Co.; Lake Katherine; Madison; Milwaukee; "Peaks Lake" (this is probably Peat's Lake, Brown Co.); Wausau.
70. *Xanthorhoe emendata* Pearsall May 21–Aug. 1
Lake Katherine; N.E. Price Co.
71. *Xanthorhoe ferrugata* Linnaeus May 21–Aug. 29
Bailey's Harbor; Columbia Co.; Door Co.; Florence Co.; Lake Katherine; Madison; Milwaukee; Wausau.

72. *Xanthorhoe algidata* Möschler July 10–Aug. 3
Florence Co.; Lake Katherine; N.E. Price Co.

73. *Xanthorhoe iduata* Guenée June 20–July 8
Lake Katherine.

74. *Xanthorhoe abrasaria* Herrich-Schäffer June 22–Aug. 23
Columbia Co.; Florence Co.; Lake Katherine.

75. *Xanthorhoe luctuata* Denis and Schiffermüller May 28–Aug. 1
Forest Co.; Lake Katherine.

76. *Xanthorhoe intermediata* Guenée May 17–Oct. 13
Dane Co.; Door Co.; Lake Katherine; Milwaukee Co.; Spencer; Spooner; Univ. Wisc. Arboretum, Madison.

77. *Mesoleuca ruficillata* Guenée May 27–Aug. 21
Florence Co.; Lake Katherine; Milwaukee; "Peaks Lake"; Wausau.

78. *Epirrhoe alternata* Müller June 10–Aug. 6
Florence Co.; Lake Katherine; Wausau.

79. *Spargania magnoliata* Guenée June 10–Aug. 12
Crandon; Lake Katherine; N.E. Price Co.; Wausau.

80. *Percnoptilota obstipata* Fabricius May 3–Oct. 13
Bailey's Harbor; Columbia Co.; Florence Co.; Green Bay; Grant Co.; Lake Katherine; Madison; Milwaukee; Rusk Co.; Sauk City; Spooner; Sturgeon Bay, Door Co.

81. *Percnoptilota centrostrigaria* Wollaston May 19–Oct. 31
Bailey's Harbor; Brown Co.; Door Co.; Florence Co.; Green Bay; Lake Katherine; Madison; Milwaukee; Sauk City; Washburn Co.

82. *Rheumaptera hastata* Linnaeus June 11–July 6
Green Bay; Kewaunee Co.; Lake Katherine; Madison; Milwaukee; "Peaks Lake."

83. *Perizoma basaliata* Walker July 4–30
Lake Katherine; N.E. Price Co.

84. *Earophila vasiliata* Guenée Apr. 26–June 9
Florence Co.; Lake Katherine.

85. *Earophila multiferata* Walker May 17–June 10
Lake Katherine; Madison.

86. *Venusia comptaria* Walker Apr. 25–May 19
Lake Katherine; Milwaukee.

87. *Hydrelia condensata* Walker June 5–July 1
Lake Katherine; Milwaukee.

88. *Hydrelia inornata* Hulst June 10–July 20
Florence Co.; Lake Katherine.

89. *Hydrelia albifera* Walker July 3–25
Florence Co.; Lake Katherine.

90. *Eudule mendica* Walker June 10–July 24
Bailey's Harbor; Florence Co.; Green Bay; Griffith State Nursery; Kenosha Co.; Madison; Mather; Milwaukee; Oconto Co.; "Peak's Lake"; Sauk City; Trout Lake, Vilas Co.; Wausau.

Subfamily Ennominae

91. *Bapta semiclarata* Walker May 15–July 6
Crandon; Door Co.; Marinette; Washburn Co.

92. *Bapta vestaliata* Guenée May 29–July 11
Bailey's Harbor; Blue Mounds; Brown Co.; Florence Co.; Green Bay; Lake Katherine; Madison; Milwaukee.

93. *Bapta glomeraria* Grote May 3–31
Lake Katherine; Waupaca.

94. *Cabera quadrifasciaria* Packard June 7–24
Green Bay; Sauk City. Fletcher (1966, p. 12) shows *Deilinia* Hübner (1825) to be a junior objective synonym of *Cabera* Treitschke (1825).

95. *Cabera variolaria* Guenée June 20–Aug. 12
Bailey's Harbor; Brown Co.; Florence Co.; Forest Co.; Madison; Milwaukee; N.E. Price Co.

96. *Cabera erythemaria* Guenée May 28–Aug. 26
Bailey's Harbor; Brown Co.; Florence Co.; Green Bay; Milwaukee; N.E. Price Co.

97. *Apodrepanulatrix liberaria* Walker
Rindge (1949, p. 293) states that this species ranges "to Wisconsin."

98. *Syrrhodia cruentaria* Hübner June 25
Milwaukee.

99. *Isturgia truncataria* Walker May 11–June 29
Crandon; Lake Katherine; Marinette Co.

100. *Heliomata cycladata* Grote June 26–July 2
Brown Co.; Sauk City.

101. *Semiothisa aemulataria* Walker May 21–July 30
Bailey's Harbor; Florence Co.; Lake Katherine; Madison, Dane Co.; Marinette Co.; Sauk City; Wausau.

102. *Semiothisa ulsterata* Pearsall June 5–22
Lake Katherine; Vilas Co.

103. *Semiothisa minorata* Packard June 25–July 13
Dane Co.; Lake Katherine; Trout Lake; Wausau.

104. *Semiothisa bisignata* Walker June 23–Sept. 13
Bailey's Harbor; Florence Co.; Green Bay; Lake Katherine; Madison; Trout Lake; Vilas Co.; Wausau.

105. *Semiothisa bicolorata* Fabricius May 19–July 26
Lake Katherine.

106. *Semiothisa distribuaria* Hübner May 5–July 19
Arena, Iowa Co.; Lake Katherine; Madison; Trout Lake; Wausau.

107. *Semiothisa punctolineata* Packard Sept. 7
Dane Co.

108. *Semiothisa granitata* Guenée May 29–Aug. 15
American Legion State Forest, Oneida Co.; Bailey's Harbor; Florence Co.; Lake Katherine; Madison; Trout Lake; Vilas Co.; Wausau. This name represents a complex of several species, needing revisionary study.

109. *Semiothisa oweni* Swett May 28–July 11
Lake Katherine.

110. *Semiothisa sexmaculata* Packard May 13–Aug. 9
Florence Co.; Green Bay; Lake Katherine.

111. *Semiothisa denticulata* Grote June 23–Aug. 1
Milwaukee; Poynette.

112. *Semiothisa eremiata* Guenée July 12
Dane Co.

113. *Semiothisa orillata* Walker May 24–Aug. 29
Bailey's Harbor; Dane Co.; Door Co.; Florence Co.; Green Bay; Lake Katherine; Madison; Sauk City; Wausau.

114. *Semiothisa ocellinata* Guenée July 8–Oct. 3
Kenosha Co.; Madison; Milwaukee.

115. *Semiothisa mellistrigata* Grote May 15–Aug. 25
Belleville; Crandon; Door Co.; Florence Co.; Green Bay; Madison; Milwaukee; Oconto Co.

116. *Semiothisa snoviata* Packard Aug. 30
Columbia Co.

117. *Semiothisa gnophosaria* Guenée May 13–Aug. 17
Bailey's Harbor; Dane Co.; Florence Co.; Lake Katherine; Madison; Wausau; Wood Co.

118. *Itame pustularia* Guenée June 5–Sept. 8
Bailey's Harbor; Brown Co.; Florence Co.; Green Bay; Lake Katherine; Madison; Milwaukee; N.E. Price Co.; Sauk City; Trout Lake; Wood Co.

119. *Itame ribearia* Fitch — May 15–July 30
Belleville; Dodgeville, Iowa Co.; Madison; Milwaukee; Sauk City; Wausau.

120. *Itame argillacearia* Packard — June 9–July 23
Bailey's Harbor; Lake Katherine.

121. *Itame occiduaria* Packard — June 28–July 20
Lake Katherine.

122. *Itame evagaria* Hulst — June 20–Aug. 2
Crandon; Lake Katherine; Madison; N.E. Price Co.; Wausau.

123. *Itame fulvaria* deVillers — June 12–July 10
Crandon; Florence Co.; Lake Katherine; Spooner; Summit Lake; Wood Co.

124. *Itame subcessaria* Walker — June 21–Aug. 20
Crandon; Florence Co.

125. *Itame coortaria* Hulst — June 5–July 30
Door Co.; Madison; Milwaukee; Sauk City.

126. *Itame anataria* Swett — July 7–13
Lake Katherine.

127. *Itame bitactata* Walker — July 3–Aug. 4
Lake Katherine; N.E. Price Co.

128. *Itame loricaria* Eversmann — June 19–July 13
Lake Katherine; Wausau.

129. *Eumacaria latiferrugata* Walker — June 1–Aug. 28
Griffith State Nursery; Lake Katherine; Sauk City; Wausau.

130. *Thysanopyga intractata* Walker
The type of synonym *gausaparia* Grote is from Wisconsin.

131. *Hesperumia sulphuraria* Packard — June 18–Aug. 4
Madison; Wausau.

132. *Ematurga amitaria* Guenée — May 30–Aug. 10
Crandon; Marinette Co.; Vilas Co.

133. *Eufidonia notataria* Walker — June 7–July 23
Griffith State Nursery, Wood Co.; Lake Katherine; Marinette Co.; Northern Highlands; Vilas Co.

134. *Eufidonia discospilata* Walker — June 10–22
Lake Katherine; Vilas Co.

135. *Orthofidonia tinctaria* Walker — May 8–June 17
Lake Katherine; Sauk City.

136. *Hypagyrtis pustularia* Hübner — July 4–Aug. 21
Lake Katherine; Wausau.

137. *Hypagyrtis subatomaria* Wood June 4–Aug. 23
Dane Co.; Douglas Co.; Florence Co.; Lake Katherine; N.E. Price Co.; Trout Lake.

138. *Hypagyrtis piniata* Packard June 19–Aug. 6
Bailey's Harbor; Florence Co.; Gordon, Douglas Co.; Griffith State Nursery, Wood Co.; Madison; Summit Lake; Trout Lake, Vilas Co.

139. *Tornos scolopacinarius* Guenée
Rindge (1954, p. 221) includes "southern Wisconsin" in his range notes for this species.

140. *Melanolophia canadaria* Guenée Apr. 27–July 22
Bailey's Harbor; Lake Katherine; Madison; Milwaukee; Patton Lake Spur, Florence Co.

141. *Melanolophia signataria* Walker May 14–July 3
Bailey's Harbor; Lake Katherine; Patton Lake Spur, Florence Co.

142. *Protoboarmia porcelaria* Guenée June 10–Aug. 12
Bailey's Harbor; Florence Co.; Sayner; Summit Lake.

143. *Cleora manitoba* Grossbeck May 8–July 13
Lake Katherine.

144. *Pseudoboarmia umbrosaria* Hübner June 29–July 28
Crandon; Lake Katherine; N.E. Price Co.

145. *Stenoporpia polygrammaria* Packard June 27
Waushara Co.

146. *Anavitrinella pampinaria* Guenée May 8–Sept. 15
Bailey's Harbor; Bone Rock, Sauk Co.; Columbia Co.; Gays Mills; Griffith State Nursery; Lake Katherine; Madison; Patton Lake, Florence Co.; Neshkoro; Platteville; Sauk City; Waushara Co.

147. *Iridopsis larvaria* Guenée June 20–July 20
Bailey's Harbor; Florence Co.; Lake Katherine.

148. *Anacamptodes ephyraria* Walker June 29–Aug. 12
Crandon; Florence Co.; Forest Co.; Lake Crandon; Lake Katherine; Madison; Milwaukee.

149. *Anacamptodes humaria* Guenée May 5–Aug. 14
Griffith State Nursery; Lake Katherine, near Hazelhurst; Madison; Neshkoro.

150. *Anacamptodes vellivolata* Hulst May 8–Aug. 22
Lake Katherine; Wausau.

151. *Aethalura anticaria* Walker May 30–July 3
Lake Katherine.

152. *Ectropis crepuscularia* Denis and Schiffermüller Apr. 15–Aug. 5
Arbor; Boscobel State Nursery; Door Co.; Florence Co.; Grant Co.; Lake Latherine; Madison; Milkaukee; Patton Lake, Florence Co.; Vilas Co.; Northern Highlands; Wausau.

153. *Phaeoura quernaria* Abbott and Smith May 19–July 11
Bailey's Harbor; Door Co.; Florence Co.; Lake Katherine; Milwaukee; Neshkoro. One reared larva emerged Apr. 4.

154. *Phigalia olivacearia* Morrison Apr. 17–May 7
Dane Co.; Lake Katherine; Madison; Milwaukee; Wausau.

155. *Phigalia titea* Cramer Apr. 18–May 12
Griffith State Nursery; Lake Katherine; Madison; Milwaukee.

156. *Palaeacrita vernata* Peck March 13–Apr. 28
Lake Katherine; Madison; Milwaukee; Wausau.

157. *Erannis tiliaria* Harris Oct. 6–Nov. 2
Brown Co.; Dane Co.; Kewaunee Co.; Lake Katherine; Madison; Wausau.

158. *Biston ursaria* Walker Apr. 12–May 23
Dane Co.; Griffith State Nursery; Lake Katherine; Madison; Milwaukee; Wausau.

159. *Biston cognataria* Guenée May 15–Sept. 19
Arlington; Bailey's Harbor; Boscobel State Nursery; Brown Co.; Columbia Co.; DeForest, Dane Co.; Green Bay; Lake Katherine; Madison; Marinette Co.; Milwaukee; Sauk City; Trout Lake, Vilas Co.; Washburn Co.

160. *Eugonobapta nivosaria* Guenée June 28–Aug. 12
Bailey's Harbor; Door Co.; Florence Co.; Madison; Milwaukee; Sauk City.

161. *Lytrosis unitaria* Herrich-Schäffer June 24–July 30
Madison; Sauk City; Wausau.

162. *Euchlaena serrata* Drury "May"; June 28–Aug. 14
Bailey's Harbor; Brown Co.; Dousman; Door Co.; Green Bay; Griffith State Nursery; Lake Katherine; Madison; "Peaks Lake"; Sauk City; Sturgeon Bay.

163. *Euchlaena obtusaria* Hübner June 9–July 19
Bailey's Harbor; Crandon; Dane Co.; Door Co.; Florence Co.; Lake Katherine; Madison; Milwaukee; Summit Lake.

164. *Euchlaena effecta* Walker June 18–July 30
Florence Co.; Lake Katherine; Madison; Wausau.

165. *Euchlaena johnsonaria* Fitch June 9–Aug. 29
Bailey's Harbor; Florence Co.; Lake Katherine; Madison; Marinette Co.; Sauk City; Trout Lake; Wausau; Wood Co.

166. *Euchlaena amoenaria* Guenée June 22
Marinette Co.

167. *Euchlaena marginata* Minot May 30–July 8
Florence Co.; Lake Katherine; Vilas Co.; Waushara Co.

168. *Euchlaena tigrinaria* Guenée June 14–July 15
Bailey's Harbor; Florence Co.; Lake Katherine; Milwaukee; Summit, Langlade Co.

169. *Euchlaena irraria* Barnes and McDunnough June 17–July 10
Florence Co.; Lake Katherine; Madison; Marinette Co.; Sauk City.

170. *Euchlaena milnei* McDunnough July 1
Sauk City.

171. *Xanthotype sospeta* Drury June 6–Aug. 25
Bailey's Harbor; Brown Co.; Crandon; Door Co.; Florence Co.; Green Bay; Lake Katherine; Madison; Milwaukee; "Peaks Lake"; Rusk Co.; Sauk City; Shawano Co.; Star Lake; Trout Lake, Vilas Co.

172. *Xanthotype urticaria* Swett July 5–Sept. 8
Arpin; Brown Co.; Columbia Co.; Florence Co.; Lake Katherine; Madison; Milwaukee; Wausau.

173. *Campaea perlata* Guenée June 1–Oct. 2
Bailey's Harbor; Columbia Co.; Door Co.; Florence Co.; Lake Katherine; Madison; N.E. Price Co.; Oneida Co.; Patton Lake; Sauk City; Summit Lake, Langlade Co.; Trout Lake, Vilas Co.; Verona; Wausau.

174. *Gueneria basiaria* Walker July 8–11
Florence Co.

175. *Homochlodes fritillaria* Guenée May 28–July 23
Door Co.; Florence Co.; Lake Katherine; Vilas Co.

176. *Tacparia detersata* Guenée May 21–July 8
Florence Co.; Lake Katherine; Madison.

177. *Lozogramma subaequaria* Walker May 19–Aug. 10
Brown Co.; Dane Co.; Florence Co.

178. *Cepphis armataria* Herrich-Schäffer Apr. 21–Aug. 24
Bailey's Harbor; Florence Co.; Lake Katherine; Madison; Milwaukee; Washburn Co.

179. *Plagodis serinaria* Herrich-Schäffer May 22–June 27
Florence Co.; Lake Katherine; Sauk City.

180. *Plagodis keutzingi* Grote July 1–13
Bailey's Harbor; Door Co.; Madison.

181. *Plagodis fervidaria* Herrich-Schäffer May 24–July 5
Bailey's Harbor; Brown Co.; Dane Co.; Door Co.; Sauk City.

182. *Plagodis alcoolaria* Guenée May 17–July 29
Bailey's Harbor; Dane Co.; Florence Co.; Lake Katherine; Madison; Milwaukee; Patton Lake; Sauk City; Vilas Co.

183. *Plagodis phlogosaria* Guenée Apr. 30–Aug. 1
Bailey's Harbor; Florence Co.; Lake Katherine; Milwaukee; Sauk City; Trout Lake; Wausau. I have seen typical *phlogosaria, p. keutzingaria* Packard, and *p. purpuraria* Pearsall.

184. *Anagoga occiduaria* Walker May 29–July 12
Bailey's Harbor; Florence Co.; Lake Katherine; Vilas Co.

185. *Hyperetis amicaria* Herrich-Schäffer May 29–Aug. 29
Bailey's Harbor; Florence Co.; Lake Katherine; Madison; Marinette Co.; Milwaukee; Patton Lake; Rush Co.; Vilas Co.; Wausau; Waushara Co.

186. *Hyperetis alienaria* Herrich-Schäffer May 22–July 4
Bailey's Harbor; Brown Co.; Florence Co.; Green Bay; Lake Katherine; Milwaukee; "Peaks Lake"; Wausau.

187. *Nematocampa filamentaria* Guenée June 4–Aug. 26
Bailey's Harbor; Florence Co.; Madison; Milwaukee; Rusk Co.; Rust Lake; Sauk City.

188. *Metarranthis hypochraria* Herrich-Schäffer Apr. 13–Aug. 10
Brown Co.; Door Co.; Florence Co.; Lake Katherine; Madison; Marinette Co.; Milwaukee.

189. *Metarranthis broweri* Rupert May 29–July 8
Bailey's Harbor; Dodgeville; Florence Co.; Madison.

190. *Metarranthis apiciaria* Packard May 29
Lake Katherine.

191. *Metarranthis warneri* Harvey June 4–6
Wausau; a paratype ♂ of *M. warneri cappsaria* Rupert collected 4 June, 1932, is from Madison.

192. *Metarranthis duaria* Guenée May 28–June 20
Lake Katherine; Madison; Milwaukee; Vilas Co.; Wausau; Waushara Co.

193. *Metarranthis amyrisaria* Walker May 27–July 4
Bailey's Harbor; Florence Co.; Madison.

194. *Metarranthis angularia* Barnes and McDunnough July 8
Milwaukee.

195. *Metarranthis obfirmaria* Hübner June 30
Milwaukee.

196. *Metanema inatomaria* Guenée May 29–Aug. 15
Bailey's Harbor; Dane Co.; Florence Co.; Lake Katherine; Milwaukee; Rusk Co.; Sauk City; Waushara Co.

197. *Metanema determinata* Walker June 17–Aug. 16
Bailey's Harbor; Florence Co.; Lake Katherine; Milwaukee; Rusk Co.; Summit Lake.

198. *Selenia alciphearia* Walker May 7–June 7
Lake Katherine.

199. *Selenia kentaria* Grote and Robinson Apr. 30–July 22
Florence Co.; La Crosse; Lake Katherine.

200. *Ennomos subsignarius* Hübner June 19–Sept. 10
Bailey's Harbor; Brown Co.; Florence Co.; Green Bay; Lake Katherine; Madison; Milwaukee.

201. *Pero honestaria* Walker May 16–Sept. 1
Bailey's Harbor; Brown Co.; Dane Co.; Green Bay; La Crosse; Madison; Milwaukee; Platteville; "Shaw" (probably Shawano) Co.

202. *Pero morrisonaria* H. Edwards May 28–July 9
Dane Co.; Door Co.; Florence Co.; Lake Katherine; Washburn Co.

203. *Pero marmorata* Grossbeck July 29–Aug. 9
Dane Co.; Platteville.

204. *Caripeta divisata* Walker June 23–Aug. 14
Door Co.; Florence Co.; Lake Katherine; N.E. Price Co.; Northern Highlands, Vilas Co.; Trout Lake; Wausau.

205. *Caripeta piniata* Packard May 26–Aug. 5
Lake Katherine; Northern Highlands; Trout Lake; Wausau.

206. *Caripeta angustiorata* Walker June 4–Aug. 6
American Legion State Forest, Oneida Co.; Florence Co.; Lake Katherine; Trout Lake, Vilas Co.; Washburn Co.; Wausau.

207. *Lambdina athasaria* Walker May 13–July 8
Florence Co.; Lake Katherine; Sauk City.

208. *Lambdina fiscellaria* Guenée July 10–Oct. 5
Bailey's Harbor; Columbia Co.; Dane Co.; Ephraim; Lake Katherine; Shanty Bay.

209. *Besma endropiaria* Grote and Robinson June 1–July 15
Bailey's Harbor; Boscobel State Nursery; Florence Co.; Lake Katherine; Madison; Milwaukee; Patton Lake; Sauk City.

210. *Besma quercivoraria* Guenée May 28–Aug. 19
Arlington; Dane Co.; Florence Co.; Green Bay; Griffith State Nursery; Lake Katherine; Madison; Neshkoro; Platteville; Sauk City.

211. *Cingilia catenaria* Drury Aug. 9–Oct. 2
Columbia Co.; Eau Claire; Lake Katherine; Madison; "Peaks Lake."

212. *Cingilia canosaria* Walker July 11–Oct. 10
Bailey's Harbor; Dousman; Lake Katherine; Wausau; Wood Co.

213. *Cingilia pellucidaria* Packard Sept. 7–Oct. 4
Lake Katherine.

214. *Sicya macularia* Harris June 5–Aug. 18
Bailey's Harbor; Door Co.; Florence Co.; Griffith State Nursery; Lake Katherine; Madison; Sauk City; Trout Lake.

215. *Deuteronomos magnarius* Guenée July 30–Nov. 11
Arlington; Bailey's Harbor; Brown Co.; DeForest; Green Bay; Kenosha Co.; Lake Katherine; Madison; Middleton; Milwaukee; "Peaks Lake"; Sturgeon Bay; Trout Lake.

216. *Apicia confusaria* Hübner June 4–Aug. 29
Bailey's Harbor; Brown Co.; Cedar Grove; Door Co.; Dousman; Griffith State Nursery; Madison; Marinette Co.; Milwaukee; Oconto Co.; Sauk City.

217. *Patalene puber* Grote and Robinson Aug. 7
Dane Co.

218. *Tetracis crocallata* Guenée May 29–July 8
Brown Co.; Door Co.; Florence Co.; Lake Katherine; Madison; Milwaukee; Sauk City.

219. *Tetracis cachexiata* Guenée Apr. 21–July 29
Bailey's Harbor; Door Co.; Florence Co.; Green Bay; Madison; Milwaukee; Patton Lake; Sauk City; Spooner.

220. *Abbottana clemataria* Abbott and Smith May 14–Sept. 26
Bailey's Harbor; Boscobel State Nursery; Door Co.; Florence Co.; Griffith State Nursery; Lake Katherine; Milwaukee Co.; Patton Lake; Sauk City; Wausau.

221. *Sabulodes thiosaria* Guenée May 29–June 30
Lake Katherine.

222. *Prochoerodes transversata* Drury June 18–Oct. 5
Bailey's Harbor; Ferry Bluff; Florence Co.; Lake Katherine; Madison; Milwaukee; "Peaks Lake"; Rusk Co.; Sauk City; Wausau.

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FOUR NEW SPECIES RECORDS OF *SIALIS* (MEGALOPTERA: SIALIDAE) FOR WISCONSIN

K. J. Tennessen

There has been very little collecting of adult Megaloptera in Wisconsin since Ross's work on the Sialidae in the 1930's, when he reported finding two species in this state, *Sialis mohri* and *S. velata.* While recording distribution data on the order Megaloptera during the summer of 1968, I found four additional species of *Sialis* that had not been previously recorded from the state. The identifications have been confirmed by Dr. Ross. The new records are as follows:

Sialis vagans Ross. Twelve males and six females of this species have been taken, as it appears to be quite common, especially in the north-central area. Collection dates range from June 2 in the south to June 20 in the north.

County Records—Clark, Dane, Forest, Polk, Price, Taylor, Washburn, Waukesha, Waushara.

Sialis itasca Ross. Three males were taken, and the species appears to be as widespread as *S. velata.* The collection dates, June 10 and 20, indicate that this species emerges comparatively late in the seasonal succession of species.

County Records—Bayfield, Florence, Jefferson.

Sialis infumata Newman. Only two males of this species have been collected, one each from two central counties, indicating that it may not be as common as the former species. The collection date was June 5.

County Records—Clark, Wood.

Sialis americana (Rambur). Three males and seven females were collected on June 12 near the Mississippi River in Grant County. The surrounding area was quite unique, like a lagoon, and therefore this species most likely does not occur much further inland due to a habitat restriction. Adults were present in fair abundance. The collection date suggests a comparatively late emergence period.

County Record—Grant.

In addition, the following new county records were found for the two previously reported species:

Sialis mohri Ross. Kenosha County, Racine County.

Sialis velata Ross. Winnebago County.

The specimens are in the University of Wisconsin collection. Future collecting, especially early in May and June, will undoubtedly discover new county records as larvae have been found in a large number of streams and lakes; but as there is yet no key separating the larvae, species determinations must rely on adults.

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The research was carried out when the author was an undergraduate student at the University of Wisconsin, Madison.

JUNCUS EFFUSUS. I. THE SITUATION IN WISCONSIN

Seymour H. Sohmer

Juncus effusus is a species with world-wide distribution (Weimark, 1946). It is a relatively hardy perennial and can withstand considerably more abuse than most of the other species in the genus. Postgalacial conditions in Wisconsin may have been ideal for colonizing elements of the species. Indeed, such was probably the case wherever land was uncovered by the melting ice. It is believed, in this regard, that colonizing elements from disjunct populations of the species may have entered Wisconsin after the last retreat of the ice (Iltis, 1968).

As would be expected of a species with a wide distribution, the variations of form in *Juncus effusus* are numerous. Many variations have been described for North America, and many more could probably be named. The difficulty and confusion here is the same as in other widely distributed species, in that there are as many opinions regarding the basis for the delimitation of these varieties as there are taxonomists involved. The hopeful goal in these situations is a compromise between taxonomic conservatives and radicals. Certainly there are more variations in this species that can be easily delimited from one another on a general and practical basis than Gleason (1952) would recognize, but probably less than the number of varietal names presently available. One should strive to avoid carrying the recognition of variations too far. In such a case the logical conclusion is ultimately to describe and name *all* variation present. This is not only cumbersome and impractical, but the same variation may not be present some years hence—even disregarding the destructiveness of man to his environment. A great deal of the individual variation may be due more to environmental differences than genetic ones. (Snogerup, 1963. Sohmer, unpublished). A method of dealing with such a situation is shown by Davidson and Dunn (1967).

The varietal names listed below are presently available to describe the variations of *Juncus effusus* in North America. It is pointed out that though some of these varietal names may not be valid, in the author's opinion, they will be used to describe the species in Wisconsin where applicable. The question of validity may be determined at a future date by systematic work now underway in the author's laboratory.

Var. *compactus* Lejeune et Courtois Fl. Belg. ii. 23 (1831), also see Fernald and Wiegand (1910).
Var. *conglomeratus* Engelm. in Gray, Manual, ed. 5, (537, 1867), also see Fernald and Wiegand (1910).
Var. *decipiens* Buchenau in Engler's Bot. Jahrb. Xii. 229 (1890), also see Fernald and Wiegand (1910).
Var. *exiguus* Fernald and Wiegand (1910).
Var. *gracilis* Hooker, Fl. Bor. Am. ii 190 (1840).
Var. *brunneus* Engelm., Trans. St. Louis Acad. ii. 491 (1868). According to Fernald and Wiegand (1910) *Juncus effusus* var. *hesperius* Piper is synonomous with this.
Var. *pacificus* Fernald and Wiegand (1910).
Var. *caeruleomontanus* St. John (1931).
Var. *solutus* Fernald and Wiegand (1910).
Var. *pylaei* (Laharpe) Fernald and Wiegand (1910).
Var. *costulatus* Fernald (1922).

In Wisconsin the species demonstrates a considerable amount of individual variation, principally within the variety *pylaei*. This variation, however, does not appear spatially related to given areas.

The information concerning the species in Wisconsin that will be presented here has come through study of the specimens available from the herbaria of the Universities of Wisconsin and Minnesota as well as the Milwaukee Public Museum. The variable characters measured were: culm length; number of flowers per inflorescence; length of bract subtending the inflorescence (but in the species appearing as a continuation of the culm); width of culm above the sheath; length of perianth parts; length of capsule; and length of seed. Figure 1 illustrates the distribution of the species in Wisconsin as revealed by the specimens mentioned above. There are reports from 45 counties. Among the specimens available the sepals were found to exceed the petals in most cases. The length of the former ranged from 1.9 mm (N. C. Fassett #22676, Chippewa County) to 3.9 mm (H. Brawn #69228, Forest County). The correlation between sepal and petal length is illustrated in figure 4. Figures 2 and 3 illustrate the occurrence of petal and sepal variability by county within the state.

There were no significant differences observed in the length or the shape of the seeds. They were found to vary between .5 and .6 mm in length and were generally fusiform.

The bracts varied between 6 cm (D. F. Grether #6855, Jackson County), and 38 cm (R. Melville #397). The latter was two-thirds the length of the culm itself.

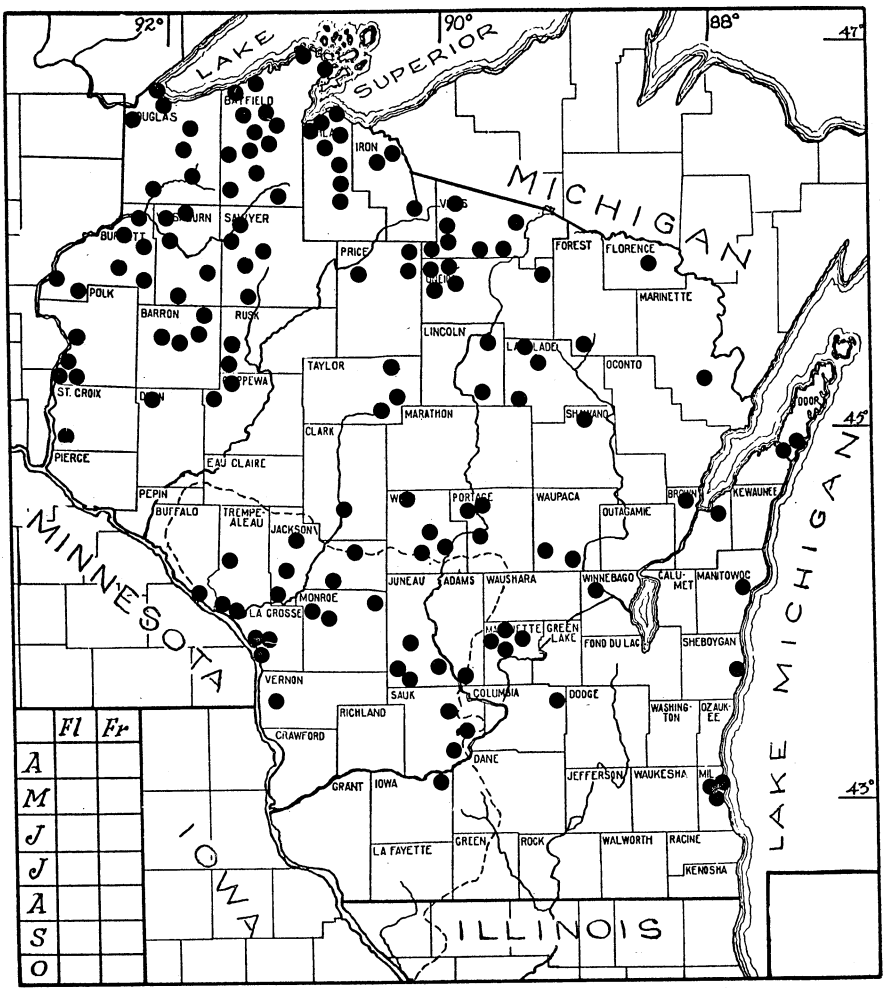
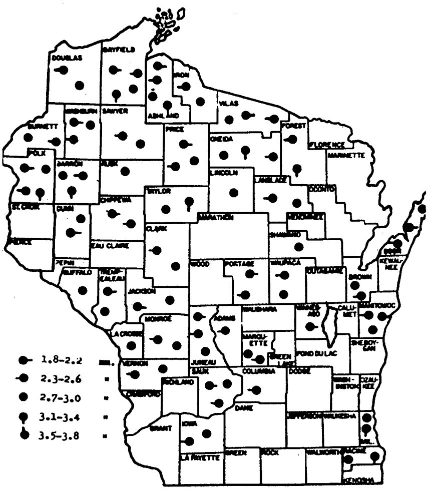


FIGURE 1. Distribution of *Juncus effusus* in Wisconsin. Each symbol represents an individual. Information from herbarium specimens of the University of Wisconsin, University of Minnesota, and the Milwaukee Public Museum. Map provided by H. Iltis.

The most striking variability is expressed in the length of these culms and the number of flowers per inflorescence. Only mature plants with intact culms and inflorescences were utilized. The length of these culms in mature specimens was found to vary from 25 cm (L. S. Cheney, #1068, Oneida County) to 118 cm (N. C. Fasset, #16190, Oneida County). It is interesting to not that the minimum and maximum lengths examined occurred in populations within



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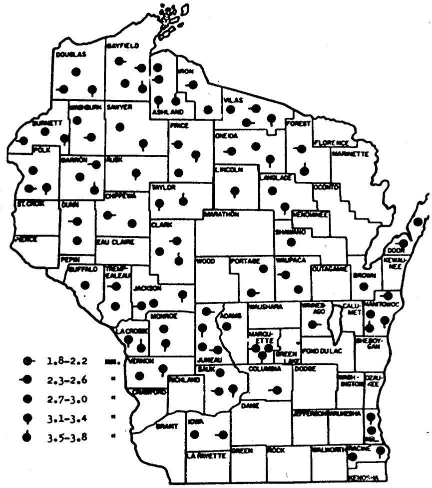

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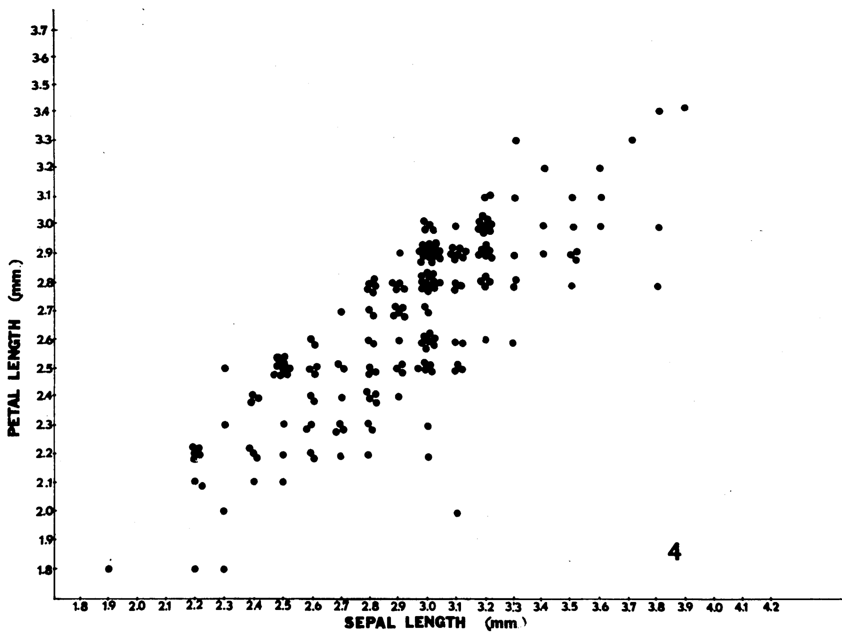


FIGURES 2 and 3. Spatial relationships of artificial groupings of petal and sepal lengths by county within Wisconsin. Each symbol represents one or more individuals within each county whose specific character attributes fall into the artificial groups shown. 2-petal lengths; 3-sepal lengths.

FIGURE 4. Scatter diagram illustrating the correlation between petal and sepal lengths. Each symbol represents an individual.

TABLE 1. VARIABILITY IN CULM LENGTH AND FLOWER NUMBERS IN WISCONSIN REPRESENTATIVES OF *Juncus Effusus*

CULM LENGTH (185 SPECIMENS)		FLOWER NUMBER (183 SPECIMENS)	
Length (in cm)	% of Plants	No. of Flowers	% of Plants
31	6	21	6
31 to 50	27	21 to 60	28
51 to 70	40	61 to 100	39
71 to 90	17	101 to 200	17
90	10	200	10

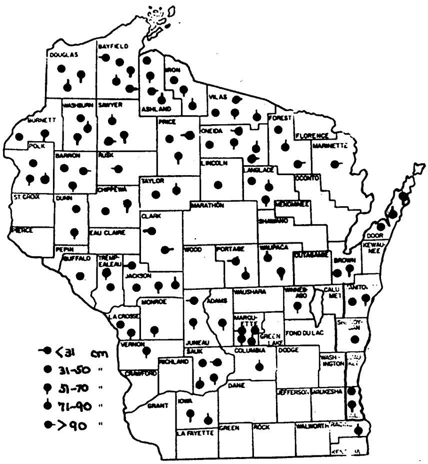
the same county. The number of flowers was found to vary from 11 (H. H. Iltis, #6882, Juneau County) to 370 (C. Gossel #1393, Clark County) per inflorescence. Table 1 illustrates the proportions of the individuals studied that fall into artificial groups based on culm length and flower number.

There does not appear to be a relationship between the number of flowers per inflorescence and location within the state. This is shown in Figure 6. Nor is there an apparent relationship between culm length and location. The shortest and tallest plants, on the basis of the specimens available, seem to have equal probability of occurring anywhere in the state. This is illustrated in Figure 5. The correlation between culm length and the number of flowers per inflorescence is illustrated in Figure 7.

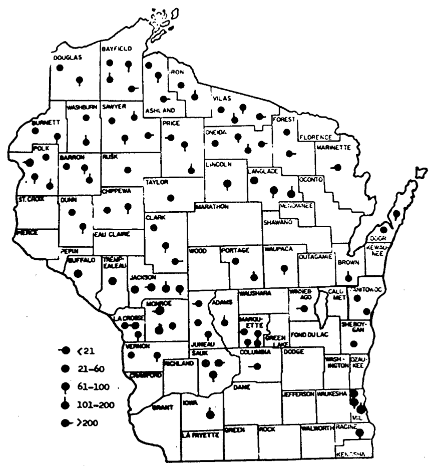
The varieties *pylaei* and *solutus* are found within the state, with the former much more frequent. There is also a dubius report for var. *costulatus* from Lincoln county. Most members of variety *solutus* appear in the northeastern part of the state, with scattered reports elsewhere. Some individual examples of *Juncus effusus* are shown in figures 8–12. Figure 13 represents the distribution of these varieties within the state by county.

SUMMARY

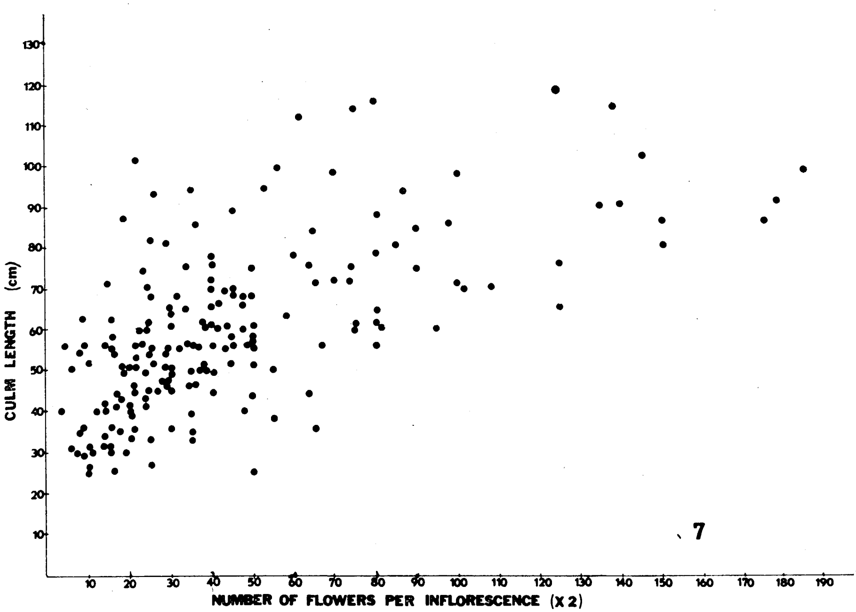
Specimens of *Juncus effusus* from the herbaria of the Universities of Wisconsin and Minnesota, and the Milwaukee Public Museum were studied with regard to the kind of variation present. It appears that two varieties are established in the state *(pylaei* and *solutus)* and possibly a third *(costulatus)*. There is a considerable amount of individual variation within the delimited varieties, which is not, however, apparently correlated with space within the state of Wisconsin.



5 Culm length



6 No. of flowers



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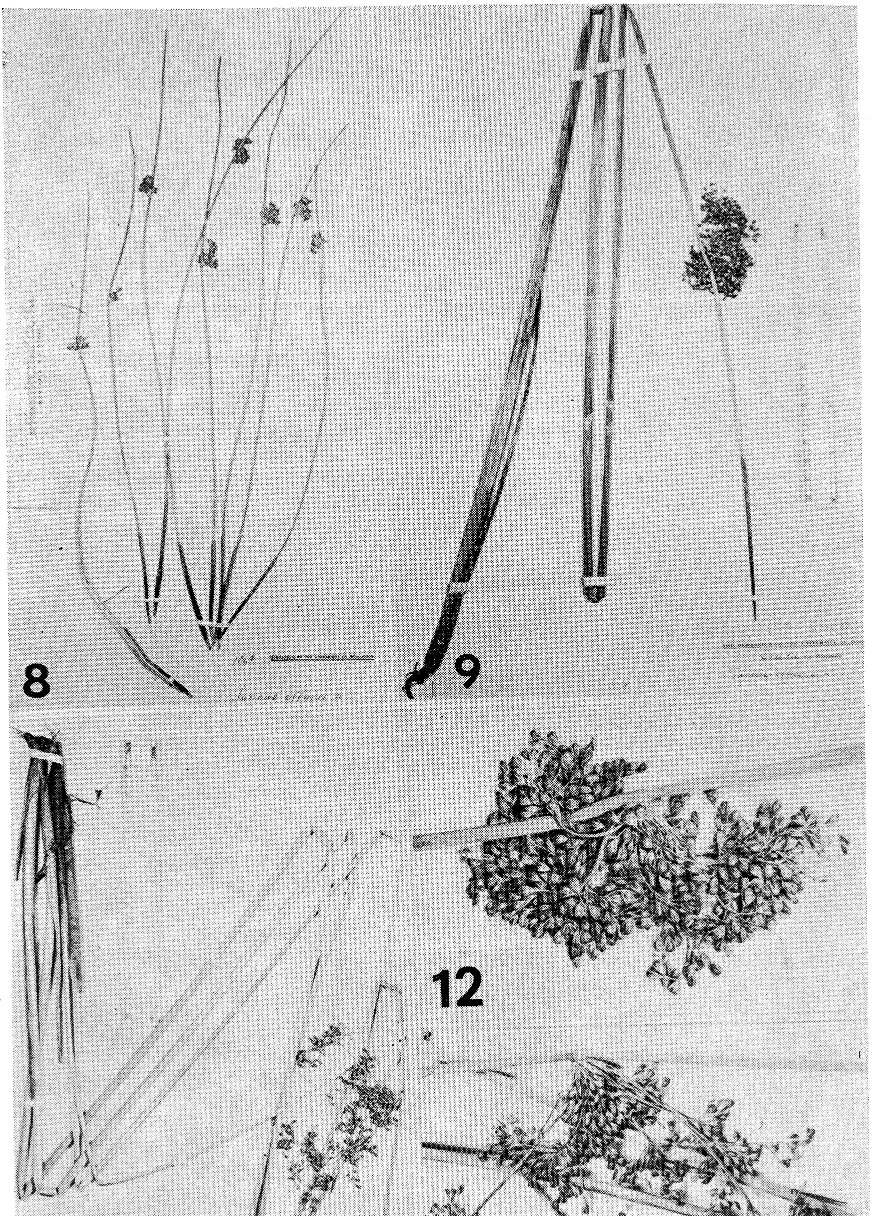
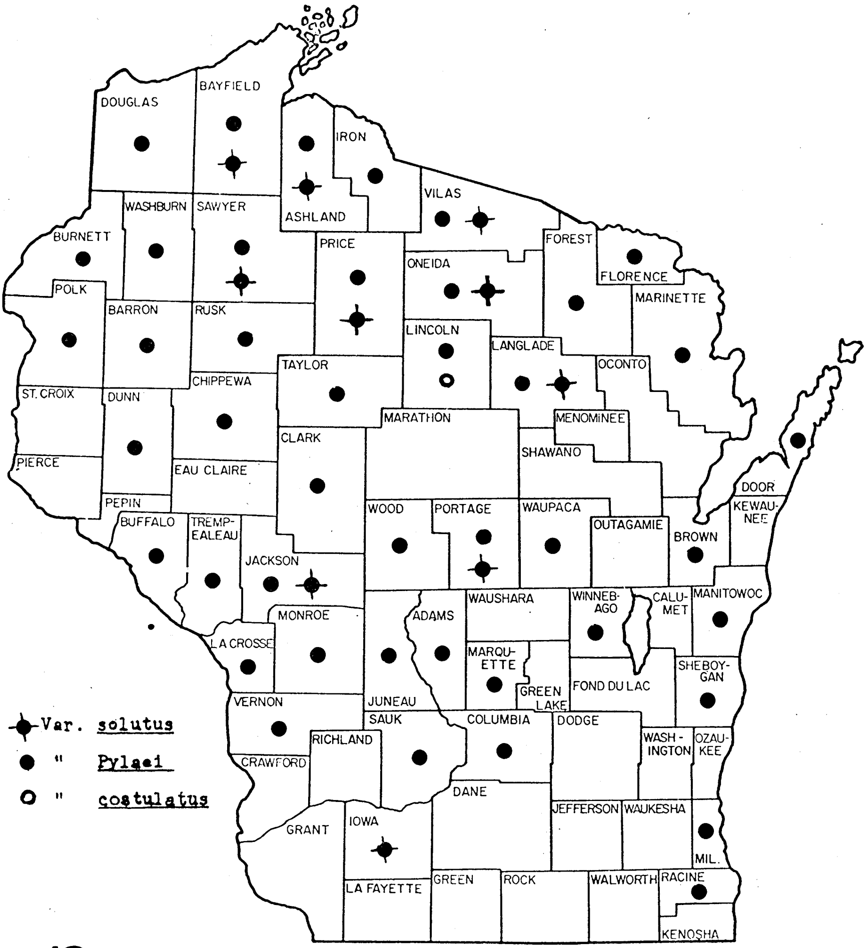
FIGURES 5 and 6. Spatial relationships of the variability present in the length of culm and number of flowers per inflorescence respectively. Each symbol represents at least one individual within each county whose specific character attribute falls into an artificial group as shown.
FIGURE 7. Scatter diagram illustrating the relationship between culm length and number of flowers per inflorescence. Each symbol represents an individual.



FIGURES 8–12. Examples of variation in *Juncus effusus* in Wisconsin. 8-Var. pylaei, L. S. Cheney #1068, Oneida Co.; 9-Var. solutus, N. C. Fassett #16190, Oneida Co.; 10-Var. solutus, N. C. Fassett #5699, Ashland Co.; 11-close-up of inuorescence of plant in figure 10; 12-close-up of inflorescence of plant in figure 9.



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Varieties of *Juncus effusus* in Wisconsin

FIGURE 13. Distribution of the varieties recognized in Wisconsin. Each symbol represents at least one report for the variety within a county.

ACKNOWLEDGEMENTS

The aid of Dr. H. H. Iltis, curator of the Herbarium, University of Wisconsin, Madison, in obtaining specimens for study and his advice are gratefully acknowledged. The monetary aid, in part, of the institutional Studies and Grants Committee of Wisconsin State University, La Crosse, is also gratefully acknowledged here. This aid has permitted the use of student assistance and helped defray the cost of an extensive field trip.

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GROWTH POTENTIAL OF WISCONSIN NATIVE PINES ON WEED-INVADED SOILS[1]

S. A. Wilde

"No knowledge can be rated as science unless it is anchored in mathematics."—René Descartes

A reasonably reliable prediction of the outcome of tree planting can seldom be made without an appraisal of the growth-depressing effect of competing ground vegetation. In most cases, the amount of water and nutrients taken away from trees by ground cover plants is closely related to their biomass, the oven-dry weight of tops and roots. Knowledge of this factor is essential for determination of the expected yield of trees to be planted, for establishment of suitable tree spacing, and for estimate of the cost of either chemical or mechanical eradication of weeds.

This paper reports a method for determination of the biomass of weed cover and the expected yield of plantations of Wisconsin native pines, *Pinus banksiana, P. resinosa,* and *P. strobus.*

Determination of Expected Site Index

The expected site index of the proposed plantation is established on the basis of determination of four soil constituents (Wilde *et al.,* 1964): fine earth (F), organic matter (H), available phosphorus (P_2O_5), and available potassium (K_2O). The site index of the stand or the average height of a stand at 50 years (I) is obtained by solution of the following simplified regression equation, adjusted to meet requirements of the three native pines of Wisconsin.

$$I = (8.1 + 0.2\ F\% + 2.3\ H\% + 0.03\ P_2O_5\ \text{lbs/a} + 0.01\ K_2O\ \text{lbs/a}) \times 3.4$$

An application of this equation may be illustrated by an appraisal of Plainfield sand, a widely distributed non-podzolic soil of Wisconsin glacial outwash. Let us assume that this soil of the proposed planting site has the following composition: fine earth (silt and clay particles)—9%, organic matter—2%, available P_2O_5

[1] Contribution from Soil Science Department, University of Wisconsin, in cooperation with and supported in part by the Wis. Dept. of Natural Resources. Publication approved by the Director of the Wis. Agr. Exp. Sta., Madison, Wis.

—40 pounds per acre, and available potassium—100 pounds per acre. Consequently:

$$I = (8.1 + 0.2 \times 9 + 2.3 \times 2 + 0.03 \times 40 + 0.01 \times 100) \times 3.4 = 56.8 \text{ feet}$$

The site index corresponds to definite yields of timber produced at various ages by different tree species. Thus, for the calculated site index of about 57, the volumes expected at the end of a short, 40-year rotation would be 30 cords for jack pine, 34 cords for red pine, and at best 20 cords per acre for white pine. Because 0.7 cords per acre is the minimum average annual increment, promising under Wisconsin conditions a reasonable financial return, the calculation indicates that the analysed soil has a too low productive potential for planting white pine.

The equation under discussion was derived from analyses of non-phreatic sandy soils of Wisconsin supporting about 300 plantations of jack pine, red pine, and white pine of different site indices and of age range from 15 to 37 years (Wilde *et al.*, 1965). The disclosure of an intimate correlation between growth of forest stands and physico-chemical properties of soils, rendered by this equation, presents a remarkable by-product of recent progress in soil analysis, forest mensuration, and statistics.

The degree of the equation's reliability can be inferred from Tables 1 and 2, incorporating the average results of soil and timber analyses published in 1965 (Lit. cit.). A substitution of these results into the equation and subsequent comparison of calculated site indices with those reported in yield tables (Wackerman *et al.*, 1929, for jack pine; Wilde *et al.*, 1964 for red pine; Gevorkiantz

TABLE 1. AVERAGE STATE OF SOIL FERTILITY FACTORS OF SOILS SUPPORTING JACK PINE, RED PINE, AND WHITE PINE OF DIFFERENT SITE INDICES (AFTER WILDE *et al.*, 1965).

Tree Species and Site Index	Reaction pH	Silt + Clay Percent	Org. Matter Percent	Avail. P_2O_5 Lbs./Acre	Avail. K_2O Lbs./Acre
Jack pine, low	4.9	6.9	0.86	21.0	54.8
Jack pine, medium	5.1	9.4	1.80	62.8	80.0
Jack pine, high	5.0	10.0	2.10	72.0	91.4
Red pine, low	5.0	7.3	1.22	47.2	77.8
Red pine, medium	5.1	8.5	1.37	59.0	87.5
Red pine, high	5.1	12.5	2.11	85.2	134.2
White pine, medium	5.1	13.7	2.90	51.0	70.0
White pine, high	4.8	26.7	3.20	83.0	90.0

TABLE 2. AVERAGE GROWTH OF JACK PINE, RED PINE, AND WHITE PINE PLANTATIONS ON SOIL OF DIFFERENT PRODUCTIVITY RATINGS; AS GIVEN IN TABLE 1 (AFTER WILDE *et al.*, 1965).

TREE SPECIES AND SITE QUALITY	AGE YRS.	AVE. HT. FT.	HT.: AGE INS.	AVE. DBH INS.	STEMS NO./A.	BASAL AREA SQ. FT./A.	VOLUME CU. FT./A.
Jack pine, low	22	22.0	12	3.4	1,241	74	473
Jack pine, medium	24	30.5	15	4.1	1,177	107	1,106
Jack pine, high	23	38.6	20	4.6	1,029	117	1,589
Red pine, low	23	21.3	11	4.0	1,282	101	688
Red pine, medium	21	27.5	15	4.8	978	117	1,300
Red pine, high	20	32.9	19	5.1	1,054	136	1,960
White pine, medium	24	28.6	14	5.7	648	118	1,420
White pine, high	24	39.3	19	6.6	627	136	2,257

and Zon, 1930, for white pine) give a picture of a rather astonishing accuracy (Table 3).

Nearly all deviations of calculated values from those given in the yield tables are well within experimental error. The maximum deviation of the calculated site index for jack pine of low site quality (3 feet) is due to the deficiency of organic matter in soils of this group and the presence of a large fraction of nutrients in the form of silicate minerals which are decomposable by mycorrhizal rootlets, but not by weak extracting solutions (Wilde and Iyer, 1962; Spyridakis *et al.*, 1967).

DETERMINATION OF THE BIOMASS OF WEED COVER

The average weight of tops and roots of weeds is determined by excavating entire plants on several 1/10,000 acre plots (2.1 by 2.1 foot squares). Sampling is done at random, and the number of samples required for obtaining an acceptable standard deviation depends on type of soil and nature of ground cover. In many instances a half dozen sampled quadrats are sufficient for an area as large as 40 acres.

The obtained information facilitates in reaching a decision on tree spacing most advantageous with regard to potential site index, biomass of weeds, species and age of trees to be planted, and other conditions (Wilde *et al.*, 1968).

Next, the tree planter must establish the approximate age of the plantation (n) at which the biomass of weeds (b) will be reduced to the harmless level of less than 2 tons per acre. The total of the

TABLE 3. RELATION BETWEEN THE PREDICTED AND ACTUAL SITE INDICES.

Tree Species	Site Indices: Calculated from the Equation	Site Indices: Determined from the Yield Tables	Deviation in 50 Year Height Growth Feet
Jack pine	43	46	−3
	57	55	+2
	61	62	−1
Red pine	49	48	+1
	53	55	−2
	65	65	0
White pine*	67	69	−2
	82	82	0

*A large number of white pine of low site quality were underplantings suppressed in growth by overhead canopy of aspen and were excluded from statistical analysis. As should be expected, both the calculated and actually determined height growth of white pine plantations on fertile soils by far exceeded the maximum of the yield tables obtained largely on the basis of indigenous stand of this tree (75 feet at the age of 50 years), which undoubtedly lost a fraction of their height increment in the struggle with weeds and volunteer trees.

biomass (G), present in the plantation through the years, is then determined from the formula:

$$G = 0.7 \text{ bn}$$

For trees with heavy crowns, such as red pine, growing on fertile soils at a spacing of 4 by 4 feet, the n period is about 15 years. However, at 6 by 6 foot spacing this period is extended to approximately 25 years.

With weed cover of blueberries, sweet fern, and other heath plants weighing 10 metric tons per acre, total biomass of a 4 by 4 foot red pine plantation would be:

$$G = 10{,}000 \times 0.7 \times 15 = 105{,}000 \text{ kg/a}$$

A similar calculation for a red pine plantation, established at a spacing of 6 by 6 feet, gives the active weed biomass of 175,00 kg/a.

DETERMINATION OF THE LOSS OF TIMBER VOLUME DUE TO COMPETITION OF WEED COVER

Evapotranspiration of weeds consumes under Wisconsin conditions approximately 85 kg of water per kilogram of oven-dry biomass (Wilde *et al.*, 1968). On the other hand, production of one kilogram of merchantable wood, having specific gravity of 0.32–0.35, requires close to 1,200 kg of transpiration water (Wilde, 1967;

Shaw *et al.*, 1968). Therefore, the loss of timber (L) is expressed by the formula:

$$L = \frac{85\ G}{1200} = 0.07\ G$$

Assuming active weed biomass of a 6 by 6 foot red pine plantation to be equal to 175 m.t. per acre, the loss of timber would be:

$$L = 175{,}000 \times 0.07 = 12{,}250\ kg/a$$

This weight of oven-dry wood of specific gravity 0.35 approaches 14 cords.

In the event calculated site index of the proposed plantation is 60, the expected maximum yield of fully stocked stand at the end of a 40-year rotation should be 40 cords per acre. Actually in our case the volume is likely to be 40 — 14 or 26 cords.

The given calculation, featuring 35% loss of merchantable timber, is based on observations in Wisconsin. In this state tree planting on weed-invaded soils was usually accomplished by plowing deep and wide furrows which greatly reduce adverse effects of weed competition. On the other hand, losses of timber volume exceeding 50% were recorded in our study in plantations established without adequate ground preparation.

Competing vegetation deprives trees not only of water but also of nutrients. However, this loss is of a temporary nature; suppression of weeds by tree crowns in time returns nutrients to the plantations cycle via mineralization of plant remains.

Summary

The productive potential of planting sites for *Pinus banksiana*, *P. resinosa*, and *P. strobus* is predicted on the basis of soil analysis, simplified regression equation, and biomass of weeds. Under local conditions pine plantations require about 1,200 kg of water to produce 1 kg of merchantable wood of approximate specific gravity of 0.35, whereas evapotranspiration of ground vegetation consumes circa 85 kg of water per kg of oven-dry tissues. In turn, each kg of weed biomass present in the plantation through the years reduces production of merchantable wood by 0.07 kg. At this rate, plantations established on soils with a heavy cover of heath plants may suffer within a 40-year rotation a loss of timber exceeding 15 cords per acre.

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CORIXIDAE (WATER BOATMEN) OF WISCONSIN[1]

William L. Hilsenhoff[2]

In 1948 H. B. Hungerford published his monumental monograph on the Corixidae of the Western Hemisphere, which included a monograph on the *Trichocorixa* by R. I. Sailer. In it are keys, descriptions and the recorded distribution for all the known species. Numerous collection records were listed from the four states that border Wisconsin, especially from Michigan and Minnesota, but records from Wisconsin were meager, with only 23 species reported from this state.

In November and December of 1965, large aggregates of corixids were collected from the Wisconsin River and its tributaries. These were mixtures of several species, many of which had not previously been reported from Wisconsin. Subsequent sampling showed that these aggregates occurred only in the late fall, when corixids apparently congregate in the larger streams to spend the winter. These aggregates often contained 15 or more species, with one collection from the St. Croix River in Douglas County on November 20, 1968, containing 23 different species.

Since it was obvious that Wisconsin's Corixidae were largely unknown, an effort was made to collect Corixidae from all areas of the state in 1968, with a special emphasis on collecting from larger streams in October and November to take advantage of the large aggregations of wintering individuals. Collections were made in all counties, but some counties were sampled more thoroughly than others, or were sampled at times more advantageous for collecting corixids. From 1962 through 1968, nearly 22,000 corixids were collected and identified, and of the 47 species that were collected, 25 are new records for the state. All specimens were preserved in 70% ethanol and have been deposited in the University of Wisconsin Insect Collection, along with detailed collection data.

Keys to the Wisconsin species, maps of their distribution, comments on their distribution, abundance, and identification, and a

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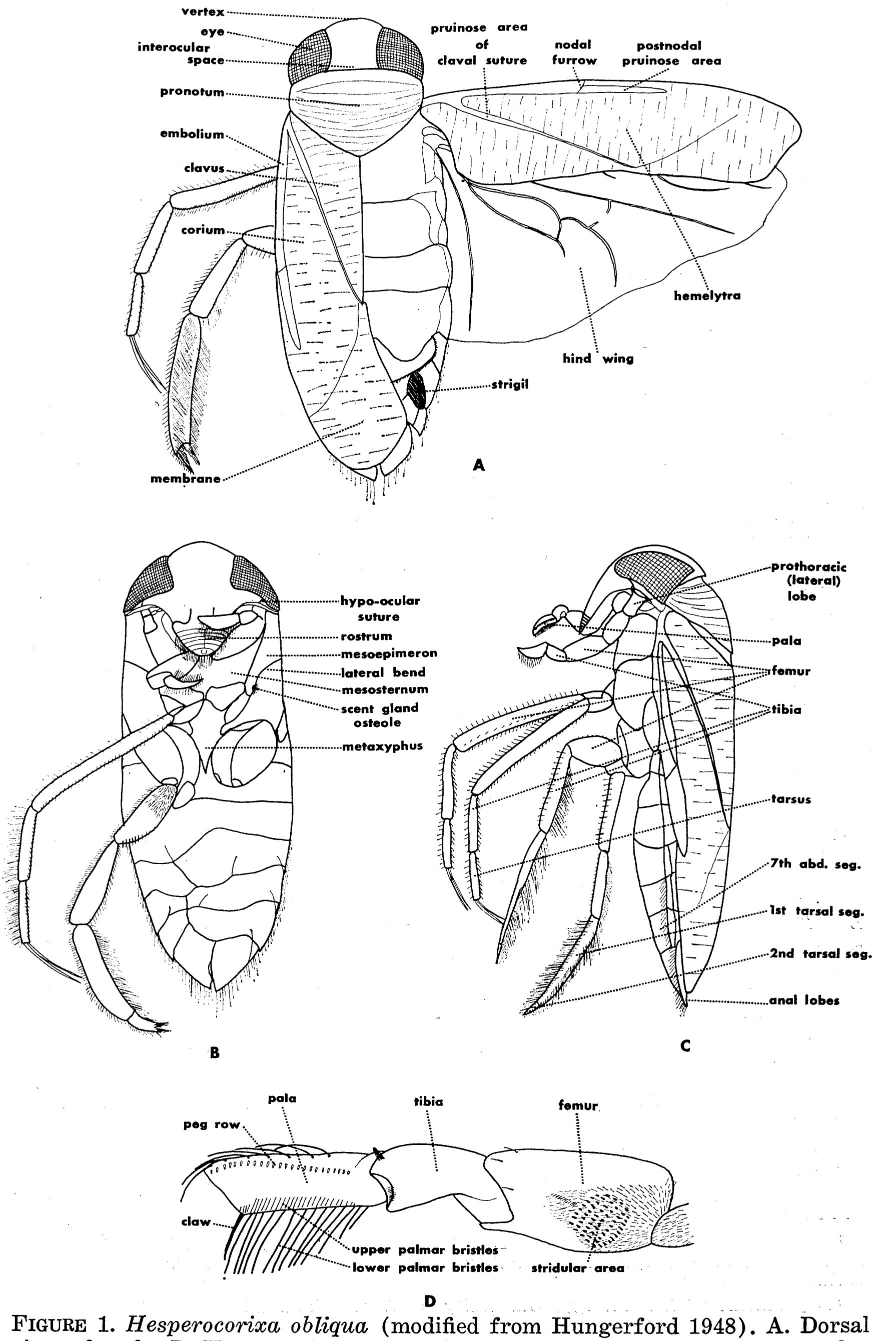

FIGURE 1. *Hesperocorixa obliqua* (modified from Hungerford 1948). A. Dorsal view of male. B. Ventral view of male. C. Lateral view of female. D. Foreleg of male.

summary of the collection records are reported below. The keys are adapted from those of Hungerford (1948), Sailer (1948), and Brooks and Kelton (1967). Figure 1 illustrates the morphological terms used in these keys. Records of previous collections from Wisconsin and from its neighboring states are summarized from Hungerford (1948) and Sailer (1948), since there have been no records published for these states since 1948. Descriptions and illustrations of the various species are not included, because Hungerford and Sailer have thoroughly described and illustrated all of the species.

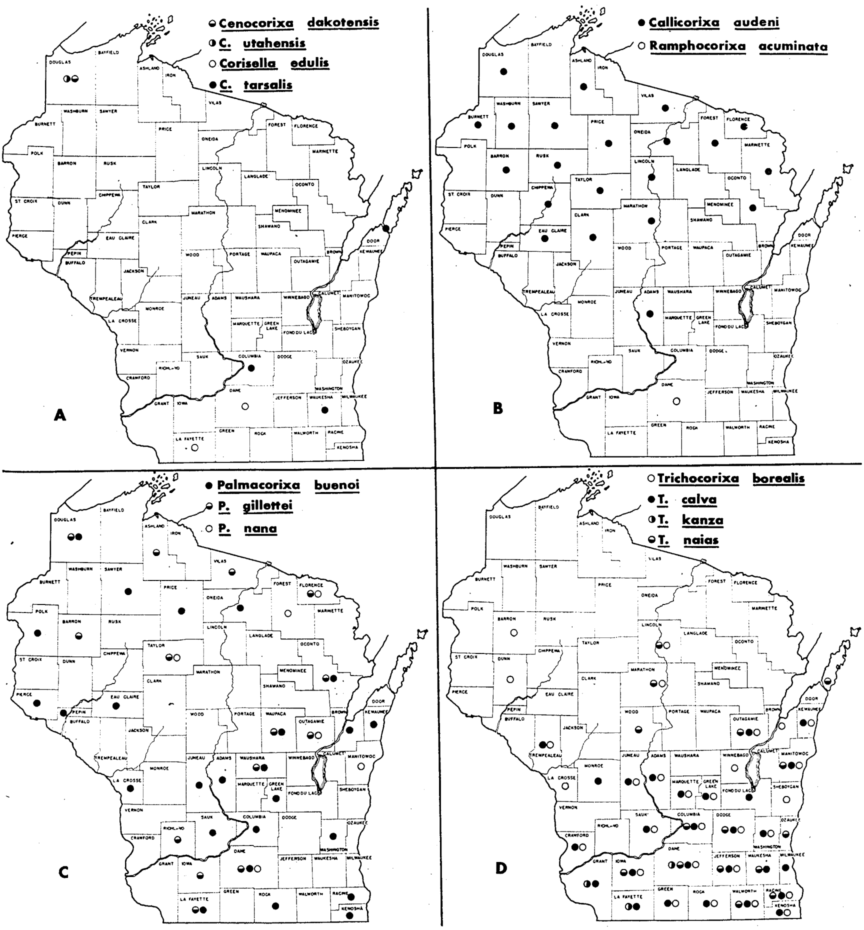

FIGURE 2. Collections of Wisconsin Corixidae, 1962–1968, of the genera *Callicorixa, Cenocorixa, Corisella, Palmacorixa, Ramphocorixa,* and *Trichocorixa.*

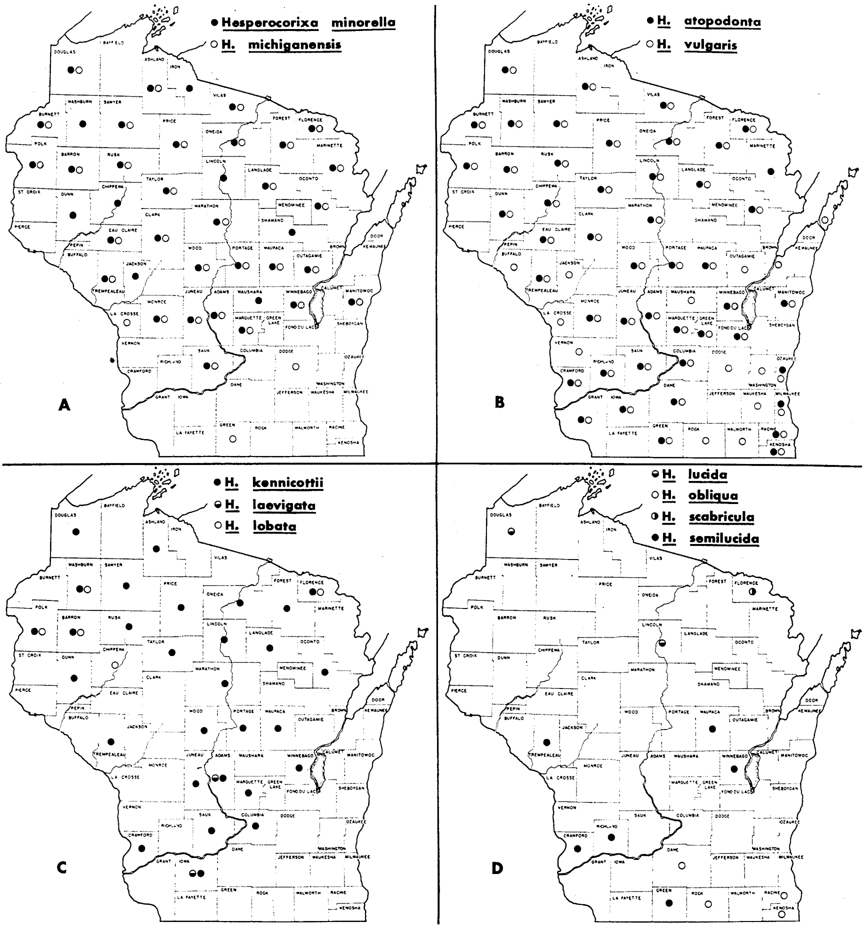

FIGURE 3. Collections of Wisconsin Corixidae, 1962–1968, of the genus *Hesperocorixa.*

KEY TO WISCONSIN GENERA

1. Rostrum without transverse grooves; pronotum without transverse dark bands ________________________________ *Cymatia*
   Rostrum with transverse grooves; pronotum with transverse bands although they may be indistinct ____________________ 2
2. Entire hemelytral pattern usually effaced; upper surface of male pala deeply incised; vertex of male acuminate; both sexes with palar claw serrate at base; less than 5.5 mm long _*Ramphocorixa*
   Hemelytral pattern distinct, although limited areas may be effaced in some species ___________________________________ 3

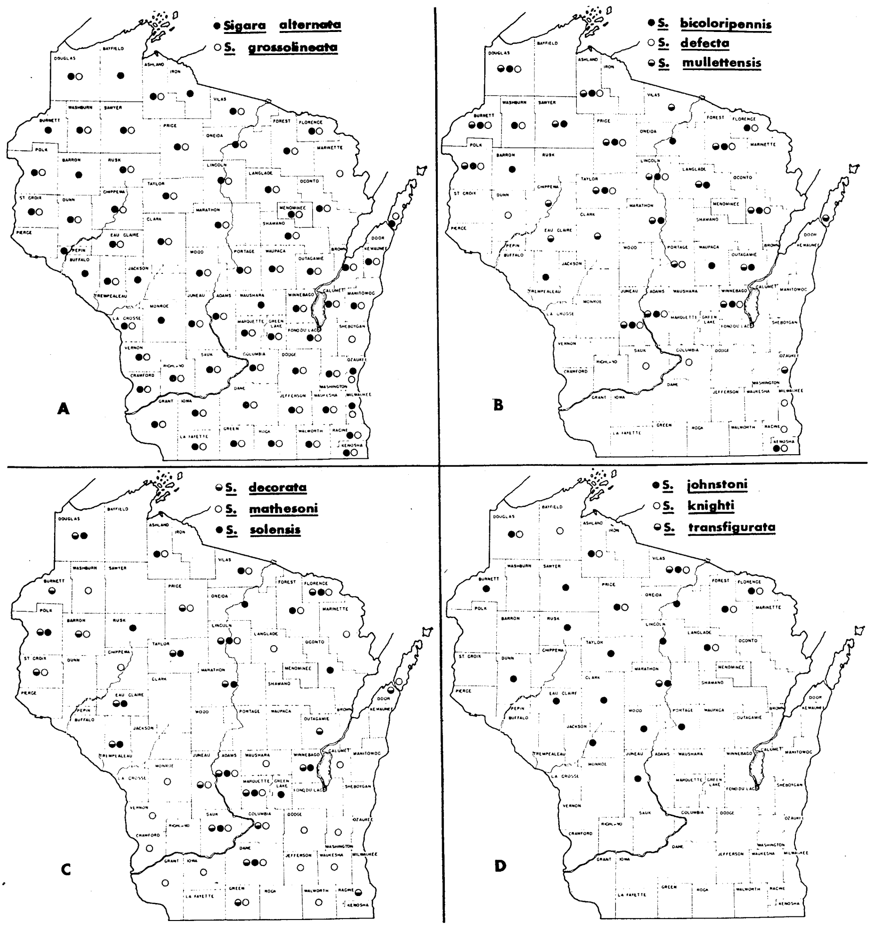

FIGURE 4. Collections of Wisconsin Corixidae, 1962–1968, of the genus *Sigara*.

3. Small shining corixids, the males with sinistral asymmetry; apex of clavus not, or scarcely, exceeding a line drawn through costal margins at nodal furrows ______________________ *Trichocorixa*
Male asymmetry dextral; apex of clavus plainly exceeding a line drawn through costal margins at nodal furrows ____________ 4
4. Pruinose area at base of claval suture short and broadly rounded at apex, usually about ⅔ as long as postnodal pruinose area; prothoracic lobe truncate ____________________ *Hesperocorixa*
Pruinose area at base of claval suture narrowly rounded or pointed at apex and almost as long as postnodal pruinose area; prothoracic lobe rounded ______________________________ 5

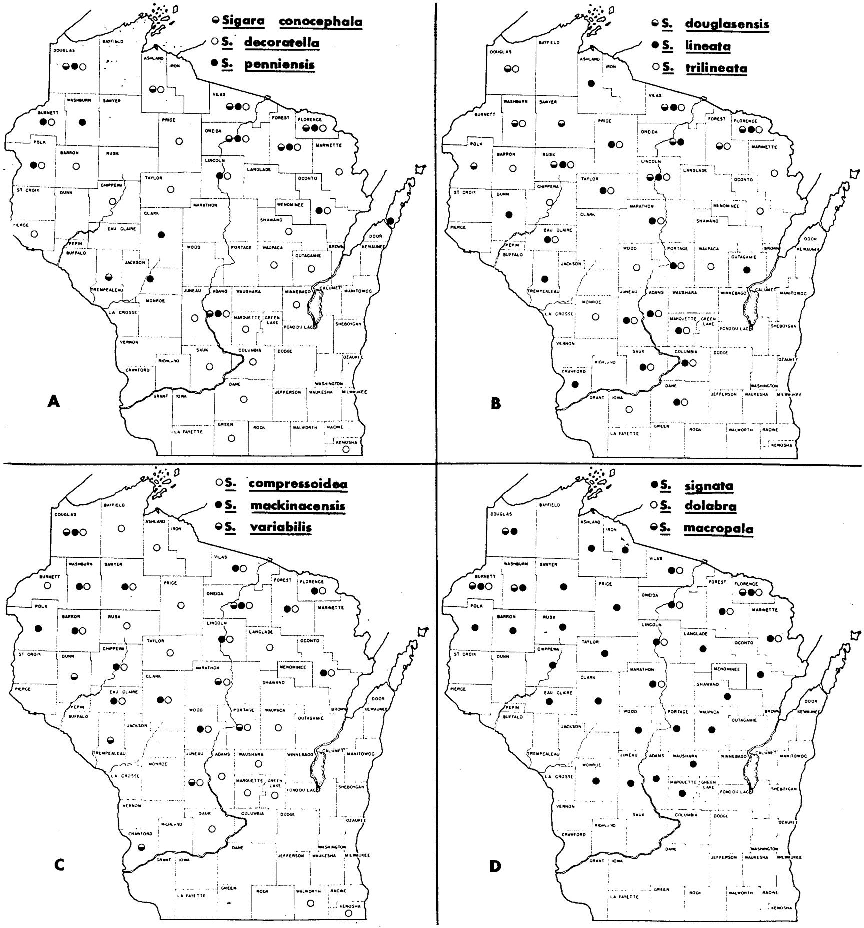

FIGURE 5. Collections of Wisconsin Corixidae, 1962–1968, of the genus *Sigara*.

5. Markings on clavis transverse, those on corium transverse, longitudinal, or reticulate ______________________________6
   Markings on clavus and corium narrow and broken, usually open reticulate with many interconnections ______________7
6. Corial pattern transverse and with little contrast; male strigil absent; male pala with two rows of pegs __________*Callicorixa*
   Corium usually with contrasting pattern, either transverse, longitudinal, or reticulate; male strigil present; male pala with one row of pegs (2 exceptions) ______________________*Sigara*

7. Rear margin of head sharply curved, embracing a very short pronotum; interocular space much narrower than the width of an eye -- *Palmacorixa*
   Rear margin of head gently curved; interocular space about equal to the width of an eye ------------------------------ 8
8. Smooth, shining insects; male pala triangular; prothoracic lobe tapering to a narrowly rounded apex ---------------- *Corisella*
   Rastrate, hairy species ------------------------------------ 9
9. Eyes protuberant with inner anterior angles broadly rounded; postocular space broad ---------------------------- *Dasycorixa*
   Eyes normal; postocular space narrow ------------- *Cenocorixa*

Callicorixa White 1873

Two species of *Callicorixa* probably occur in Wisconsin, but only *C. audeni* was collected. The second species, *C. alaskensis* Hungerford 1926, has been recorded from Michigan, Pennsylvania, New York, and New Hampshire to the east of Wisconsin, and from Utah, Montana, and Wyoming to the west. It has also been found in most of the Canadian Provinces.

Key to Wisconsin species

1. First tarsal segment of hind leg unicolorous --------- *C. audeni*
   First tarsal segment of hind leg infuscated on distal third ---- -- *C. alaskensis*

Callicorixa audeni Hungerford 1928

Distribution and abundance: Common in the northern half of the state (Fig. 2B), with three being collected as far south as Adams County.

Identification: This species can be separated from other *Callicorixa* that may occur in Wisconsin by the lack of a dark spot on the first tarsal segment of the hind leg. The black prothoracic lobe of almost all Wisconsin specimens serves to separate this species from all other Wisconsin corixids. The females may be most easily confused with female *Sigara alternata* (which may have a smoky prothoracic lobe), but can be distinguished by their longer, more acutely pointed metaxyphus, by a slightly wider mesoepimeron, and by light markings that often extend all the way across the corium.

Collection Records: Adams Co. 1 ♂, 2 ♀; Ashland Co. 19 ♂, 12 ♀; Barron Co. 1 ♀; Burnett Co. 1 ♂; Chippewa Co. 1 ♀; Clark Co. 1 ♂, 1 ♀; Douglas Co. 8 ♂, 7 ♀; Eau Claire Co. 1 ♂, 2 ♀; Florence Co. 54 ♂, 65 ♀; Forest Co. 17 ♂, 20 ♀; Lincoln Co. 14 ♂, 30 ♀;

Marathon Co. 15 ♂, 22 ♀; Marinette Co. 2 ♀; Oconto Co. 1 ♂; Oneida Co. 5 ♂, 8 ♀; Price Co. 10 ♂, 14 ♀; Rusk Co. 6 ♂, 10 ♀; Sawyer Co. 4 ♂, 4 ♀; Taylor Co. 9 ♂, 9 ♀; Vilas Co. 12 ♂, 9 ♀; Washburn Co. 1 ♀. *Totals: 398* individuals, *71* collections, *21* counties.

Previous Records: None. Recorded from Michigan and Minnesota.

Cenocorixa Hungerford 1948

Only two species, *C. dakotensis* and *C. utahensis*, have been collected in Wisconsin, but both are rare. A third species, *C. bifida* (Hungerford) 1926, has been collected nearby in Minnesota and could occur in Wisconsin. Both Wisconsin records were from large lakes in the extreme northwest, and perhaps intensive collecting of such habitats would yield additional specimens and specimens of *C. bifida* as well.

KEY TO WISCONSIN SPECIES

1. Last tarsal segment of hind leg black or dark brown; hind femur pubescent for about one-third its length .... *C. dakotensis*
   Last tarsal segment pale; hind femur pubescent for at least 40% of its length 2
2. Shining costal area just anterior to nodal furrow longer than middle tarsus; male peg row entire .... *C. bifida*
   Shining costal area just anterior to nodal furrow equal to middle tarsus in length; peg row of male pala divided .... *C. utahensis*

Cenocorixa dakotensis (Hungerford) 1928

Distribution and Abundance: Apparently rare in the western part of the state (Fig. 2A).

Collection Records: Douglas Co. 1 ♀. *Totals: 1* individual, *1* collection, *1* county.

Previous Records: None. Reported from Illinois and Minnesota.

Cenocorixa utahensis (Hungerford) 1925

Distribution and Abundance: Apparently rare in the western part of the state (Fig. 2A).

Collection Records: Douglas Co. 1 ♂. *Totals: 1* individual, *1* collection, *1* county.

Previous Records: None. Reported from Iowa.

Corisella Lundblad

Two species have been collected in Wisconsin, and it is unlikely that any others occur in this state. The members of this genus are rare in Wisconsin.

Key to Wisconsin species

1. Less than 6.5 mm long; hind tarsus embrowned ------*C. tarsalis*
   More than 6.5 mm long; hind tarsus pale; pattern of clavis effaced at inner, basal angle -------------------------*C. edulis*

Corisella edulis (Champion) 1901

Distribution and Abundance: Rare in Wisconsin, it has been collected only in the southwestern part of the state (Fig. 2A).

Collection Records: Dane Co. 1 ♀; Lafayette Co. 2 ♂, 6 ♀. *Totals: 9* individuals, *2* collections, *2* counties.

Previous Records: None. Reported from Iowa and Minnesota.

Corisella tarsalis (Fieber) 1851

Distribution and Abundance: Rare in Wisconsin, this species appears to be confined to the southern two-thirds of the state (Fig. 2A).

Collection Records: Columbia Co. 1 ♂, 2 ♀; Door Co. 1 ♂; Waukesha Co. 2 ♀. *Totals: 6* individuals, *4* collections, *3* counties.

Previous Records: "Parco" (probably Portage Co.) 1 ♀. No records from adjoining states.

Cymatia Flor 1860

The only described North American species, *C. americana* Hussey 1920, has not been found in Wisconsin but should occur in the northern half of the state. It has been reported in Michigan and Minnesota.

Dasycorixa Hungerford 1948

One species, *D. hybrida* (Hungerford) 1926, has been collected in Minnesota and could occur in the northwestern part of Wisconsin.

Hesperocorixa Kirkaldy 1908

Twelve species of *Hesperocorixa* have been collected in Wisconsin, eleven in this present study. Four of these species are very common. One additional species, *H. nitida* (Fieber) 1851, probably occurs in Wisconsin, since it has been found in all four of the neighboring states. Its distribution is generally southern, and it would most likely be found in the southern counties of the state.

KEY TO WISCONSIN SPECIES

1. Mesoepimeron at level of scent gland osteole as broad or broader than the lateral lobe of the prothorax ---------- 2
   Mesoepimeron plainly narrower than the lateral lobe of the prothorax ---------- 6
2. Mesoepimeron at level of scent gland osteole about equal in width to the lateral lobe of the prothorax; a conspicuous V-shaped yellow band bordering the apex of the corium ---------- *H. atopodonta*
   Mesoepimeron plainly broader than the prothoracic lobe ---------- 3
3. 8 mm long or longer; tip of metaxyphus blunt or truncated ---------- *H. kennicottii*
   7.5 mm long or less; tip of metaxyphus pointed ---------- 4
4. Dorsal surface of hind femur with two stout spines ---------- *H. minorella*
   Dorsal surface of hind femur armed with many spines ---------- 5
5. Corial pattern crossbanded ---------- *H. michiganensis*
   Corial pattern in longitudinal series ---------- *H. semilucida*
6. Pattern of hemelytra reticulate; pronotum nonrastrate ---------- *H. laevigata*
   Pattern of hemelytra not reticulate; pronotum rastrate ---------- 7
7. Pronotal disc short, less than half as long as wide ---------- *H. scabricula*
   Pronotal disc more than half as long as wide ---------- 8
8. Color pattern of corium effaced laterally ---------- *H. lucida*
   Color pattern normal ---------- 9
9. Pale bands of corium beyond hemelytral suture forming slender transverse series. Membrane not plainly separated from corium ---------- *H. vulgaris*
   Pala bands of corium beyond hemelytral suture in an interrupted transverse series. Membrane may be distinctly separated from corium ---------- 10
10. Hind femur with a row of about 10 spines ventrally on distal portion of rear margin ---------- *H. nitida*
    Hind femur with only about 6 spines on rear margin ---------- 11
11. Corium and membrane not separated by a coalescing of the pale figures; upper distal angle of male pala acutely, obliquely produced ---------- *H. obliqua*
    Corium and membrane separated by a coalescing of the pale figures ---------- 12

12. Interocular space almost equal to the width of an eye; metaxyphus as broad as long; male pala rounded at tip; male strigil oval -- *H. lobata*
    Interocular space much narrower than width of an eye; metaxyphus longer than broad; male pala truncated at tip; male strigil very long ------------------------------ *H. interrupta*

Hesperocorixa atopodonta (Hungerford) 1927

Distribution and Abundance: This species is found throughout Wisconsin (Fig. 3B) and is very common in the northern two-thirds of the state.

Identification: The mesoepimeron that is the same width as the prothoracic lobe and the conspicuous V-shaped yellow band bordering the apex of the corium readily distinguish this species. The male pala with the last peg out of line is also distinctive.

Collection Records: Adams Co. 14 ♂, 11 ♀; Ashland Co. 26 ♂, 30 ♀; Barron Co. 1 ♂, 1 ♀; Burnett Co. 9 ♂, 2 ♀; Chippewa Co. 16 ♂, 15 ♀; Clark Co. 5 ♂, 4 ♀; Columbia Co. 1 ♂, 2 ♀; Crawford Co. 2 ♂; Dane Co. 12 ♂, 9 ♀; Douglas Co. 32 ♂, 33 ♀; Dunn Co. 7 ♂, 8 ♀; Eau Claire Co. 29 ♂, 33 ♀; Florence Co. 89 ♂, 92 ♀; Fond du Lac Co. 2 ♂, 4 ♀; Forest Co. 20 ♂, 22 ♀; Grant Co. 1 ♀; Green Co. 1 ♂, 1 ♀; Green Lake Co. 1 ♀; Iowa Co. 5 ♂, 3 ♀; Juneau Co. 65 ♂, 93 ♀; Kenosha Co. 1 ♂; Langlade Co. 1 ♂; Lincoln Co. 77 ♂, 58 ♀; Manitowoc Co. 1 ♀; Marathon Co. 45 ♂, 36 ♀; Marinette Co. 1 ♂, 2 ♀; Marquette Co. 1 ♀; Milwaukee Co. 5 ♂, 5 ♀; Monroe Co. 1 ♂, 4 ♀; Oconto Co. 7 ♂, 12 ♀; Oneida Co. 9 ♂, 10 ♀; Ozaukee Co. 1 ♂; Polk Co. 5 ♂, 8 ♀; Portage Co. 9 ♂, 12 ♀; Price Co. 25 ♂, 39 ♀; Racine Co. 1 ♂; Richland Co. 3 ♂, 5 ♀; Rusk Co. 40 ♂, 45 ♀; Sauk Co. 2 ♂, 4 ♀; Sawyer Co. 8 ♂; Taylor Co. 9 ♂, 9 ♀; Trempealeau Co. 42 ♂, 36 ♀; Vilas Co. 15 ♂, 16 ♀; Washburn Co. 7 ♂, 6 ♀; Waupaca Co. 17 ♂, 9 ♀; Winnebago Co. 22 ♂, 28 ♀; Wood Co. 5 ♂, 4 ♀. *Totals: 1409* individuals, *145* collections, *47* counties.

Previous Records: Bayfield Co. 2 ♀; Dane Co. 6 ♂, 7 ♀; Douglas Co. 1 ♂, 1 ♀; Fond du Lac Co. 1 ♂, 1 ♀; Polk Co. 1 ♀; Rusk Co. 1 ♀; Sauk Co. 2 ♀; St. Croix R. 3 ♀; Wisconsin 2 ♂, 2 ♀. Also reported from Michigan and Minnesota.

Hesperocorixa interrupta (Say) 1825

Distribution and Abundance: The only Wisconsin record is one male collected at Beaver Dam (Dodge Co.) by W. E. Snyder in 1909 (Hungerford 1948). Most of the records for this species are from states south of Wisconsin, indicating that it would most likely occur in the southern part of the state.

Identification: A series of specimens from the Snow Collection was examined. This species is similar to *H. lobata,* but can be separated from that species by its narrow interocular space, which is only ⅔ the width of an eye. In *H. lobata* the interocular space is about 12/13 the width of an eye. The metaxyphus is longer and more pointed than that of *H. lobata.* Males have a pala that is truncate at the tip as compared to the rounded pala of *H. lobata,* and they have a very elongate and large strigil. *H. interrupta* can be separated from the smaller *H. nitida* by the characters given in the key.

Previous Records: Dodge Co. 1 ♂. Also reported from Illinois and Michigan.

Hesperocorixa kennicottii (Uhler) 1897

Distribution and Abundance: This species is common in all but the extreme southeastern corner of the state, where it was not collected but probably occurs (Fig. 3C).

Identification: This species is very distinctive. It has a very wide, pale mesoepimeron, a metaxyphus that is truncate or broadly rounded at the tip, and a golden-brown membrane that is almost devoid of markings and is separated from the corium by the wide, yellow, V-shaped border of the corium.

Collection Records: Adams Co. 1 ♂, 2 ♀; Ashland Co. 1 ♀; Barron Co. 1 ♂; Columbia Co. 2 ♂; Crawford Co. 4 ♂, 2 ♀; Douglas Co. 23 ♂, 34 ♀; Dunn Co. 1 ♂, 3 ♀; Florence Co. 2 ♂, 5 ♀; Forest Co. 3 ♀; Iowa Co. 1 ♂; Juneau Co. 1 ♂; Langlade Co. 1 ♂; Lincoln Co. 20 ♂, 11 ♀; Marathon Co. 18 ♂, 28 ♀; Marquette Co. 1 ♂; Oconto Co. 1 ♂, 1 ♀; Oneida Co. 2 ♂, 1 ♀; Polk Co. 1 ♀; Portage Co. 1 ♂, 2 ♀; Price Co. 1 ♀; Rusk Co. 2 ♂, 1 ♀; Sauk Co. 2 ♀; Sawyer Co. 1 ♂, 2 ♀; Taylor Co. 1 ♂, 2 ♀; Trempealeau Co. 3 ♂; Washburn Co. 8 ♂, 3 ♀; Waupaca Co. 1 ♂, 8 ♀; Winnebago Co. 47 ♂, 50 ♀; Wood Co. 1 ♂, 2 ♀. *Totals: 309* individuals, *51* collections, *29* counties.

Previous Records: Dane Co. 44 ♂, 75 ♀; Douglas Co. 1 ♂. Also reported from Illinois, Michigan and Minnesota.

Hesperocorixa laevigata (Uhler) 1893

Distribution and Abundance: Although apparently rare in Wisconsin, having been collected from only two sites (Fig. 3C), at one of these sites it was abundant and thousands could have been collected. This is a common western corixid, and Wisconsin is east of its principal range.

Identification: The reticulate pattern and non-rastrate pronotum set this species apart from all other *Hesperocorixa.*

Collection Records: Adams Co. 1 ♂; Iowa Co. 24 ♂, 36 ♀. *Totals: 61* individuals, *2* collections, *2* counties.

Previous Records: St. Croix R. 1 ♂ (Hungerford 1948). Also reported from Illinois and Minnesota.

Hesperocorixa lobata (Hungerford) 1925

Distribution and Abundance: Although collected in only five northern counties in this study (Fig. 3C), its distribution in the United States (Hungerford 1948) and a previous collection from Dane County indicate that it probably occurs throughout the state.

Identification: The separation of this species from *H. interrupta* was discussed under *H. interrupta.* The male pala is rounded at the tip, and is not as illustrated by Hungerford (1948). A series of specimens from the Snow Collection was studied, as well as those collected in Wisconsin.

Collection Records: Barron Co. 3 ♀; Chippewa Co. 1 ♂; Florence Co. 4 ♂, 3 ♀; Polk Co. 1 ♂, 1 ♀; Washburn Co. 2 ♀. *Totals: 15* individuals, *5* collections, *5* counties.

Previous Records: Dane Co. 1 ♂, 1 ♀. Also reported from Michigan and Minnesota.

Hesperocorixa lucida (Abbott) 1916

Distribution and Abundance: A distinct rarity in Wisconsin, *H. lucida* was collected from only two counties in northern Wisconsin (Fig. 3D). Its distribution to the south of Wisconsin indicates that it may be found in all parts of the state.

Identification: The lack of markings on the clavis and the effaced markings of the corium separate this species from other *Hesperocorixa.*

Collection Records: Douglas Co. 1 ♂, 1 ♀; Lincoln Co. 1 ♂. *Totals: 3* individuals, *2* collections, *2* counties.

Previous Records: None. Reported from Illinois and Michigan.

Hesperocorixa michiganensis (Hungerford) 1926

Distribution and Abundance: Although it was also collected in the extreme south, the distribution is mostly throughout the northern two-thirds of the state (Fig. 3A). In the north this is a very common species.

Identification: The mesoepimeron is pale, much lighter than either *H. minorella* or *H. semilucida,* the other two small *Hespero-*

corixa with a wide mesoepimeron. The pale markings on the membrane are also more distinct than in either of these two species.

Collection Records: Adams Co. 6 ♂, 5 ♀; Ashland Co. 45 ♂, 20 ♀; Barron Co. 4 ♂, 10 ♀; Burnett Co. 31 ♂, 15 ♀; Clark Co. 7 ♂, 5 ♀; Dodge Co. 1 ♂; Douglas Co. 10 ♂, 8 ♀; Eau Claire Co. 2 ♂, 9 ♀; Florence Co. 203 ♂, 197 ♀; Forest Co. 82 ♂, 99 ♀; Green Co. 1 ♂, 2 ♀; Juneau Co. 1 ♀; La Crosse Co. 1 ♂; Langlade Co. 3 ♀; Lincoln Co. 72 ♂, 84 ♀; Manitowoc Co. 2 ♀; Marathon Co. 42 ♂, 29 ♀; Marinette Co. 2 ♂, 1 ♀; Marquette Co. 3 ♂, 1 ♀; Monroe Co. 1 ♀; Oconto Co. 30 ♂, 12 ♀; Oneida Co. 22 ♂, 17 ♀; Outagamie Co. 1 ♀; Polk Co. 3 ♂, 6 ♀; Portage Co. 4 ♂, 2 ♀; Price Co. 53 ♂, 60 ♀; Rusk Co. 33 ♂, 5 ♀; Sauk Co. 1 ♂; Sawyer Co. 7 ♂, 12 ♀; Taylor Co. 14 ♂, 7 ♀; Trempealeau Co. 10 ♂, 22 ♀; Vilas Co. 26 ♂, 44 ♀; Waupaca Co. 4 ♂, 2 ♀; Winnebago Co. 3 ♂, 4 ♀; Wood Co. 7 ♂, 7 ♀. *Totals: 1422* individuals, *120* collections, *35* counties.

Previous Records: Dane Co. 1 ♂, 3 ♀; Douglas Co. 3 ♂, 7 ♀; Wisconsin 2 ♀. Also reported from Michigan and Minnesota.

Hesperocorixa minorella (Hungerford) 1926

Distribution and Abundance: A very common species of *Hesperocorixa* that is widely distributed throughout the northern two-thirds of the state (Fig. 3A). It is most abundant in the far north.

Identification: This very dark species can be distinguished by the two spines on the dorsal surface of the hind femur.

Collection Records: Adams Co. 1 ♂, 10 ♀; Ashland Co. 18 ♂, 18 ♀; Barron Co. 1 ♂; Burnett Co. 3 ♂, 7 ♀; Chippewa Co. 2 ♂, 2 ♀; Clark Co. 2 ♂, 5 ♀; Douglas Co. 17 ♂, 39 ♀; Dunn Co. 2 ♂, 3 ♀; Eau Claire Co. 36 ♂, 54 ♀; Florence Co. 434 ♂, 458 ♀; Forest Co. 195 ♂, 260 ♀; Iron Co. 8 ♂, 20 ♀; Jackson Co. 3 ♂, 4 ♀; Juneau Co. 18 ♂, 14 ♀; Langlade Co. 1 ♀; Lincoln Co. 44 ♂, 78 ♀; Manitowoc Co. 1 ♀; Marathon Co. 14 ♂, 30 ♀; Marinette Co. 4 ♂, 3 ♀; Marquette Co. 1♂; Monroe Co. 1 ♂, 1 ♀; Oconto Co. 38 ♂, 66 ♀; Oneida Co. 62 ♂, 119 ♀; Outagamie Co. 1 ♀; Polk Co. 1 ♂; Portage Co. 7 ♂, 6 ♀; Price Co. 29 ♂, 52 ♀; Rusk Co. 62 ♂, 58 ♀; Sauk Co. 1 ♀; Sawyer Co. 25 ♂, 34 ♀; Shawano Co. 1 ♂, 1 ♀; Taylor Co. 12 ♂, 12 ♀; Trepealeau Co. 1 ♀; Vilas Co. 198 ♂, 231 ♀; Washburn Co. 11 ♂, 21 ♀; Waupaca Co. 3 ♀; Waushara Co. 2 ♂, 1 ♀; Winnebago Co. 5 ♂, 6 ♀; Wood Co. 4 ♂, 7 ♀. *Totals: 2889* individuals, *125* collections, *39* counties.

Previous Records: Douglas Co. 1 ♂; Wisconsin (no sex or number). Also reported from Michigan and Minnesota.

Hesperocorixa obliqua (Hungerford) 1925

Distribution and Abundance: This species was collected only in the extreme southern part of the state, where it is uncommon (Fig. 3D).

Identification: The acute and obliquely produced upper distal angle of the male pala is distinctive, but the females closely resemble those of the much more abundant *H. vulgaris*. The pale transverse lines of the corium are shorter in *H. obliqua,* and seldom traverse the entire corium, while the longer lines of *H. vulgaris* extend entirely across the corium in the basal third.

Collection Records: Dane Co. 5 ♂, 4 ♀; Kenosha Co. 5 ♂, 9 ♀; Racine Co. 1 ♂; Rock Co. 1 ♂, 1 ♀. *Totals: 26* individuals, *6* collections, *4* counties.

Previous Records: None. Reported from Illinois, Iowa, Michigan and Minnesota.

Hesperocorixa scabricula (Walley) 1936

Distribution and Abundance: Apparently rare in Wisconsin, this species was collected only from one site in Florence County (Fig. 3D). Its occurrence in Illinois, Michigan, and Minnesota suggests that it may occur throughout Wisconsin.

Identification: Readily distinguished by its large size and the very short pronotal disc.

Collection Records: Florence Co. 5 ♀. *Totals: 5* individuals, *1* collection, *1* county.

Previous Records: None. Reported from Illinois, Michigan, and Minnesota.

Hesperocorixa semilucida (Walley) 1930

Distribution and Abundance: This uncommon species is apparently distributed throughout the southern half of the state (Fig. 3D), although it has not been collected in the extreme southeastern counties.

Identification: The small size and wide mesoepimeron distinguish this species, *H. minorella,* and *H. michiganensis.* The mesoepimeron is dusky, as in *H. minorella,* but the arrangement of the corial pattern into a definite longitudinal series separates it from both *H. minorella* and *H. michiganensis.*

Collection Records: Crawford Co. 3 ♂, 7 ♀; Green Co. 1 ♂; Richland Co. 6 ♂, 4 ♀; Trempealeau Co. 1 ♂, 1 ♀; Waupaca Co. 3 ♂; Winnebago Co. 1 ♂, 1 ♀. *Totals: 28* individuals, *9* collections, *6* counties.

Previous Records: None. Reported from Illinois and Michigan.

Hesperocorixa vulgaris (Hungerford) 1925

Distribution and Abundance: This species is very common throughout the state (Fig. 3B).

Identification: The narrow metaxyphus, the lack of any pale figures separating the corium from the membrane, and the long, narrow, transverse pale markings of the corium distinguish this species. The truncated tip of the male pala is slightly indented at the middle.

Collection Records: Adams Co. 10 ♂, 10 ♀; Ashland Co. 1 ♂, 4 ♀; Barron Co. 21 ♂, 29 ♀; Brown Co. 1 ♂; Buffalo Co. 1 ♂; Burnett Co. 5 ♂, 5 ♀; Chippewa Co. 3 ♂, 11 ♀; Clark Co. 1 ♂, 6 ♀; Columbia Co. 10 ♂, 10 ♀; Crawford Co. 1 ♀; Dane Co. 39 ♂, 22 ♀; Dodge Co. 7 ♂, 11 ♀; Door Co. 1 ♂; Douglas Co. 16 ♂, 17 ♀; Eau Claire Co. 34 ♂, 42 ♀; Dunn Co. 3 ♂; Florence Co. 12 ♂, 11 ♀; Forest Co. 5 ♂, 5 ♀; Fond du Lac Co. 1 ♀; Grant Co. 2 ♂, 2 ♀; Green Co. 16 ♂, 13 ♀; Green Lake Co. 3 ♂, 4 ♀; Iowa Co. 8 ♂, 12 ♀; Jackson Co. 4 ♂, 1 ♀; Juneau Co. 5 ♂, 11 ♀; Kenosha Co. 24 ♂, 13 ♀; La Crosse Co. 1 ♂, 1 ♀; Langlade Co. 2 ♂, 3 ♀; Lincoln Co. 6 ♂, 7 ♀; Manitowoc Co. 1 ♂, 2 ♀; Marathon Co. 12 ♂, 6 ♀; Marquette Co. 5 ♂, 1 ♀; Milwaukee Co. 30 ♂, 39 ♀; Monroe Co. 3 ♂, 2 ♀; Oconto Co. 2 ♂, 9 ♀; Oneida Co. 1 ♂, 1 ♀; Outagamie Co. 6 ♀; Ozaukee Co. 1 ♂, 2 ♀; Polk Co. 6 ♂, 3 ♀; Portage Co. 2 ♂; Price Co. 6 ♂, 15 ♀; Racine Co. 22 ♂, 12 ♀; Richland Co. 3 ♂, 5 ♀; Rock Co. 2 ♂, 6 ♀; Rusk Co. 6 ♂, 17 ♀; Sauk Co. 24 ♂, 33 ♀; Sawyer Co. 6 ♂, 7 ♀; Taylor Co. 3 ♂, 5 ♀; Trempealeau Co. 25 ♂, 22 ♀; Vernon Co. 2 ♂, 1 ♀; Vilas Co. 2 ♂, 2 ♀; Walworth Co. 28 ♂, 45 ♀; Washburn Co. 1 ♂, 1 ♀; Washington Co. 1 ♂, 1 ♀; Waukesha Co. 4 ♂, 8 ♀; Waupaca Co. 2 ♂, 2 ♀; Waushara Co. 3 ♂, 2 ♀; Winnebago Co. 52 ♂, 78 ♀; Wood Co. 2 ♀. *Totals: 1083* individuals, *160* collections, *59* counties.

Previous Records: Dane Co. 1 ♂, 19 ♀; Dodge Co. (no numbers); Douglas Co. 1 ♂, 2 ♀; St. Croix R. 8 ♂, 6 ♀. Also reported from Illinois, Iowa, Michigan and Minnesota.

Palmacorixa Abbott 1912

Three species of *Palmacorixa* occur throughout Wisconsin, but none of them is very common. The males of the three species are easily distinguished, but the females are very difficult to separate, especially those of *P. nana* and *P. buenoi*. The identification of the females collected in this study is based on the following key, and on other criteria listed under each species, but the separation of *P. nana* from *P. buenoi* remains uncertain.

KEY TO WISCONSIN SPECIES

1. The pronotal disc with well marked anterolateral depressions; male pala very broad, almost disc-like, with poorly defined pegs -- *P. gillettei*
   Anterolateral depression on pronotum weak or absent; male pala elongate -- 2
2. Middle femur of male with a longitudinal row or pegs on its ventral surface; female less than 5.2 mm long -------- *P. nana*
   Middle femur of male without a row of pegs; female 5.4 mm or longer -- *P. buenoi*

Palmacorixa buenoi Abbott 1913

Distribution and Abundance: This is the most common species of *Palmacorixa* in Wisconsin. It has been collected throughout most of the state, being fairly common in the southeastern half and less common in the northwest (Fig. 2C).

Identification: The females of this species are difficult to separate from *Palmacorixa nana*. Size is perhaps the most important criteria, with *P. nana* females being less than 5.2 mm long and *P. buenoi* females being 5.4 to 6.5 mm. Also, the dark posterior border of the pronotum is usually wider than in *P. nana*. The pronotum lacks the strong antero-lateral depressions that are found in females of *P. gillettei*.

Collection Records: Adams Co. 2 ♀; Brown Co. 2 ♀; Columbia Co. 12 ♂, 19 ♀; Dane Co. 2 ♀; Douglas Co. 1 ♀; Eau Claire Co. 2 ♀; Green Lake Co. 1 ♂, 1 ♀; Juneau Co. 5 ♂, 7 ♀; Kenosha Co. 4 ♂; Kewaunee Co. 12 ♂, 7 ♀; La Crosse Co. 1 ♂; Lafayette Co. 2 ♀; Oconto Co. 1 ♀; Oneida Co. 1 ♀; Pepin Co. 1 ♀; Pierce Co. 1 ♀; Polk Co. 1 ♂; Price Co. 2 ♀; Racine Co. 1 ♂; Rock Co. 3 ♀; Sauk Co. 2 ♂, 2 ♀; Sawyer Co. 1 ♀; Washington Co. 2 ♂, 3 ♀; Waupaca Co. 1 ♀; Waushara Co. 1 ♂, 3 ♀. *Totals: 106* individuals, *30* collections, *25* counties.

Previous Records: None. Reported from Iowa, Michigan and Minnesota.

Palmacorixa gillettei Abbott 1912

Distribution and Abundance: Scattered records from throughout the state indicate a statewide distribution, with the possible exception the extreme southeastern counties (Fig. 2C). This species is fairly common, but less common than *P. buenoi*.

Identification: The males are easily distinguished by their dilated and flattened palae. The females can be identified by the strong antero-lateral depressions of the pronotum and the wide, dark, posterior border of the pronotum.

Collection Records: Ashland Co. 1 ♀; Barron Co. 1 ♂; Dane Co. 2 ♂, 8 ♀; Douglas Co. 1 ♂; Florence Co. 2 ♀; Iowa Co. 3 ♂, 3 ♀; Lafayette Co. 2 ♀; Oconto Co. 2 ♂, 2 ♀; Outagamie Co. 1 ♀; Richland Co. 1 ♀; Taylor Co. 2 ♂, 6 ♀; Vilas Co. 1 ♂; Waupaca Co. 1 ♂, 2 ♀; Waushara Co. 1 ♀. *Totals: 42* individuals, *19* collections, *14* counties.

Previous Records: None. Reported from Michigan, Iowa and Minnesota.

Palmacorixa nana Walley 1930

Distribution and Abundance: The scattered records indicate that this uncommon species probably occurs throughout the state (Fig. 2C).

Identification: The row of pegs on the middle femur separates the males from those of *P. buenoi*. The females can be distinguished by their small size (less than 5.2 mm) and the very narrow, often interrupted, dark posterior border of the pronotum.

Collection Records: Dane Co. 1 ♀; Florence Co. 1 ♂; Forest Co. 1 ♂, 6 ♀; Manitowoc Co. 1 ♂, 1 ♀; Outagamie Co. 1 ♀; Taylor Co. 7 ♂, 9 ♀. *Totals: 28* individuals, *6* collections, *6* counties.

Previous Records: None. Reported from Michigan and Minnesota.

Ramphocorixa Abbott 1912

Only one species occurs in Wisconsin.

Ramphocorixa acuminata (Uhler) 1897

Distribution and Abundance: This species is rare in Wisconsin, with but a single specimen having been collected. This individual was collected with a black-light trap at Madison (Fig. 2B).

Identification: The effaced pattern of the clavis and corium of this species serves to separate it from all other small Wisconsin corixids. The male is also recognized by its accuminate vertex.

Collection Records: Dane Co. 1 ♂. *Totals: 1* individual, *1* collection, *1* county.

Previous Records: None. Reported from Illinois and Minnesota.

Sigara Fabricius 1775

This is the most common corixid genus in Wisconsin, 23 species having been collected in the state. The only species likely to occur in Wisconsin that have not been collected are *S. hubbelli* (Hungerford) 1928 and *S. modesta* (Abbott) 1916. Both are distributed throughout the southeastern United States and have been collected in the neighboring states of Illinois, Iowa and Minnesota. *S. hubbelli* is closely related to *S. defecta* while *S. modesta* resembles *S. grossolineata*. Both can be separated by the characters given in the key.

Key to Wisconsin species

1. Pronotal disk with median longitudinal pale line ____________ 2
   Pronotal disk without a median pale longitudinal line ______ 7
2. Tip of mesoepimeron as close or closer to scent gland osteole than to mesosternum ____________________________________ 3
   Scent gland osteole remote from tip of mesoepimeron, farther than distance from tip to mesosternum __________________ 5
3. Hemelytra nearly black; pale markings wide but obscure, transverse on clavis and somewhat longitudinal on corium; male pala thickened, with a prominent keel on the outside ____ *S. variabilis*
   Markings on hemelytra narrower and more distinct ________ 4
4. Male pala with a single row of pegs; female abdomen with anal lobes not notched on inner ventral margin ______ *S. johnstoni*
   Male pala with two rows of pegs; female with anal lobes notched on inner ventral margin __________________ *S. knighti*
5. Pronotum and hemelytra boldly cross-barred; vertex produced beyond the eye curve in both sexes __________ *S. transfigurata*
   Pattern less striking; vertex not noticeably produced ______ 6
6. Pattern of membrane effaced or indistinct; pale figures on corium and clavis transverse _______________ *S. compressoidea*
   Pattern of membrane usually distinct; pale figures on corium and distal half of clavis arranged more or less longitudinally ____ *S. mackinacensis*
7. Large species, greater than 7.0 mm long __________________ 8
   Small species, less than 7.0 mm long ____________________ 11
8. Metaxyphus broad, truncated or notched at the tip; claw of pala serrate at base in both sexes _________________ *S. decorata*
   Metaxyphus pointed; palar claw normal __________________ 9
9. Palae of both sexes with only 14 to 16 lower palmar hairs ____ *S. decoratella*
   Palae with from 18 to 22 lower palmar hairs _______________ 10
10. Interocular space plainly narrower than width of an eye; hemelytra dark, with the pale markings of the corium and distal half of clavis arranged in definite longitudinal series ____ *S. penniensis*
    Interocular space equal to width of an eye; pale markings of corium and clavis bold and transverse; vertex of male produced; palae long and slender ________________ *S. conocephala*

11. Corial pattern in definite longitudinal series ---------------12
    Corial pattern not in definite longitudinal series -----------16
12. Clavus and corium with pale lines in wavy longitudinal series; hypoocular suture ending laterad of middle line of eye ---*S. douglasensis*
    Claval lineations not in wavy longitudinal series -----------13
13. Small, less than 4.3 mm long; antennae usually 3-segmented --*S. lineata*
    Larger, greater than 4.5 mm long; antennae 4-segmented --14
14. Scent gland osteole remote from tip of mesoepimeron ---*S. trilineata*
    Scent gland osteole near tip of mesoepimeron -------------15
15. Corial lineations distinct; male pala with two rows of pegs; female pala short; anal lobes of female only very slightly notched on inner ventral margin -------------*S. mullettensis*
    Corial lineations fairly distinct; male pala with one row of pegs --23
16. Metaxyphus longer than broad ---------------------------17
    Metaxyphus not longer than broad -----------------------19
17. Mesoepimeron at level of scent gland osteole about equal in width to lateral lobe of prothorax -----------------*S. dolabra*
    Mesoepimeron at level of scent gland osteole much broader than width of lateral lobe of prothorax ------------------18
18. Pale bands on base of clavus entire, bands on corium plainly transverse; dorsal surface of hind femur with only 3 or 4 pegs ---*S. solensis*
    Pale bands on base of clavus more or less broken and confused; dorsal surface of hind femur with two or three rows of pegs ---*S. signata*
19. Scent gland osteole nearer lateral bend of mesoepimeron than tip ---20
    Scent gland osteole near tip of mesoepimeron ------------22
20. Head with median longitudinal brown line; mesoepimeron with a deep incision at or near the lateral bend ------*S. mathesoni*
    Head without line; mesoepimeron without incision --------21
21. Osteole almost in lateral bend of mesoepimeron, at least 4/5 from tip; metaxyphus with a truncated point --*S. grossolineata*
    Osteole not so far laterad, 1/2–3/5 from tip; metaxyphus with a rounded point -------------------------------*S. modesta*
22. Corial pattern in a more or less definite longitudinal series --23
    Corial pattern not in a longitudinal series -----------------24
23. Pronotal disc laterally reduced; 4 to 6 pegs on dorsal surface of hind femur; pattern of membrane obscure ------*S. hubbelli*
    Pronotal disc not reduced laterally; row of at least 12 pegs on

dorsal surface of hind femur; pattern of membrane distinct; distal pegs of male pala becoming widely separated; anal lobes of female notched on inner ventral margin; pala of female long -- *S. defecta*

24. Metaxyphus small and rounded at tip; male pala with peg row close to palm; anal lobes of female not notched -- *S. bicoloripennis*

Metaxyphus pointed at an angle of less than 90 degrees ----25

25. Pronotum crossed by 5 or 6 dark bands --------- *S. macropala*

Pronotum crossed by 8 or 9 dark bands ----------- *S. alternata*

Sigara alternata (Say) 1825

Distribution and Abundance: The most common Wisconsin corixid, this species is very common in the northern half of the state and abundant in the southern half. It has been collected in almost every county (Fig. 4A).

Identification: The short, pointed metaxyphus forms an angle at the tip of about 70°. This, the alternate dark and pale transverse markings on the clavis, and the vermiform markings of the corium separate this species from others with a narrow mesoepimeron.

Collection Records: Adams Co. 78 ♂, 114 ♀; Ashland Co. 4 ♂, 6 ♀; Barron Co. 12♂, 16 ♀; Bayfield Co. 1 ♀; Brown Co. 1 ♂, 9 ♀; Buffalo Co. 10 ♂, 6 ♀; Burnett Co. 14 ♂, 34 ♀; Calumet Co. 2 ♂, 4 ♀; Chippewa Co. 2 ♂, 4 ♀; Clark Co. 2 ♂, 3 ♀; Columbia Co. 104 ♂, 128 ♀; Crawford Co. 46 ♂, 62 ♀; Dane Co. 155 ♂, 203 ♀; Dodge Co. 4 ♀; Door Co. 11 ♂, 3 ♀; Douglas Co. 66 ♂, 93 ♀; Dunn Co. 3 ♂, 6 ♀; Eau Claire Co. 24 ♂, 30 ♀; Florence Co. 68 ♂, 77 ♀; Forest Co. 1 ♂, 5 ♀; Fond du Lac Co. 1 ♂, 6 ♀; Grant Co. 11 ♂, 13 ♀; Green Co. 40 ♂, 49 ♀; Green Lake Co. 7 ♂, 23 ♀; Iowa Co. 31 ♂, 22 ♀; Iron Co. 1 ♂; Jackson Co. 7 ♂, 10 ♀; Jefferson Co. 1 ♀; Juneau Co. 50 ♂, 61 ♀; Kenosha Co. 70 ♂, 93 ♀; Kewaunee Co. 1 ♂, 8 ♀; La Crosse Co. 7 ♂, 14 ♀; Lafayette Co. 3 ♂, 7 ♀; Langlade Co. 2 ♂, 1 ♀; Lincoln Co. 29 ♂, 20 ♀; Manitowoc Co. 3 ♂, 8 ♀; Marathon Co. 48♂, 54♀; Marquette Co. 9 ♂, 17 ♀; Menominee Co. 1 ♂; Milwaukee Co. 61 ♂, 61 ♀; Monroe Co. 3♂, 32 ♀; Oconto Co. 16 ♂, 28 ♀; Oneida Co. 9 ♂, 11 ♀; Outagamie Co. 6 ♂, 7 ♀; Ozaukee Co. 1 ♂, 1 ♀; Pepin Co. 1 ♂; Polk Co. 1 ♀; Portage Co. 28 ♂, 31 ♀; Price Co. 15 ♂, 14 ♀; Racine Co. 30 ♂, 34 ♀; Richland Co. 13 ♂, 9 ♀; Rock Co. 8 ♂, 19♀; Rusk Co. 1 ♂, 1 ♀; St. Croix Co. 3 ♀; Sauk Co. 45 ♂, 39 ♀; Sawyer Co. 4 ♂, 9 ♀; Shawano Co. 2 ♂; Taylor Co. 12 ♂, 10 ♀; Trempealeau Co. 78 ♂, 92 ♀; Vernon Co. 11 ♂, 6 ♀; Vilas Co. 3 ♂, 8 ♀; Walworth Co. 59 ♂, 89 ♀; Washburn Co. 2 ♂; Washington Co. 1 ♂; Waukesha Co. 19 ♂, 16 ♀; Waupaca Co. 6

♂, 9 ♀; Waushara Co. 1 ♂; Winnebago Co. 17 ♂, 28 ♀; Wood Co. 6 ♂, 6 ♀. *Totals: 3168* individuals, *248* collections, *69* counties.

Previous Records: Burnett Co. 1 ♀; Dane Co. 2 ♂, 5 ♀; Douglas Co. 1 ♂, 1 ♀; Fond du Lac Co. 1 ♀; Jackson Co. 1 ♀; Lafayette Co. 1 ♀; Sauk Co. 1 ♂, 6 ♀. Also reported from Illinois, Iowa, Michigan and Minnesota.

Sigara bicoloripennis (Walley) 1936

Distribution and Abundance: This species is fairly common throughout the northern two-thirds of the state (Fig. 4B). One specimen was collected in Kenosha County in the extreme southeast.

Identification: The small, rounded metaxyphus separates this species from *S. alternata.* The females might be confused with *S. defecta,* but the pala is shorter in *S. bicoloripennis* and the anal lobes are not notched on the mesal margin.

Collection Records: Adams Co. 8 ♂, 20 ♀; Ashland Co. 1 ♂; Barron Co. 1 ♂, 2 ♀; Burnett Co. 3 ♂, 7 ♀; Douglas Co. 6 ♂, 6 ♀; Florence Co. 39 ♂, 44 ♀; Forest Co. 2 ♀; Juneau Co. 1 ♂; Kenosha Co. 1 ♂; Langlade Co. 1 ♀; Lincoln Co. 1 ♂, 1 ♀; Marathon Co. 1 ♂, 2 ♀; Oconto Co. 2 ♂; Oneida Co. 1 ♂, 1 ♀; Outagamie Co. 6 ♂, 5 ♀; Polk Co. 6 ♂, 3 ♀; Price Co. 1 ♂, 3 ♀; Sawyer Co. 1 ♂; Taylor Co. 11 ♂, 11 ♀; Trempealeau Co. 9 ♂, 10 ♀; Washburn Co. 1 ♂; Waupaca Co. 1 ♀; Winnebago Co. 1 ♀. *Totals: 220* individuals, *34* collections, *23* counties.

Previous Records: Dane Co. 3 ♂, 12 ♀. Also reported from Michigan and Minnesota.

Sigara compressoidea (Hungerford) 1928

Distribution and Abundance: While common in the northern two-thirds of the state, it also has been collected in two extreme southeastern counties (Fig. 5C).

Identification: The pale longitudinal line on the prothorax and the effaced membrane distinguish this species. It might be confused only with *S. mackinacensis,* but the lines on the basal third of the clavis are mostly entire and not zig-zag, and the corial pattern is transverse while that in *S. mackinacensis* is arranged in a longitudinal series.

Collection Records: Adams Co. 2 ♂, 1 ♀; Ashland Co. 3 ♂, 1 ♀; Barron Co. 1 ♂; Bayfield Co. 1 ♀; Burnett Co. 1 ♂, 2 ♀; Chippewa Co. 1 ♂, 3 ♀; Clark Co. 9 ♂, 6 ♀; Douglas Co. 2 ♂; Eau Claire Co. 3 ♂, 1 ♀; Florence Co. 69 ♂, 93 ♀; Forest Co. 5 ♀; Green Lake Co. 1 ♀; Juneau Co. 1 ♂; Kenosha Co. 1 ♀; Langlade Co. 3 ♂, 3 ♀; Lincoln Co. 41 ♂, 37 ♀; Marathon Co. 82 ♂, 109 ♀; Marquette Co. 2 ♂, 1 ♀; Oconto Co. 9 ♂, 15 ♀; Oneida Co. 3 ♂, 7 ♀; Polk Co. 6 ♀; Portage Co. 1 ♀; Price Co. 4 ♂, 18 ♀; Rusk Co. 6 ♂, 5 ♀; Sauk Co. 3 ♂, 1 ♀; Sawyer Co. 5 ♀; Taylor Co. 33 ♂, 50 ♀; Vilas Co. 9 ♂, 17 ♀; Walworth Co. 1 ♂, 1 ♀; Washburn Co. 1 ♂, 1 ♀; Waupaca Co. 1 ♂; Waushara Co. 1 ♀; Wood Co. 8 ♂, 1 ♀. *Totals: 692* individuals, *96* collections, *33* counties.

Previous Records: Dane Co. 7 ♀. Also reported from Michigan and Minnesota.

Sigara conocephala (Hungerford) 1926

Distribution and Abundance: Fairly common in the northeast, this species is apparently confined to the northern two-thirds of the state (Fig. 5A).

Identification: The strongly produced vertex identifies the male, while the female can be recognized by her large size and unusually long palae.

Collection Records: Adams Co. 1 ♂, 1 ♀; Ashland Co. 1 ♂; Douglas Co. 1 ♂; Florence Co. 34 ♂, 66 ♀; Forest Co. 2 ♂, 5 ♀; Oneida Co. 1 ♂; Trempealeau Co. 1 ♂, 2 ♀; Vilas Co. 1 ♂. *Totals: 116* individuals, *23* collections, *8* counties.

Previous Records: None. Reported from Michigan and Minnesota.

Sigara decorata (Abbott) 1916

Distribution and Abundance: This species is fairly common throughout the state (Fig. 4C).

Identification: S. decorata is easily distinguished by its large size and broadly rounded or truncated metaxyphus.

Collection Records: Adams Co. 14 ♂, 35 ♀; Barron Co. 2 ♀; Burnett Co. 1 ♀; Columbia Co. 1 ♂, 2 ♀; Dane Co. 5 ♂, 2 ♀; Door Co. 2 ♂, 1 ♀; Douglas Co. 1 ♀; Eau Claire Co. 2 ♂, 1 ♀; Florence Co. 1 ♂; Green Co. 1 ♀; Juneau Co. 3 ♂, 3 ♀; Lincoln Co. 1 ♀; Marathon Co. 3 ♂, 2 ♀; Marquette Co. 2 ♂, 1 ♀; Outagamie Co. 1 ♀; Polk Co. 1 ♀; Price Co. 2 ♀; Racine Co. 2 ♂; St. Croix Co. 1 ♂; Sauk Co. 2 ♂, 6 ♀; Taylor Co. 4 ♂, 2 ♀; Trempealeau Co. 14 ♂, 9 ♀; Vilas Co. 1 ♂; Winnebago Co. 5 ♂, 6 ♀. *Totals: 142* individuals, *39* collections, *24* counties.

Previous Records: None. Reported from Illinois and Minnesota.

Sigara decoratella (Hungerford) 1926

Distribution and Abundance: This is a common species that is distributed throughout the state (Fig. 5A).

Identification: The reduced number of lower palmar hairs is distinctive for this large species.

Collection Records: Adams Co. 27 ♂, 47 ♀; Ashland Co. 4 ♂; Barron Co. 1 ♂; Burnett Co. 2 ♂, 5 ♀; Chippewa Co. 1 ♂; Columbia Co. 1 ♂, 1 ♀; Dane Co. 1 ♂, 2 ♀; Douglas Co. 4 ♂, 2 ♀; Florence Co. 21 ♂, 21 ♀; Forest Co. 9 ♂, 4 ♀; Green Co. 1 ♀; Juneau Co. 1 ♂, 1 ♀; Kenosha Co. 1 ♀; Lincoln Co. 3 ♂, 8 ♀; Marinette Co. 1 ♂; Marquette Co. 1 ♀; Oconto Co. 1 ♀; Oneida Co. 2 ♀; Outagamie Co. 2 ♂, 2 ♀; Pierce Co. 1 ♂; Polk Co. 4 ♂; Price Co. 7 ♂, 8 ♀; Sauk Co. 2 ♂, 14 ♀; Shawano Co. 1 ♀; Taylor Co. 1 ♂, 4 ♀; Vilas Co. 1 ♂; Waupaca Co. 1 ♂, 1 ♀; Winnebago Co. 18 ♂, 11 ♀. *Totals: 251* individuals, *60* collections, *28* counties.

Previous Records: Dane Co. 1 ♂, 4 ♀; St. Croix R. 8 ♂, 11 ♀. Also reported from Iowa, Michigan and Minnesota.

Sigara defecta Hungerford 1948

Distribution and Abundance: Although not collected in the extreme southwestern counties, it probably occurs throughout the state (Fig. 4B). It is fairly common in many parts of the state.

Identification: The male pala is distinctive, but the female can be easily confused with *S. bicoloripennis* or *S. mullettensis*. The pala is longer than that of *S. bicoloripennis,* and much longer than that of *S. mullettensis*. The anal lobes are distinctly notched mesally, while those of *S. bicoloripennis* are unnotched and those of *S. mullettensis* are only very slightly notched.

Collection Records: Adams Co. 12 ♂, 25 ♀; Ashland Co. 1 ♀; Burnett Co. 3 ♂, 3 ♀; Columbia Co. 1 ♀; Douglas Co. 42 ♂, 40 ♀; Dunn Co. 1 ♂; Florence Co. 7 ♂, 4 ♀; Forest Co. 1 ♂, 1 ♀; Juneau Co. 1 ♂, 1 ♀; Kenosha Co. 1 ♀; Lincoln Co. 1 ♂, 1 ♀; Milwaukee Co. 1 ♀; Oconto Co. 4 ♂, 4 ♀; Polk Co. 5 ♀; Portage Co. 1 ♂; Price Co. 3 ♂, 4 ♀; Racine Co. 3 ♂, 1 ♀; Sauk Co. 1 ♀; Taylor Co. 1 ♂, 1 ♀; Washburn Co. 1 ♀; Winnebago Co. 2 ♀. *Totals: 178* individuals, *30* collections, *21* counties.

Previous Records: Dane Co. 1 ♂, 2 ♀; Sauk Co. 1 ♂. Also reported from Illinois, Michigan and Minnesota.

Sigara dolabra Hungerford and Sailer 1942

Distribution and Abundance: S. dolabra has been collected only in the northern half of the state and it is uncommon (Fig. 5D).

Identification: The very long, pointed metaxyphus and the mesoepimeron equal in width to the prothoracic lobe separate this species.

Collection Records: Burnett Co. 1 ♀; Florence Co. 8 ♂, 12 ♀; Forest Co. 1 ♂; Lincoln Co. 1 ♂; Marathon Co. 1 ♂; Marinette Co. 1 ♂; Onedia Co. 1 ♂, 1 ♀; Vilas Co. 2 ♀. *Totals: 29* individuals, *12* collections, *8* counties.

Previous Records: None. Reported from Michigan and Minnesota.

Sigara douglasensis (Hungerford) 1926

Distribution and Abundance: The distribution of this fairly common species is confined to the northern third of the state (Fig. 5B).

Identification: The wavy longitudinal lines on the clavis and corium separate this species, and the location of the hypo-ocular suture is distinctive.

Collection Records: Douglas Co. 2 ♂, 1 ♀; Florence Co. 2 ♂, 4 ♀; Forest Co. 3 ♂; Lincoln Co. 1 ♂, 3 ♀; Oneida Co. 1 ♀; Polk Co. 3 ♂, 2 ♀; Rusk Co. 1 ♂; Sawyer Co. 1 ♂, 1 ♀; Vilas Co. 5 ♂, 6 ♀; Washburn Co. 1 ♀. *Totals: 37* individuals, *17* collections, *10* counties.

Previous Records: None. Reported from Michigan and Minnesota.

Sigara grossolineata Hungerford 1948

Distribution and Abundance: An abundant species, it occurs throughout the state (Fig. 4A).

Identification: Closely related to *S. modesta,* which has not been collected in Wisconsin but might occur in the south. In *S. modesta* the scent gland osteole is only 1/2 to 3/5 from the tip of the mesoepimeron to the lateral bend, and not close to the lateral bend as in *S. grossolineata.* Also in *S. modesta* the dark pattern of the clavis is effaced along the margin bordering the pronotum, while in *S. grossolineata* the lines may become narrow, but they remain distinct. Several specimens of *S. modesta* from the Snow Collection were examined.

Collection Records: Adams Co. 2 ♂, 7 ♀; Ashland Co. 3 ♂, 6 ♀; Brown Co. 12 ♂, 28 ♀; Calumet Co. 7 ♂, 16 ♀; Chippewa Co. 5 ♂, 9 ♀; Clark Co. 1 ♂, 1 ♀; Columbia Co. 3 ♂, 8 ♀; Crawford Co. 28 ♂, 60 ♀; Dane Co. 26 ♂, 39 ♀; Dodge Co. 11 ♂, 15 ♀; Door Co. 10 ♂, 9 ♀; Douglas Co. 1 ♀; Dunn Co. 2 ♂, 8 ♀; Eau Claire Co. 1 ♂, 2 ♀; Florence Co. 11 ♂, 21 ♀; Fond du Lac Co. 5 ♂, 5 ♀; Forest Co. 13 ♂, 19 ♀; Grant Co. 14 ♂, 37 ♀; Green Co. 13 ♂, 17 ♀; Green Lake Co. 5 ♂, 8 ♀; Iowa Co. 77 ♂, 81 ♀; Jefferson Co. 11 ♂, 6 ♀; Juneau Co. 6 ♂, 13 ♀; Kenosha Co. 4 ♂, 13 ♀; Kewaunee Co. 8 ♂, 7 ♀; La Crosse Co. 3 ♀; Lafayette Co. 4 ♂, 14 ♀; Langlade Co. 2 ♂, 5 ♀; Lincoln Co. 10 ♂, 14 ♀; Manitowoc Co. 9 ♂, 21 ♀; Marathon Co. 19 ♂, 27 ♀; Marinette Co. 1 ♂, 3 ♀; Marquette Co. 2 ♂, 3 ♀; Menominee Co. 1 ♀; Milwaukee Co. 2 ♂, 4 ♀; Oconto Co. 15 ♂, 20 ♀; Oneida Co. 2 ♂, 5 ♀; Outagamie Co. 8 ♂, 12 ♀; Ozaukee Co. 3 ♀; Polk Co. 2 ♀; Portage Co. 3 ♂, 6 ♀; Price Co. 8 ♂, 10 ♀; Racine Co. 3 ♂, 10 ♀; Richland Co. 4 ♀; Rock Co. 2 ♂, 2 ♀; Rusk Co. 2 ♂, 1 ♀; St. Croix Co. 3 ♂; Sauk Co. 18 ♂, 21 ♀; Sawyer Co. 2 ♂, 3 ♀; Shawano Co.

1 ♂, 6 ♀; Sheboygan Co. 3 ♂, 8 ♀; Taylor Co. 29 ♂, 59 ♀; Trempealeau Co. 3 ♂, 4 ♀; Vernon Co. 1 ♂, 6 ♀; Vilas Co. 19 ♂, 33 ♀; Walworth Co. 19 ♂, 29 ♀; Washburn Co. 1 ♂; Washington Co. 4 ♂, 6 ♀; Waukesha Co. 3 ♂, 3 ♀; Waupaca Co. 5 ♂, 8 ♀; Winnebago Co. 11 ♂, 17 ♀; Wood Co. 6 ♂, 2 ♀. *Totals: 1309* individuals, *212* collections, *62* counties.

Previous Records: Dane Co. 15 ♂, 22 ♀; Douglas Co. 3 ♂, 4 ♀. Also reported from Illinois, Iowa, Michigan and Minnesota.

Sigara johnstoni Hungerford 1948

Distribution and Abundance: This species is fairly common in the northwest half of the state (Fig. 4D). The Illinois record suggests that it might occur in the southern part of the state as well.

Identification: The females may be confused with those of *S. variabilis* or *S. knighti.* The anal lobes are not notched mesally as they are in *S. knighti;* those of *S. variabilis* are slightly notched. Most distinctive is the metaxyphus, which is very slightly notched at the tip in *S. johnstoni.*

Collection Records: Ashland Co. 1 ♀; Burnett Co. 1 ♀; Clark Co. 1 ♂, 2 ♀; Douglas Co. 3 ♂; Dunn Co. 1 ♂; Eau Claire Co. 1 ♂; Florence Co. 1 ♂; Forest Co. 1 ♂, 3 ♀; Jackson Co. 1 ♀; Juneau Co. 2 ♂, 2 ♀; Langlade Co. 6 ♂, 6 ♀; Lincoln Co. 4 ♂, 5 ♀; Marathon Co. 11 ♂, 6 ♀; Oneida Co. 1 ♂; Portage Co. 5 ♀; Price Co. 2 ♀; Rusk Co. 2 ♂; Sawyer Co. 4 ♂, 3 ♀; Taylor Co. 3 ♂, 7 ♀; Vilas Co. 1 ♂; Wood Co. 2 ♂, 2 ♀. *Totals: 90* individuals, *34* collections, *21* counties.

Previous Records: None. Reported from Illinois and Minnesota.

Sigara knighti Hungerford 1948

Distribution and Abundance: This uncommon species occurs only in the northern third of the state (Fig. 4D).

Identification: The females may be separated from *S. johnstoni* and *S. variabilis* by their mesally notched anal lobes.

Collection Records: Ashland Co. 1 ♀; Bayfield Co. 2 ♂, 1 ♀; Douglas Co. 1 ♂; Florence Co. 5 ♂, 6 ♀; Forest Co. 8 ♂, 12 ♀; Langlade Co. 4 ♀; Price Co. 4 ♀; Vilas Co. 2 ♂, 3 ♀. *Totals: 49* individuals, *12* collections, *8* counties.

Previous Records: None. Reported from Michigan and Minnesota.

Sigara lineata (Forster) 1771

Distribution and Abundance: Where it occurs, this species may be found in tremendous numbers. It is common throughout much of the state, and has been collected mostly in areas where there is sandy soil (Fig. 5B).

Identification: The very small size and striped hemelytra make this species easy to recognize.

Collection Records: Adams Co. 76 ♂, 101 ♀; Ashland Co. 93 ♂, 164 ♀; Columbia Co. 335 ♂, 329 ♀; Crawford Co. 7 ♂, 14 ♀; Dane Co. 7 ♂, 13 ♀; Dunn Co. 7 ♂, 3 ♀; Eau Claire Co. 1 ♀; Florence Co. 491 ♂, 515 ♀; Juneau Co. 24 ♂, 19 ♀; Lincoln Co. 2 ♂, 1 ♀; Marathon Co. 91 ♂, 157 ♀; Marquette Co. 1 ♀; Oneida Co. 1 ♂, 2 ♀; Outagamie Co. 3 ♀; Portage Co. 8 ♂, 17 ♀; Price Co. 18 ♂, 20 ♀; Rusk Co. 4 ♂, 4 ♀; Sauk Co. 62 ♂, 59 ♀; Taylor Co. 5 ♂, 4 ♀; Trempealeau Co. 41 ♂, 122 ♀; Vilas Co. 84 ♂, 76 ♀. *Totals: 2981* individuals, *78* collections, *21* counties.

Previous Records: None. Reported from Illinois and Minnesota.

Sigara mackinacensis (Hungerford) 1928

Distribution and Abundance: The distribution of this species is restricted to the northern half of the state where it is fairly common (Fig. 5C).

Identification: The distinctly marked membrane separates it from *S. compressoidea,* the only species with which it might be confused.

Collection Records: Barron Co. 1 ♀; Chippewa Co. 1 ♀; Clark Co. 2 ♂, 1 ♀; Douglas Co. 1 ♀; Eau Claire Co. 2 ♂; Florence Co. 5 ♂, 8 ♀; Forest Co. 4 ♂, 5 ♀; Lincoln Co. 4 ♂, 2 ♀; Oconto Co. 1 ♀; Oneida Co. 2 ♂, 3 ♀; Polk Co. 4 ♀; Sawyer Co. 3 ♀; Vilas Co. 4 ♂, 7 ♀; Washburn Co. 25 ♂, 36 ♀; Wood Co. 4 ♂, 4 ♀. *Totals: 129* individuals, *27* collections, *15* counties.

Previous Records: None. Reported from Michigan and Minnesota.

Sigara macropala (Hungerford) 1926

Distribution and Abundance: This species is uncommon in Wisconsin, and has been collected only in the extreme north (Fig. 5D).

Identification: The large dorsal extension of the male pala is distinctive. The sharply pointed metaxyphus separates this species from *S. bicoloripennis* and *S. defecta,* and it can be easily separated from the larger *S. alternata* by the pattern on the clavis and the fewer number of black bars on the prothorax.

Collection Records: Burnett Co. 1 ♀; Douglas Co. 1 ♀; Florence Co. 21 ♂, 20 ♀; Washburn Co. 11 ♂, 11 ♀. *Totals: 65* individuals, *5* collections, *4* counties.

Previous Records: None. Reported from Michigan and Minnesota.

Sigara mathesoni Hungerford 1948

Distribution and Abundance: A very common species throughout the entire state, it seems to have an affinity for spring ponds (Fig. 4C).

Identification: The median brown stripe on the head and the deep incision at the lateral bend of the mesoepimeron are distinctive.

Collection Records: Adams Co. 4 ♂, 9 ♀; Ashland Co. 1 ♂, 2 ♀; Barron Co. 1 ♀; Calumet Co. 1 ♂; Chippewa Co. 1 ♂, 2 ♀; Columbia Co. 12 ♂, 28 ♀; Crawford Co. 12 ♂, 16 ♀; Dane Co. 36 ♂, 56 ♀; Dodge Co. 13 ♂, 16 ♀; Door Co. 16 ♂, 51 ♀; Florence Co. 30 ♂, 86 ♀; Forest Co. 1 ♂, 3 ♀; Grant Co. 1 ♂; Green Co. 1 ♂; Iowa Co. 39 ♂, 29 ♀; Jefferson Co. 5 ♂, 13 ♀; Juneau Co. 2 ♂, 4 ♀; Langlade Co. 2 ♀; Lincoln Co. 16 ♂, 22 ♀; Marinette Co. 1 ♀; Marquette Co. 4 ♀; Monroe Co. 29 ♂, 33 ♀; Price Co. 83 ♂, 124 ♀; St. Croix Co. 3 ♀; Sauk Co. 1 ♂; Vernon Co. 1 ♂; Vilas Co. 1 ♂, 3 ♀; Walworth Co. 2 ♂, 5 ♀; Washburn Co. 1 ♂, 2 ♀; Washington Co. 1 ♀; Waukesha Co. 67 ♂, 106 ♀; Waushara Co. 5 ♂, 4 ♀. *Totals : 1007* individuals, *69* collections, *33* counties.

Previous Records: Dane Co. 4 ♂, 5 ♀; Douglas Co. 14 ♂, 13 ♀; Sauk Co. 1 ♀. Also reported from Michigan and Minnesota.

Sigara mullettensis (Hungerford) 1928

Distribution and Abundance: This species is fairly common throughout the northern two-thirds of the state, with only two scattered records from the southern counties (Fig. 4B).

Identification: The females could be confused with those of *S. defecta*, which also tend to have the corial pattern in a longitudinal series. In *S. mullettensis* the female pala is much shorter, and the anal lobes are only slightly notched.

Collection Records: Ashland Co. 7 ♂, 6 ♀; Burnett Co. 4 ♂, 4 ♀; Chippewa Co. 1 ♂; Clark Co. 1 ♂; Door Co. 1 ♀; Douglas Co. 1 ♀; Eau Claire Co. 1 ♂; Forest Co. 1 ♀; Juneau Co. 1 ♂; Langlade Co. 2 ♂, 5 ♀; Lincoln Co. 2 ♂, 5 ♀; Marathon Co. 1 ♂, 3 ♀; Oconto Co. 3 ♂, 1 ♀; Outagamie Co. 2 ♂, 3 ♀; Ozaukee Co. 1 ♂; Polk Co. 1 ♀; Portage Co. 1 ♂, 1 ♀; Price Co. 1 ♀; Sawyer Co. 2 ♂; Taylor Co. 16 ♂, 14 ♀; Vilas Co. 3 ♀; Winnebago Co. 11 ♂, 27 ♀. *Totals: 133* individuals, *35* collections, *23* counties.

Previous Records: Dane Co. 1 ♀. Also reported from Michigan and Minnesota.

Sigara penniensis (Hungerford) 1928

Distribution and Abundance: This species is fairly common in the northern two-thirds of the state (Fig. 5A).

Identification: This large, dark colored *Sigara* can be recognized by the narrow interocular space and the pale markings of the corium being arranged in a definite longitudinal series.

Collection Records: Adams Co. 1 ♀; Burnett Co. 2 ♂, 3 ♀; Clark Co. 1 ♂; Door Co. 1 ♀; Douglas Co. 4 ♂, 10 ♀; Forest Co. 1 ♀; Florence Co. 3 ♂, 7 ♀; Jackson Co. 2 ♀; Lincoln Co. 7 ♂, 9 ♀; Oconto Co. 3 ♂; Oneida Co. 1 ♂, 3 ♀; Polk Co. 1 ♂; Vilas Co. 6 ♂, 2 ♀; Washington Co. 3 ♂, 1 ♀. *Totals: 71* individuals, *26* collections, *14* counties.

Previous Records: None. Reported from Michigan and Minnesota.

Sigara signata (Fieber) 1851

Distribution and Abundance: This species is common in the northern two-thirds of the state but has not been collected in the southern counties or the counties bordering Lake Michigan or the Mississippi River (Fig. 5D).

Identification: This dark little species looks like a miniature *H. minorella.* It is much darker than *S. solensis,* and can be easily separated by the characters given in the key.

Collection Records: Adams Co. 1 ♂, 7 ♀; Ashland Co. 3 ♂, 3 ♀; Barron Co. 1 ♂; Burnett Co. 1 ♂, 6 ♀; Chippewa Co. 1 ♀; Clark Co. 6 ♀; Douglas Co. 3 ♀; Eau Claire Co. 3 ♂, 9 ♀; Florence Co. 34 ♂, 67 ♀; Forest Co. 3 ♂, 8 ♀; Iron Co. 2 ♀; Juneau Co. 5 ♂, 5 ♀; Langlade Co. 2 ♂, 1 ♀; Lincoln Co. 26 ♂, 29 ♀; Marathon Co. 9 ♂, 13 ♀; Marinette Co. 2 ♀; Marquette Co. 1 ♀; Monroe Co. 1 ♂, 1 ♀; Oconto Co. 5 ♂, 7 ♀; Oneida Co. 13 ♂, 17 ♀; Polk Co. 1 ♂, 5 ♀; Portage Co. 2 ♂; Price Co. 3 ♂, 4 ♀; Rusk Co. 5 ♂, 7 ♀; Sawyer Co. 4 ♂, 2 ♀; Shawano Co. 1 ♀; Taylor Co. 4 ♂, 4 ♀; Vilas Co. 19 ♂, 45 ♀; Washburn Co. 2 ♀; Waupaca Co. 1 ♀; Waushara Co. 1 ♂, 1 ♀; Wood Co. 1 ♂, 4 ♀. *Totals: 411* individuals, *96* collections, *31* counties.

Previous Records: Douglas Co. 1 ♀. Also reported from Illinois, Michigan and Minnesota.

Sigara solensis (Hungerford) 1926

Distribution and Abundance: Except for the extreme southern and eastern counties, this species has been collected throughout the state (Fig. 4C). It is fairly common in many areas.

Identification: Readily distinguished by the characters in the key.

Collection Records: Adams Co. 5 ♂, 6 ♀; Ashland Co. 1 ♂; Dane Co. 2 ♂, 2 ♀; Douglas Co. 1 ♂; Eau Claire Co. 2 ♂, 1 ♀; Florence Co. 11 ♂, 23 ♀; Forest Co. 1 ♂; Green Lake Co. 2 ♂; Lincoln Co. 5 ♂, 3 ♀; Marathon Co. 2 ♂; Marquette Co. 12 ♂, 10 ♀; Oconto Co. 1 ♂; Oneida Co. 1 ♂; Polk Co. 1 ♂; Rusk Co. 1 ♀; Sauk Co. 1 ♀; Taylor Co. 3 ♂, 2 ♀; Trempealeau Co. 1 ♀;

Vilas Co. 1 ♀; Winnebago Co. 34 ♂, 37 ♀. *Totals: 172* individuals, *40* collections, *20* counties.

Previous Records: Dane Co. 24 ♂, 23 ♀. Also reported from Michigan and Minnesota.

Sigara transfigurata (Walley) 1930

Distribution and Abundance: This rare species was collected at only two sites, one in Vilas Co. in the extreme north and one in Marathon Co. in the central part of the state (Fig. 4D).

Identification: The bold cross-bars on the corium separate this species from others with a pale longitudinal line on the pronotum.

Collection Records: Marathon Co. 1 ♂; Vilas Co. 2 ♂. *Totals: 3* individuals, *2* collections, *2* counties.

Previous Records: None. Reported from Michigan.

Sigara trilineata (Provancher) 1872

Distribution and Abundance: Collected throughout the state, except in the extreme eastern and western counties (Fig. 5B). Like *S. lineata,* with which it often occurs, it seems most prevalent in sandy areas.

Identification: The bold longitudinal stripes on the hemelytra and the wide mesoepimeron separate it from all other species.

Collection Records: Adams Co. 129 ♂, 199 ♀; Barron Co. 1 ♂, 1 ♀; Chippewa Co. 1 ♂, 2 ♀; Columbia Co. 3 ♂, 3 ♀; Dane Co. 7 ♂, 7 ♀; Douglas Co. 2 ♂; Eau Claire Co. 1 ♂, 1 ♀; Florence Co. 101 ♂, 159 ♀; Forest Co. 2 ♂; Iowa Co. 50 ♂, 41 ♀; Juneau Co. 56 ♂, 82 ♀; Lincoln Co. 6 ♂, 9 ♀; Marathon Co. 44 ♂, 50 ♀; Marinette Co. 6 ♀; Marquette Co. 2 ♂; Monroe Co. 2 ♀; Oconto Co. 6 ♂, 8 ♀; Portage Co. 1 ♂, 2 ♀; Price Co. 1 ♂; Rusk Co. 13 ♂, 6 ♀; Sauk Co. 22 ♂, 29 ♀; Taylor Co. 2 ♂, 2 ♀; Vilas Co. 78 ♂, 162 ♀; Washburn Co. 1 ♂, 4 ♀; Waupaca Co. 2 ♂, 5 ♀; Wood Co. 1 ♂. *Totals: 1312* individuals, *83* collections, *26* counties.

Previous Records: Burnett Co. 1 ♂, 4 ♀. Also reported from Michigan and Minnesota.

Sigara variabilis (Hungerford) 1926

Distribution and Abundance: Although it was collected only in the northwestern half of the state (Fig. 5C), collections in Illinois and Michigan suggest that this uncommon species should be found in the rest of the state as well.

Identification: The pala of the male is distinctive, but the females resemble *S. johnstoni.* They can be separated from that species by the lack of an incision in the metaxyphus, the wider and more widely spaced pale figures on the corium, and the slight mesal indentation of the anal lobes.

Collection Records: Crawford Co. 2 ♂, 1 ♀; Douglas Co. 3 ♀; Dunn Co. 1 ♂, 1 ♀; Juneau Co. 1 ♀; Marathon Co. 1 ♂; Oneida Co. 3 ♂, 5 ♀; Portage Co. 1 ♂; Trempealeau Co. 1 ♂, 3 ♀. *Totals: 23* individuals, *10* collections, *8* counties.

Previous Records: None. Reported from Illinois and Michigan.

Trichocorixa Kirkaldy

Four species of *Trichocorixa* have been collected in Wisconsin, with all species being most common in the southern third of the state (Fig. 2D). A fifth species, *T. macroceps* (Kirkaldy) 1908, has been found in Illinois and Michigan and may occur in Wisconsin.

Key to Wisconsin species

Males

1. Strigil small and round -- 2
   Strigil very elongate -- 3
2. Nodal furrow appearing absent or at apex of embolar groove; length of pronotal disc about one-fourth its width --*T. macroceps*
   Nodal furrow dividing embolar groove; length of pronotal disc one-third or more its width -------------------------*T. naias*
3. Strigil extremely narrow, little more than a heavy dark line and usually curved abruptly upward at the mesal end ------*T. calva*
   Strigil about 7 times as long as wide ------------------------ 4
4. Strigil noticeably widened in region of the bend ----*T. borealis*
   Strigil about the same width along its entire length, any slight widening occurring near the lateral end ------------*T. kanza*

Females

1. Nodal furrow appearing absent or at apex of embolar groove -- 2
   Nodal furrow dividing embolium ------------------------------ 3
2. Length of pronotal disc about one-fourth its width -*T. macroceps*
   Length of pronotal Disc one-third or more its width ----*T. naias*
3. Length of apical area of embolar groove exceeding length of middle tarsus --*T. borealis*
   Length of apical area less than that of middle tarsus -------- 4
4. At least 2 patches of bristle-like setae on right side of seventh abdominal sternite ----------------------------------*T. kanza*
   Only fine pubescence on right side of seventh abdominal sternite ---*T. calva*

Trichocorixa borealis Sailer 1948

Distribution and Abundance: This species is common throughout the southern third of the state and has been collected as far north as Barron and Langlade Counties (Fig. 2D).

Identification: The strigil of the male, which is widened at the bend, and the long postnodal pruinose area in the female separate this species. In most females there is a distinct outward projection at the anterior end of the polished prenodal area.

Collection Records: Adams Co. 13 ♂, 15 ♀; Barron Co. 2 ♀; Brown Co. 12 ♂, 31 ♀; Columbia Co. 16 ♂, 49 ♀; Crawford Co. 1 ♂, 2 ♀; Dane Co. 64 ♂, 100 ♀; Dodge Co. 12 ♂, 25 ♀; Dunn Co. 3 ♂, 2 ♀; Green Co. 1 ♀; Green Lake Co. 84 ♂, 141 ♀; Iowa Co. 5 ♂, 6 ♀; Jefferson Co. 2 ♂, 5 ♀; Juneau Co. 3 ♂; Kenosha Co. 18 ♂, 26 ♀; Kewaunee Co. 2 ♀; La Crosse Co. 1 ♀; Lincoln Co. 2 ♂, 1 ♀; Manitowoc Co. 1 ♀; Marathon Co. 1 ♂, 2 ♀; Marquette Co. 4 ♂, 8 ♀; Outagamie Co. 6 ♂, 7 ♀; Racine Co. 2 ♂; Rock Co. 2 ♀; Sauk Co. 24 ♂, 25 ♀; Sheboygan Co. 1 ♂, 1 ♀; Trempealeau Co. 1 ♀; Walworth Co. 65 ♂, 69 ♀; Washington Co. 1 ♂, 2 ♀; Winnebago Co. 1 ♂. *Totals: 867* individuals, *65* collections, *29* counties.

Previous Records: None. Reported from Iowa and Minnesota.

Trichocorixa calva (Say) 1832

Distribution and Abundance: This species is fairly common in the southern half of the state, and apparently does not occur in the north (Fig. 2D).

Identification: The males can be identified by their extremely narrow strigil. The females can be separated from *T. kanza* by the lack of patches of setae on the right side of the seventh abdominal sternite.

Collection Records: Adams Co. 1 ♀; Columbia Co. 1 ♀; Crawford Co. 30 ♂, 35 ♀; Dane Co. 2 ♀; Dodge Co. 1 ♂, 1 ♀; Fond du Lac Co. 1 ♂; Grant Co. 6 ♂, 10 ♀; Green Co. 1 ♂, 3 ♀; Green Lake Co. 1 ♀; Iowa Co. 1 ♀; Jefferson Co. 1 ♀; Juneau Co. 2 ♂, 1 ♀; Kenosha Co. 80 ♂, 90 ♀; Kewaunee Co. 1 ♀; Lafayette Co. 1 ♂, 3 ♀; Manitowoc Co. 1 ♂; Marquette Co. 14 ♂, 15 ♀; Milwaukee Co. 2 ♂, 1 ♀; Monroe Co. 1 ♂; Outagamie Co. 1 ♀; Racine Co. 7 ♂, 11 ♀; Rock Co. 1 ♀; Sauk Co. 1 ♀; Trempealeau Co. 2 ♂, 1 ♀; Walworth Co. 1 ♂, 8 ♀; Washington Co. 3 ♂, 2 ♀; Waukesha Co. 1 ♀. *Totals: 346* individuals, *37* collections, *26* counties.

Previous Records: Dane Co. (no numbers). Also reported from Illinois, Iowa, Michigan and Minnesota.

Trichocorixa kanza Sailer 1948

Distribution and Abundance: Found only in the extreme southwest corner of the state, this species is uncommon (Fig. 2D).

Identification: The male strigil is much wider than that of *T. calva,* and slightly narrower than *T. borealis*. The female has three small and distinct patches of setae on the right side of the seventh abdominal sternite.

Collection Records: Dane Co. 1 ♂, 2 ♀; Grant Co. 1 ♂, 1 ♀; Lafayette Co. 8 ♂, 4 ♀. *Totals: 17* individuals, *7* collections, *3* counties.

Previous Records: Dane Co. (no numbers). Also reported from Illinois and Iowa.

Trichocorixa naias (Kirkaldy) 1908

Distribution and Abundance: This species is fairly common in the southern fourth of the state, and has been collected as far north as Door and Lincoln Counties (Fig. 2D).

Identification: The absence of a postnodal pruinose area in the female and the small rounded strigil of the male separate this species from other Wisconsin *Trichocorixa,* except *T. macroceps,* which has a very short pronotal disc.

Collection Records: Columbia Co. 16 ♂, 22 ♀; Dane Co. 39 ♂, 41 ♀; Dodge Co. 3 ♀; Door Co. 4 ♂, 4 ♀; Iowa Co. 1 ♀; Jefferson Co. 1 ♀; Lincoln Co. 3 ♂, 3 ♀; Manitowoc Co. 4 ♂, 6 ♀; Marathon Co. 1 ♂; Outagamie Co. 2 ♂, 1 ♀; Ozaukee Co. 3 ♂, 1 ♀; Racine Co. 1 ♂; Walworth Co. 2 ♀; Waukesha Co. 1 ♀; Wood Co. 6 ♂, 3 ♀. *Totals: 168* individuals, *30* collections, *15* counties.

Previous Records: Dane Co. (no numbers). Also reported from Illinois, Iowa, Michigan and Minnesota.

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TROPHIC NATURE OF SELECTED WISCONSIN LAKES

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Appreciable differences in the biota of Wisconsin lakes are apparent to even the most insensitive eye. Some lakes, such as Geneva (Walworth County) and Crystal (Vilas County), are essentially clear; others, such as Winnebago (Winnebago County) and Delavan (Walworth County), develop nuisance growths of algae, weeds, or both. Limnologists have long recognized these differences in biological composition and productivity to be related to the accumulation of nutrients and have referred to this aging process as "eutrophication." Most lakes when formed are nutrient poor or oligotrophic. They subsequently proceed to a nutrient rich, eutrophic condition. Although the distinction between oligotrophic and eutrophic lakes is, by definition, based on nutrient status, many parameters are often used to reflect the trophic status of a lake.

The object of this study was to evaluate several water quality parameters from well-known lakes where the recreational potential is recognized by the public and where long records of observation and aquatic nuisance control are available. Each of these "trophic parameters" is evaluated in terms of how well it relates to both the trophic status and the observed recreational values of each lake. A better understanding of these relationships should lead to more meaningful interpretation of water quality data, more efficient sampling programs, and better diagnostic and interpretive techniques for evaluating lake problems.

Lakes Included in the Study

The 12 lakes shown in Table 1 were selected because they are all well known and because they represent a broad range of conditions. Of the lakes selected, three (Pewaukee, Delavan, and Winnebago) have nuisance algae "blooms" during most of the summer months which render the waters less desirable for recreational purposes. A fourth (Mendota) has occasional nuisance algae populations. Rooted weed growths and *Chara sp.* growths also impair recreational potential, and Lakes Middle, Oconomowoc, Pine, and Pewaukee all have had extensive weed control activity. Lakes Mendota and Winnebago have received less weed control effort, but weeds produce local nuisances on both during the summer months.

TABLE 1. GENERAL LAKE INFORMATION

Lake	Crystal	Geneva	Green	Trout	Middle	Mendota
County	Vilas	Walworth	Green Lake	Vilas	Walworth	Dane
Area (Acres)	90	5,104	7,325	3,870	256	9,730
Maximum Depth (feet)	69	135	229	115	42	82
Development	minor	moderate	moderate	minor	moderate	extensive
pH (Nov.)	6.0	8.0	8.1	7.1	8.1	8.1
Hardness (Nov.)	4	208	200	50	217	180
Alkalinity (Nov.)	2	168	162	39	181	149
Plankton Nuisance	none	none	minor	none	minor	moderate
Chara Nuisance	none	none	moderate	none	none	none
Weed Nuisance	none	minor	minor	minor	moderate	moderate

Lake	Round	Oconomowoc	Pine	Pewaukee	Delavan	Winnebago
County	Waupaca	Waukesha	Waukesha	Waukesha	Walworth	Winnebago
Area (Acres)	106	767	703	2,359	2,072	137,708
Maximum Depth (feet)	67	62	85	45	56	21
Development	moderate	moderate	moderate	extensive	extensive	extensive
pH (Nov.)	9.3	8.3	8.2	8.3	8.2	8.15
Hardness (Nov.)	170	233	168	244	200	156
Alkalinity (Nov.)	144	186	143	188	160	136
Plankton Nuisance	minor	minor	minor	heavy	heavy	heavy
Chara Nuisance	none	heavy	moderate	minor	none	none
Weed Nuisance	none	moderate	moderate	heavy	minor	minor

Lakes Oconomowoc and Pine have had extensive *Chara sp.* control programs, and Big Green Lake has had an occasional *Chara sp.* nuisance but no control activity.

Trophic Parameters and Methods

Parameters selected for this study included the nutrients nitrogen and phosphorus, temperature, dissolved oxygen, water transparency and plankton analysis. Nitrogen was analyzed as organic nitrogen, Ammonia–N, Nitrate–N, Nitrite–N. The NH_3–N, NO_3–N, and NO_2–N concentrations were combined as inorganic nitrogen and considered available for utilization. Phosphorus was analyzed as soluble phosphorus (orthophosphates) and total phosphorus. All nutrient analyses were performed by the Wisconsin Laboratory of Hygiene in accordance with Standard Methods, 12th edition, 1965, and results are expressed in mg/l of nitrogen and phosphorus.

Temperature profiles were determined with an electronic resistance thermometer. Dissolved oxygen concentrations were determined by the modified Winkler technique, Standard Methods, 1965. Water transparency was measured with a Secchi disk and also with a Whitney light meter. Light meter values are expressed in per cent of surface incident light at each depth.

Plankton evaluations were based on net collections using a Clarke–Bumpus plankton sampler. The Clarke–Bumpus apparatus measures a known volume of water passed through the net, and the volume of plankton captured can then be used to evaluate the concentration of plankton in the water. The net used was a No. 20 standard mesh (.007 inch bar). Most plankton samples required a 1–5 minute tow depending on the quantity of plankton in the water. Samples were transferred from the plankton cup to 180 ml. storage jars, and 10 ml. of commercial formaldehyde were added for preservation. The samples were then returned to the laboratory for evaluation at a later date.

The volume of plankton constituents was estimated by visual observation under a dissecting or compound microscope. The samples were then dried and ashed to determine total and volatile solids. Plankton quantity was then reported as total solids and expressed as micrograms of solids per liter of water filtered.

Results and Discussion

Dissolved Oxygen and Temperature

The dissolved oxygen concentration in the hypolimnion may be used as a trophic parameter. Organic material produced in the trophogenic zone eventually settles through the thermocline into the tropholytic zone where it consumes oxygen during chemical and

TABLE 2. TEMPERATURE AND DISSOLVED OXYGEN BY MONTH—1966

	Crystal		Geneva		Green		Trout		Middle		Mendota	
	T*	DO†	T	DO	T	DO	T	DO	T	DO	T	DO
January												
Surface	32	13.2	No Sample		32	12.8	32	—	—	12.8	32	14.0
Middle of Hypolimnion	—	—			32	13.0	33	12.9	—	—	32	12.0
1 M above bottom	33	13.5			—	—	33	—	—	11.8	32	8.4
February												
Surface	32	7.3	33	14.3	32	13.2	32	12.1	32	11.8	33	12.7
Middle of Hypolimnion	36	12.5	34	14.2	34	13.2	32	12.5	..	..	34	10.1
1 M above bottom	37	12.6	34	12.5	—	—	32	11.1	37	10.2	34	4.5
March												
Surface	33	12.6	35	12.7	32	12.6	34	12.2	42	11.1	34	13.9
Middle of Hypolimnion	36	10.0	35	12.8	34	12.7	34	12.3	40	10.8	34	13.1
1 M above bottom	36	12.3	35	12.5	—	—	34	12.5	40	10.0	34	13.0
April												
Surface	40	12.4	41	12.2	38	12.2	No Sample		52	11.3	40	12.8
Middle of Hypolimnion	38	10.2	38	12.0	38	12.0			42	11.8	40	12.8
1 M above bottom	38	11.7	38	12.1	—	—			42	11.4	40	12.9
May												
Surface	46	11.45	45	11.3	41	12.2	42	11.95	52	10.5	50	10.8
Middle of Hypolimnion	43	11.85	45	11.4	41	12.2	42	11.75	50	11.2	47	10.7
1 M above bottom	42	11.65	45	11.4	—	—	42	11.55	48	8.7	47	10.7
June												
Surface	64	9.05	61	10.0	61	10.85	59	10.35	68	7.5	68	12.3
Middle of Hypolimnion	50	11.8	52	9.7	52	11.85	50	10.75	52	8.05	57	7.6
1 M above bottom	48	11.9	50	9.7	—	—	49	10.15	52	4.8	56	5.8

TABLE 2. TEMPERATURE AND DISSOLVED OXYGEN BY MONTH—1966—*Continued*

	CRYSTAL		GENEVA		GREEN		TROUT		MIDDLE		MENDOTA	
	T*	DO†	T	DO	T	DO	T	DO	T	DO	T	DO
July												
Surface	73	8.0	77	8.5	73	8.4	72	8.1	79	8.1	77	8.5
Middle of Hypolimnion	51	10.8	59	6.5	54	11.0	50	7.0	59	11.0	59	0.8
1 M above bottom	48	8.9	—	4.8	—	—	—	6.2	58	0.0	57	0.0
August												
Surface	69	8.2	70	7.6	No Sample		68	8.7	70	7.6	70	8.2
Middle of Hypolimnion	51	6.8	59	5.5			50	6.4	58	1.6	55	1.9
1 M above bottom	50	5.0	—	3.8			—	2.1	47	0.0	—	0.0
September												
Surface	65	8.65	69	9.0	67	8.7	64	8.65	67	8.8	66	8.0
Middle of Hypolimnion	56	5.15	—	3.5	67	—	52	5.4	64	1.1	54	0.0
1 M above bottom	52	3.15	—	2.0	67	9.9	—	3.0	51	0.0	—	0.0
October												
Surface	53	8.8	54	8.3	54	9.6	52	8.9	53	8.0	50	8.5
Middle of Hypolimnion	53	8.6	54	8.0	54	9.1	52	6.1	53	7.7	50	8.8
1 M above bottom	53	8.0	—	1.0	—	—	52	1.9	53	5.2	50	8.8
November												
Surface	40	10.5	46	9.5	42	8.1	40	10.6	41	11.2	44	9.6
Middle of Hypolimnion	40	10.5	46	9.4	42	8.1	40	10.5	41	11.3	44	9.0
1 M above bottom	40	10.5	46	9.3	—	—	40	10.5	41	11.3	44	10.2

TABLE 2. TEMPERATURE AND DISSOLVED OXYGEN BY MONTH—1966—*Continued*

	ROUND		OCONOMOWOC		PINE		PEWAUKEE		DELAVAN		WINNEBAGO	
	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
January												
Surface	32	11.7	32	—	32	13.4	32	13.7	—	12.7	32	12.8
Middle of Hypolimnion	37	13.1	—	—	34	12.5	—	—	—	12.4	—	—
1 M above bottom	37	14.1	34	12.5	34	12.4	35	7.55	—	11.6	33	13.0
February												
Surface	32	12.1	—	13.1	34	13.3	32	12.6	32	12.4	32	13.4
Middle of Hypolimnion	—	—	—	12.8	34	13.5	36	8.1	33	12.2	—	—
1 M above bottom	37	9.5	—	11.2	34	13.3	36	3.2	34	10.9	33	13.0
March												
Surface	34	12.2	38	11.2	36	12.2	38	10.0	39	14.6	33	13.0
Middle of Hypolimnion	—	—	38	11.3	36	12.1	—	—	39	14.8	—	—
1 M above bottom	38	12.4	38	11.2	36	12.2	38	8.9	39	14.7	34	13.0
April												
Surface	48	11.4	46	12.2	46	11.7	46	11.7	43	11.5	47	11.9
Middle of Hypolimnion	41	5.9	42	11.9	40	11.7	42	11.0	41	10.2	—	—
1 M above bottom	40	4.0	41	11.6	—	11.5	42	11.1	41	9.9	47	11.2
May												
Surface	54	10.95	49	11.0	46	11.4	50	11.0	49	10.5	45	10.2
Middle of Hypolimnion	45	4.5	49	10.7	46	11.0	50	10.8	49	10.8	—	—
1 M above bottom	42	3.55	49	10.2	46	10.5	50	10.9	49	10.6	45	10.0
June												
Surface	70	8.95	66	8.5	66	9.35	66	8.65	76	13.1	66	11.4
Middle of Hypolimnion	56	8.15	54	8.0	50	8.7	59	2.45	58	0.1	—	—
1 M above bottom	54	3.6	52	6.8	50	7.85	57	0.35	55	0.1	65	9.0

TABLE 2. TEMPERATURE AND DISSOLVED OXYGEN BY MONTH—1966—*Continued*

	ROUND		OCONOMOWOC		PINE		PEWAUKEE		DELAVAN		WINNEBAGO	
	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
July												
Surface	75	8.7	81	8.6	77	8.9	77	8.3	77	7.6	76	8.0
Middle of Hypolimnion	52	6.9	57	2.2	54	2.6	64	0.0	66	0.0	—	—
1 M above bottom	47	1.0	57	0.4	54	0.1	62	0.0	63	0.0	76	7.9
August												
Surface	74	8.2	69	7.7	70	8.3	70	7.2	70	7.4	No Sample	
Middle of Hypolimnion	52	6.0	59	0.7	50	2.7	—	—	54	0.0		
1 M above bottom	46	2.5	52	0.3	—	1.6	56	0.0	54	0.0		
September												
Surface	68	9.2	67	8.7	66	9.0	65	5.9	68	6.7	68	8.1
Middle of Hypolimnion	48	0.4	54	1.0	47	0.35	65	0.0	62	0.0	—	—
1 M above bottom	46	2.35	50	0.0	—	0.0	57	—	58	0.0	—	—
October												
Surface	53	9.0	51	10.2	49	9.1	49	10.1	56	7.9	51	8.3
Middle of Hypolimnion	51	5.1	51	9.4	48	8.4	49	10.0	56	8.2	—	—
1 M above bottom	44	0.15	51	9.2	48	0.0	49	9.7	56	8.0	—	—
November												
Surface	43	9.3	44	8.2	44	9.6	41	11.2	42	11.0	34	12.8
Middle of Hypolimnion	43	9.3	44	8.4	44	9.6	41	11.2	42	11.0	—	—
1 M above bottom	43	9.2	44	8.3	44	9.6	41	11.2	42	11.0	—	—

*Temperature in degrees Fahrenheit.
†Dissolved oxygen in mg/l.

biological stabilization. One may therefore assume that eutrophic lakes with a high productivity or standing crop would produce the most significant oxygen sag in the hypolimnion. These stabilization effects would of course be tempered by the volume of water in the hypolimnion, but nevertheless the quantity of dissolved oxygen in the hypolimnion is indicative of the trophic nature of a lake. Furthermore, a low dissolved oxygen concentration in the hypolimnion would affect the salmonoid and whitefish populations that might be present in the lakes.

It should be noted that even the most oligotrophic lake sampled (Crystal) revealed some reduction in the dissolved oxygen concentration of the hypolimnion. During August, the 5 mg/l observed at 17 meters was only 45 per cent of saturation. Trout Lake and Lake Geneva also revealed substantial dissolved oxygen reductions in the hypolimnion although zero values were not observed. All of the more productive lakes revealed zero dissolved oxygen values during most of the summer months. These dissolved oxygen observations suggest that Lakes Delavan, Pewaukee, Pine, Oconomowoc, Middle, and Mendota produce more organic matter in the trophogenic zone than can be aerobically assimilated by the hypolimnion. Lakes Geneva, Trout, Crystal, and perhaps Pine have not reached that level of production and consequently retain sufficient dissolved oxygen in the hypolimnion to sustain fish and fish food organism populations intolerant of low dissolved oxygen values. Lake Winnebago is too shallow to stratify, so although it is a productive lake, a deoxygenated hypolimnion does not develop. Observations by Birge on Mendota in 1906 suggest that oxygen depletion in the hypolimnion occurred at that time as well as now.

Transparency and Light Penetration

The transparency of a lake as measured by the Secchi disk may also be used as a measure of the trophic condition. The basic assumption is that the magnitude of organic production affects the color and turbidity of the water. Beeton, 1965, used the Secchi disk readings in the interpretation of the trophic nature of the Great Lakes and reported Lake Michigan as oligotrophic with a reading of 19½ feet. Values of fifteen to eighteen feet reported for Lakes Erie and Ontario were considered by Beeton to be comparatively eutrophic.

Only Crystal Lake had a mean Secchi disk reading that would be considered oligotrophic when compared with the Great Lakes. However, in all lakes where the mean Secchi disk values were greater than twelve feet, there has been essentially no deterioration of recreational potential due to plankton growths. Lakes

TABLE 3. TRANSPARENCY OF 12 WISCONSIN LAKES BY MONTH—1966
(Meters)

	March	April	May	June	July	August	September	October	November	Mean
1. Crystal	3–15–66	4–25–66	5–17–66	6– 6–66	8– 1–66	8–30–66	9–16–66	10–11–66	11– 8–66	Crystal
Secchi Disc	ice	7.62	6.10	5.79	8.23	9.75	9.14	6.71	8.53	7.74
5% Light Int.	ice	14.3	14.9	14.9	14.0	15.8	15.8	12.8	15.0	14.7
2. Geneva	3–22–66	4–18–66	5–10–66	6– 9–66	8– 3–66	8–25–66	9–19–66	10–18–66	11–44–66	Geneva
Secchi Disc	4.88	5.49	4.27	5.18	3.35	2.74	3.96	5.33	6.10	4.60
5% Light Int.	11.0	13.7	10.1	15.9	12.5	11.9	11.0	10.1	9.75	11.8
3. Green	3– 9–66	4–21–66	5–12–66	6–10–66	8– 2–66	—	9–14–66	10–12–66	11–15–66	Green
Secchi Disc	ice	5.49	4.57	7.62	2.74	—	5.79	5.79	5.79	5.39
5% Light Int.	ice	12.8	10.1	—	8.53	—	11.0	7.92	17.1	11.2
4. Trout	3–15–66	4–25–66	5–17–66	6– 6–66	8– 1–66	8–30–66	9–16–66	10–11–66	11– 8–66	Trout
Secchi Disc	ice	ice	3.66	2.74	3.96	4.88	5.18	3.96	4.27	4.08
5% Light Int.	ice	ice	9.14	10.1	8.99	7.92	8.84	6.40	5.49	8.11
5. Middle	3–22–66	4–18–66	5–10–66	6– 9–66	8– 3–66	8–25–66	9–19–66	10–18–66	11–14–66	Middle
Secchi Disc	3.05	5.79	5.18	5.49	4.57	3.05	3.96	4.88	3.35	4.36
5% Light Int.	7.01	11.9	9.14	10.4	7.01	11.9	8.84	11.9	7.32	9.48
6. Mendota	3–28–66	4–20–66	5–10–66	6– 8–66	8– 5–66	8–26–66	9–21–66	10–24–66	11–11–66	Mendota
Secchi Disc	1.98	3.81	5.49	1.83	2.13	2.13	2.44	2.74	5.49	3.11
5% Light Int.	3.51	7.01	7.92	2.44	3.96	3.96	4.88	4.88	8.84	5.27

TABLE 3. TRANSPARENCY OF 12 WISCONSIN LAKES BY MONTH—1966—*Continued*

7. Round	3–15–66	4–26–66	5–17–66	6– 6–66	8– 2–66	8–29–66	9–16–66	10–11–66	11– 7–66	Round
Secchi Disc	ice	2.44	3.35	6.10	4.27	3.35	4.27	3.35	4.27	3.93
5% Light Int.	ice	5.94	7.92	11.0	14.3	11.0	11.3	7.92	—	9.91
8. Oconomowoc	3–18–66	4–19–66	5– 9–66	6– 9–66	8– 4–66	8–24–66	9–20–66	10–28–66	11–10–66	Oconomowoc
Secchi Disc	4.88	3.35	4.27	7.32	3.35	6.10	4.57	3.05	2.74	4.39
5% Light Int.	11.0	7.01	7.01	10.4	11.9	8.84	8.84	4.88	5.40	8.35
9. Pine	3–18–66	4–19–66	5– 9–66	6– 9–66	8– 4–66	8–24–66	9–20–66	10–28–66	11–10–66	Pine
Secchi Disc	1.68	1.83	1.83	1.83	4.27	3.96	3.96	2.44	2.13	2.65
5% Light Int.	—	5.03	4.42	4.42	8.84	8.84	9.45	3.96	3.35	6.89
10. Pewaukee	3–18–66	4–19–66	5– 9–66	6– 9–66	8– 4–66	8–24–66	9–20–66	10–28–66	11–10–66	Pewaukee
Secchi Disc	1.98	1.37	.914	1.22	1.83	1.52	1.52	1.83	1.83	1.55
5% Light Int.	4.42	3.96	1.52	1.52	5.79	4.42	2.44	2.90	2.44	3.26
11. Delavan	3–22–66	4–18–66	5–10–66	6–22–66	8– 3–66	8–25–66	9–19–66	10–14–66	11–14–66	Delavan
Secchi Disc	.914	1.98	1.52	1.83	1.52	1.22	1.22	1.83	2.44	1.62
5% Light Int.	2.29	3.84	3.44	3.51	4.42	3.96	1.98	3.05	3.35	3.29
12. Winnebago	3– 9–66	4–21–66	5–12–66	6–15–66	7– 8–66	—	9–14–66	10–12–66	11–15–66	Winnebago
Secchi Disc	ice	.305	.914	.914	1.07	—	.457	.305	.914	.701
5% Light Int.	ice	.610	1.98	1.07	—	—	—	1.52	—	1.31

Mendota, Pine, Pewaukee, and Delavan have all had an extensive history of planktonic nuisance and all have mean seasonal Secchi disk values of ten feet or less. Those lakes that have a history of plankton nuisance conditions also reveal a 5 per cent incident light sesonal mean of twenty-five feet or less. In this respect there is good agreement between Secchi disk and per cent of incident light. However, the absolute correlation between Secchi disk and per cent of incident light on a particular lake is not readily apparent.

Plankton Population

The plankton populations on the twelve lakes studied are represented in Figure I for the months when no ice cover was present. The evaluations were based on Clarke–Bumpus net tows (No. 20 mesh net) and the results are expressed in μg/l total solids.

In the twelve lakes under consideration, Crystal, Trout, Geneva, Big Green and Round Lake revealed less than 200 μg/l of solids consistently, and nuisance-producing blue–green varieties were detectable in trace quantities only. The plankton populations in these lakes were most typically composed of zooplankton and diatoms. Middle and Oconomowoc Lakes did not reveal plankton concentrations that would be considered a nuisance, although the solids analyses revealed between 700 and 1,500 μg/l on five occasions. The plankton were principally diatoms or zooplankton, which do not have the nuisance-producing capability characteristic of the blue–green algae. Past aquatic nuisance control records of the Department of Natural Resources suggest that Delavan Lake has nuisance algae conditions during the entire summer. The plankton catches from June through October revealed 2,500 μg/l on four of five occasions. The plankton populations were dominated by blue–green varieties with *Anacystis sp.*, *Anabaena sp.*, and *Oscillatoria sp.* predominating. The aquatic nuisance control records further reveal that shoreline accumulations are a general problem on Delavan Lake and are treated with copper sulphate weekly to control odors and increase the aesthetic and recreational value of the shoreline areas.

Lake Winnebago had 1,500 μg/l of solids in the April through October samples. There is no question that plankton populations produce periodic nuisance conditions on Lake Winnebago, but the species composition estimates reveal the principal constituents of the population are diatoms and zooplankton. On only one occasion (June 15, 1966) did blue–green algae varieties *(Anabaena sp., Aphanizomenon sp.,* and *Anacystis sp.)* thoroughly dominate the plankton populations. This observation was substantiated by the

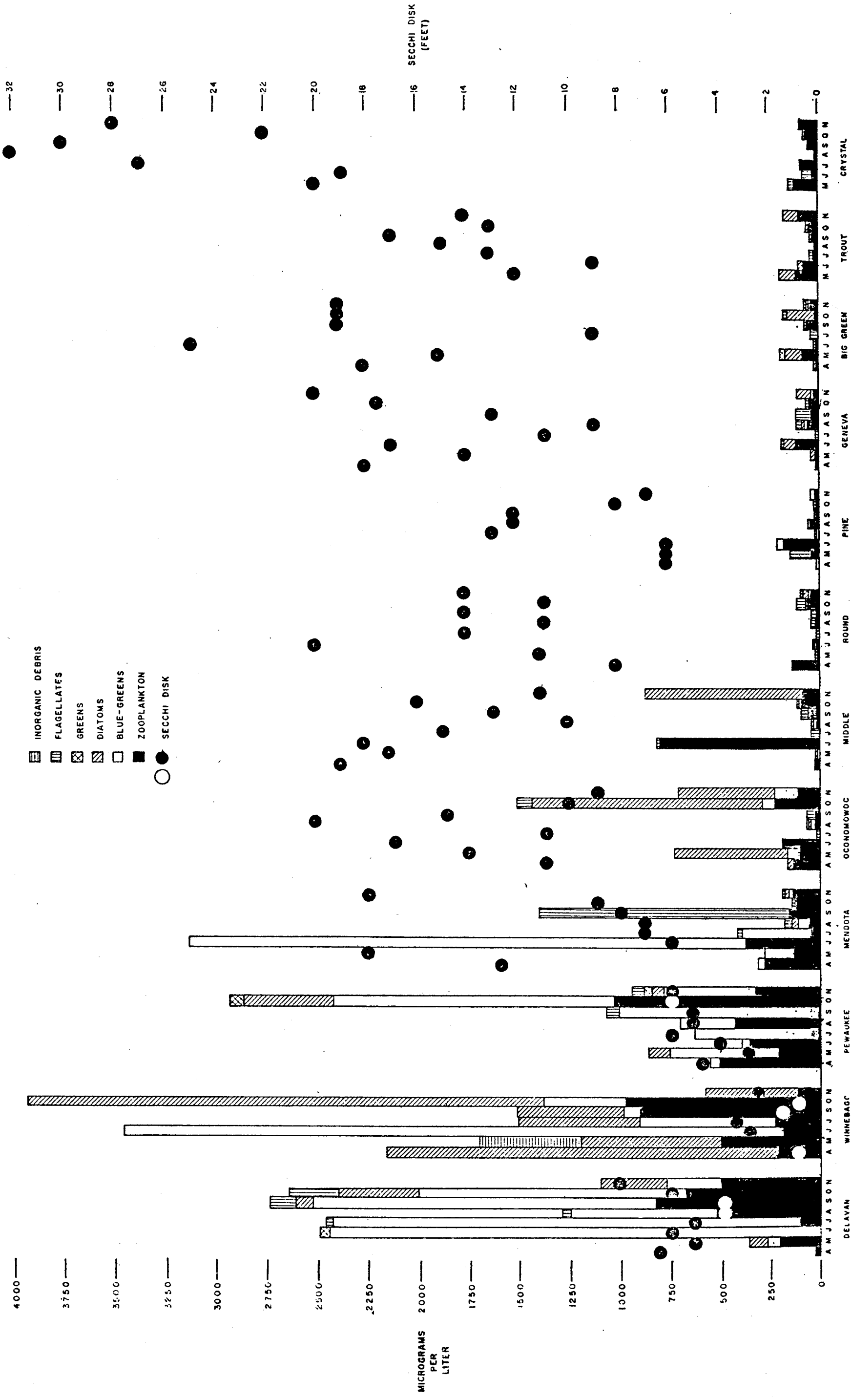

FIGURE 1. Plankton Volumes and Secchi Disks (April through November, 1966).

increased percentage of volatile solids. During the five months when varieties other than blue–green algae dominated the plankton population, the volatile solids averaged approximately 40 per cent. In June, when blue–green algae dominated the plankton volume, the volatile solids represented 90 per cent of the total solids.

Pewaukee Lake has had a long history of algae nuisance control activity, and the blue–green varieties represented a significant portion of the plankton in six of the seven summer–fall collections. A general observation for Pewaukee Lake on June ninth revealed approximately 400 μg/l total solids dominated by zooplankton with no indication of nuisance plankton. On August fourth, 700 μg/l total solids were recorded dominated by *Anabaena flosaquae*. The visual observation of the lake suggested a distinct "bloom" condition. On October twenty-eighth, nearly 2,900 μg/l of solids were recorded as a seasonal high in Pewaukee Lake.

Lake Mendota is a lake that is sporadically plagued by nuisance algae blooms. On June eighth, a visual observation suggested a high algae population, and the Clarke–Bumpus sample recorded over 3,100 μg/l total solids dominated by *Aphanizomenon sp.* Seven other monthly visual observations on Lake Mendota failed to suggest bloom conditions. Total solids were less than 500 μg/l in all other collections except September when a *Ceratium sp.* dominated 1,400 μg/l total solids. This population was not visually noticeable at the time of collection and would not affect recreational potential.

Oconomowoc and Middle Lakes revealed 500 μg/l total solids on five of sixteen occasions, but the populations were dominated by diatoms or zooplankton. At no time were nuisance plankton conditions observed in the lake water.

Round Lake revealed the lowest plankton values of the twelve lakes studied, even though organic nitrogen and Secchi disk observations suggested that there should have been more plankton present. This apparent inconsistency may be partially explained by the fact that small algae cells will not be captured in the No. 20 mesh net. In the case of Round Lake, *Chlorella sp.* was observed in the water samples in sufficient quantities to color the lake water. In this case the plankton analysis techniques were not adequate to represent the actual condition of the lake.

Figure I, which illustrates the plankton population, also shows Secchi disk readings at the time of plankton collection. In general, Delavan, Pewaukee, and Winnebago, which have relatively high plankton populations, have low Secchi disk readings. Lake Mendota, with variable plankton populations, had Secchi disk readings of twelve to sixteen feet in spring and fall but only six to nine feet in midsummer, with no apparent correlation to algae populations.

The lakes with relatively low plankton populations had higher Secchi disk readings, but the cause of variability was not determined. Crystal Lake clarity was obvious both by visual observation and by Secchi disk readings.

NUTRIENTS

Lake eutrophication, by definition, is an accumulation of nutrients. Many elements and compounds act as nutrients for the development of weeds and algae. However, nitrogen and phosphorus are usually considered the limiting nutrients and as such have received the most emphasis. Sawyer (1947) indicated that lakes containing 0.3 mg/l inorganic nitrogen (NO_3-N, NO_2-N, and NH_3N) and 0.015 mg/l soluble phosphorus at time of spring turnover are capable of producing nuisance algae growths. Gerloff and Skoog (1957) suggested that the nitrogen–phosphorus ratio as it occurred in water was an indication of the ability of that water to produce algae, and their laboratory studies indicated that a ratio of 60 to 1 (nitrogen to phosphorus) was an appropriate ratio for optimum growth. Gerloff and Skoog further suggested that nitrogen was generally the limiting factor in algae production, while other studies (Federal Water Pollution Control Administration, Lake Sebasticook) suggest phosphorus may be the limiting factor since ample nitrogen is available from the atmosphere through nitrification by bacteria and blue–green algae. Whatever the limiting factor in primary production may be, it appears that the concentration of nitrogen and phosphorus is useful in evaluating the trophic condition of a particular lake. Table IV is a summary of monthly nitrogen and phosphorus concentrations from the epilimnion and hypolimnion of the twelve lakes studied.

Inorganic Nitrogen

The inorganic nitrogen is available for utilization in the production of organic matter. The most obvious source of available nitrogen is nitrate nitrogen (NO_3). Nitrite nitrogen (NO_2) is an unstable state, and even eutrophic lakes typically have less than 0.01 mg/l. Ammonia nitrogen (NH_3) is readily oxidized by nitrifying bacteria in the presence of oxygen to nitrate nitrogen and is therefore essentially available for organic production in the epilimnion.

Five of the twelve lakes studied in this investigation (Round, Mendota, Delavan, Pewaukee, and Winnebago) revealed an eleven-month mean total inorganic nitrogen concentration greater than the 0.3 mg/l regarded as critical by Sawyer. Of these five lakes,

TABLE 4. MONTHLY NITROGEN–PHOSPHORUS CONCENTRATIONS (MILLIGRAMS PER LITER) FOR TWELVE WISCONSIN LAKES—1966

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
	E*	H†	E	H	E	H	E	H	E	H	E	H
PINE												
TION*	.178	.206	.223	.233	.213	.163	.184	.184	.188	.327	.082	.396
NH_3	.11	.14	.12	.11	.15	.10	.10	.10	.12	.26	.04	.35
NO_2	.008	.006	.003	.003	.003	.003	.004	.004	.008	.007	<.002	.006
NO_3	.06	.06	.10	.12	.06	.06	.08	.08	.06	.06	.04	.04
TON*	.92	.75	.64	.72	.69	.73	.46	.44	.65	.59	.69	.77
SP*	.26	.27	.23	.22	.23	.22	.20	.20	.22	.22	.23	.26
TP*	.26	.28	.23	.22	.26	.26	.20	.20	.28	.28	.24	.30
PEWAUKEE												
TION	.264	.606	.829	1.097	.536	.476	.376	.457	.154	.353	.112	.352
NH_3	.12	.34	.80	.80	.35	.29	.09	.21	.06	.24	.07	.31
NO_2	.004	.006	.015	.037	.006	.006	.006	.007	.014	.013	<.002	<.002
NO_3	.14	.26	.14	.26	.18	.18	.28	.24	.08	.10	.04	.04
TON	2.16	.94	2.76	1.33	1.08	1.03	.72	.61	1.00	1.27	.98	1.04
SP	.14	.18	.05	.21	.12	.13	.10	.10	.088	.085	.11	.10
TP	.26	.20	.18	.26	.16	.18	.14	.132	.16	.16	.16	.22
DELAVAN												
TION	.829	1.11	.842	.92	.51	.48	.47	.52	.372	.442	.254	1.357
NH_3	.45	.45	.43	.51	.10	.11	.12	.21	.04	.11	.19	1.29
NO_2	.019	.020	.012	.01	.01	.01	.01	.01	.012	.012	.003	.006
NO_3	.36	.64	.40	.40	.40	.36	.34	.30	.32	.32	.061	.061
TON	1.43	1.08	.97	.86	1.16	1.25	.82	.86	1.04	1.19	2.26	.89
SP	.19	.22	.15	.20	.08	.08	.07	.072	.08	.08	.02	.29
TP	.24	.24	.16	.22	.2	.18	.140	.144	.16	.22	.20	.34
WINNEBAGO												
TION	.542	—	.614	—	.72	—	.23	—	.184	—	.336	—
NH_3	.11	—	.12	—	.14	—	.06	—	.06	—	.09	—
NO_2	<.002	—	.004	—	.02	—	.01	—	.004	—	.006	—
NO_3	.43	—	.49	—	.56	—	.16	—	.12	—	.24	—
TON	.76	—	.70	—	.63	—	1.01	—	.73	—	1.04	—
SP	.06	—	.04	—	.03	—	.017	—	.009	—	.022	—
TP	.08	—	.08	—	.06	—	.132	—	.06	—	.12	—

TABLE 4. MONTHLY NITROGEN–PHOSPHORUS CONCENTRATIONS (MILLIGRAMS PER LITER) FOR TWELVE WISCONSIN LAKES—1966—*Continued*

	January		February		March		April		May		June	
	E	H	E	H	E	H	E	H	E	H	E	H
MIDDLE												
TION	.234	.448	.354	.756	.529	.589	.327	.397	.465	.546	.145	.388
NH_3	.15	.18	.15	.27	.18	.24	.12	.13	.16	.16	.11	.30
NO_2	.004	.008	.004	.006	.009	.009	.007	.007	.005	.006	.005	.008
NO_3	.08	.26	.2	.48	.34	.34	.20	.26	.3	.38	.04	.08
TON	.57	.54	.33	.48	.43	.45	.44	.47	.42	.46	.48	.50
SP	.06	.06	.02	.04	.04	.06	.012	.012	.02	.02	.039	.03
TP	.08	.06	.04	.06	.18	.13	.028	.028	.028	.048	.10	.10
MENDOTA												
TION	1.009	.551	.837	1.058	.652	.878	.373	.362	.581	.531	.192	.561
NH_3	.72	.36	.51	.73	.26	.35	.12	.09	.13	.10	.09	.37
NO_2	.009	.011	.017	.008	.012	.008	.013	.012	.011	.011	.002	.011
NO_3	.28	.18	.32	.32	.38	.52	.24	.26	.44	.42	.10	.18
TON	.76	.60	.85	.72	.72	.64	.35	.39	.53	.52	—	.56
SP	.14	.11	.48	.16	.04	.05	.035	.03	.04	.04	.007	.137
TP	.16	.12	.18	—	.08	.08	.078	.08	.066	.064	.116	.184
ROUND												
TION	.765	1.185	1.132	1.362	.723	1.064	1.156	1.766	.956	1.532	.636	1.136
NH_3	.22	.50	.44	.38	.31	.35	.10	.28	.14	.33	.03	.09
NO_2	$<.005$	$<.005$	.012	.022	.013	.014	.016	.046	.016	.042	.016	.04
NO_3	.54	.68	.68	.96	.40	.70	1.04	1.44	.80	1.16	.60	1.06
TON	.53	.37	.48	.51	.62	.66	.59	.56	.53	.48	.36	.51
SP	.03	.03	.02	$>.01$	.04	.05	.007	.003	.01	.01	.015	.012
TP	.12	.04	.04	.02	.2	.26	.018	.024	.072	.084	.034	.068
OCONOMOWOC												
TION	.428	.238	.433	.483	.257	.367	.376	.356	.319	.543	.082	.123
NH_3	.24	.15	.15	.20	.13	.14	.09	.09	.13	.25	.04	.08
NO_2	.008	.008	.003	.003	.007	.007	.006	.006	.009	.013	$<.002$	.003
NO_3	.18	.18	.28	.28	.22	.22	.28	.26	.18	.28	$<.04$	$<.04$
TON	.54	.52	.45	.63	.54	.60	.35	.34	.47	.53	.39	.37
SP	.07	.06	.07	.07	.06	.07	.034	.037	.039	.041	.012	.01
TP	.08	.08	.08	.08	.08	.08	.06	.064	.08	.08	.04	.10

TABLE 4. MONTHLY NITROGEN–PHOSPHORUS CONCENTRATIONS (MILLIGRAMS PER LITER) FOR TWELVE WISCONSIN LAKES—1966—*Continued*

	January		February		March		April		May		June	
	E	H	E	H	E	H	E	H	E	H	E	H
CRYSTAL												
TION	.152	.082	.132	.202	.132	.133	.152	.20	.112	.102	.102	.082
NH_3	.07	.04	.09	.16	.09	.09	.07	.08	.05	.04	.02	.02
NO_2	.002	.002	.002	.002	.004	.003	<.002	—	<.002	<.002	.002	<.002
NO_3	.08	.04	<.04	.04	<.04	<.04	.08	.10	.06	.06	.08	.04
TON	.16	.15	.14	<.16	.14	.18	.24	.26	.17	.18	.10	.10
SP	.04	.04	.01	<.01	.08	.05	.002	.002	.012	.10	.014	.018
TP	.04	.06	.02	.04	.36	.28	.012	.02	.086	.088	.048	.028
GENEVA												
TION	—	—	.202	.182	.143	.213	.092	.092	.183	.233	.082	.123
NH_3	—	—	.04	.04	.08	.13	.05	.05	.02	.07	.04	.08
NO_2	—	—	<.002	<.002	.003	.003	.002	.002	.003	.003	<.002	.003
NO_3	—	—	.16	.14	.06	.08	<.04	<.04	.16	.16	<.04	<.04
TON	—	—	.35	.33	.42	.43	.34	.38	.37	.14	.39	.37
SP	—	—	.03	.03	.008	.008	.006	.006	.02	<.01	.12	.01
TP	—	—	.06	.06	.03	.03	.024	.024	.044	.036	.04	.10
BIG GREEN												
TION	.283	.392	.412	.333	.286	.29	.313	—	.316	.291	.122	.333
NH_3	.04	.07	.04	.05	.02	.03	.05	—	.07	.02	.06	.09
NO_2	.003	.002	.002	.003	.006	.01	.003	—	.006	.011	<.002	.003
NO_3	.24	.32	.37	.28	.26	.25	.26	—	.24	.26	.06	.24
TON	.51	.38	.36	.36	.31	.30	.28	—	.31	.33	.32	.38
SP	.06	.05	.05	.04	.04	.04	.029	—	.03	.032	<.002	.02
TP	.06	.06	.10	.12	.06	.06	.042	—	<.04	<.04	.06	.06
TROUT												
TION	.132	.112	.092	.132	.502	.102	—	—	.102	.082	.082	.082
NH_3	.05	.05	.05	.07	—	.06	—	—	.06	.04	.04	.04
NO_2	<.002	<.002	<.002	<.002	.002	.002	—	—	<.002	<.002	<.002	.002
NO_3	.08	.06	.04	.06	<.04	<.04	—	—	<.04	<.04	<.04	<.04
TON	.21	.18	.16	.19	.21	.21	—	—	.23	.25	.17	.21
SP	.04	.04	<.01	.01	.08	.04	—	—	.003	.006	.01	.022
TP	.05	.06	.02	.02	.20	.2	—	—	.84	.096	.042	.056

TABLE 4. MONTHLY NITROGEN–PHOSPHORUS CONCENTRATIONS (MILLIGRAMS PER LITER) FOR TWELVE WISCONSIN LAKES—1966—*Continued*

	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		MEAN & SD	
	E	H	E	H	E	H	E	H	E	H	E	H
PINE												
TION	.242	.962	.162	.84	.142	.192	.094	1.304	.505	.504	.201 ±.0755	.480 ± .2554
NH_3	.05	.79	.04	.67	.06	.11	.05	1.26	.08	.08	.084 ±.0007	.361 ± .259
NO_2	.002	.002	<.002	—	.002	.002	.004	.004	.005	.004	.004 ±.0015	.001 ± .0012
NO_3	.19	.17	.12	.14	.08	.08	.04	<.04	.42	.42	.114 ±.074	.115 ± .073
TON	.64	.66	.53	.70	.71	.69	.68	.67	.35	.35	.633 ±.0992	.643 ± .0895
SP	.25	.26	.26	.33	.24	.25	.26	.14	.26	.26	.240 ±.0104	.239 ± .032
TP	.266	.36	.26	.38	.24	.40	.292	.42	.26	.264	.253 ±.0105	.306 ± .156
PEWAUKEE												
TION	.232	.843	.272	5.296	.405	2.24	.446	.467	1.003	.945	.421 ±.186	1.195 ± .984
NH_3	.07	.72	.11	5.15	.30	2.13	.35	.37	.29	.35	.237 ±.1484	.992 ±1.220
NO_2	.002	.003	.002	.006	.005	.01	.016	.017	.013	.015	.008 ±.0038	.011 ± .0308
NO_3	.16	.12	.16	.14	.10	.10	.08	.08	.70	.58	.053 ±.0674	.043 ± .0074
TON	.95	.99	1.08	1.11	1.04	1.19	.98	1.01	.53	.54	.827 ±.409	.568 ± .295
SP	.14	.19	.13	.30	.13	.33	.154	.15	.128	.123	.009 ±.0555	.020 ± .0882
TP	.196	.34	.18	.44	.18	.48	.218	.232	.52	.166	.042 ±.079	.043 ± .0128
DELAVAN												
TION	.193	2.003	.112	3.092	.233	.853	.696	.728	.662	.693	.470 ±.173	.625 ± .628
NH_3	.05	1.86	.05	3.03	.13	.77	.57	.64	.45	.48	.040 ±.1569	.410 ± .662
NO_2	.003	.003	<.002	.002	.003	.003	.006	.008	.012	.013	.013 ±.0127	.009 ± .007
NO_3	.14	.14	.06	.06	.10	.08	.12	.08	.20	.20	.227 ±.0926	.240 ± .123
TON	1.17	.75	1.16	.93	1.25	.81	1.02	1.02	.87	.99	1.195 ±.264	.966 ± .106
SP	.01	.56	.012	.70	.024	.71	.10	.12	.09	.095	.075 ±.039	.284 ± .169
TP	.12	.62	.126	.72	.128	.78	.24	.34	.158	.162	.170 ±.0294	.361 ± .157
WINNEBAGO												
TION	.282	—	—	—	.212	—	.202	—	.215	—	.354 ±.141	—
NH_3	.12	—	—	—	.07	—	.06	—	.05	—	.088 ±.023	—
NO_2	.002	—	—	—	<.002	—	<.002	—	.005	—	.006 ±.040	—
NO_3	.16	—	—	—	.14	—	.14	—	.16	—	.260 ±.119	—
TON	1.02	—	—	—	1.91	—	1.22	—	.80	—	.982 ±.269	—
SP	.01	—	—	—	.94	—	<.03	—	.017	—	.031 ±.0678	—
TP	.14	—	—	—	.248	—	.24	—	.128	—	.129 ±.108	—

TABLE 4. MONTHLY NITROGEN–PHOSPHORUS CONCENTRATIONS (MILLIGRAMS PER LITER) FOR TWELVE WISCONSIN LAKES—1966—*Continued*

	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		MEAN & SD	
	E	H	E	H	E	H	E	H	E	H	E	H
MIDDLE												
TION	.173	1.154	.112	.882	.103	.218	.193	.404	.256	.336	.263 ± .0951	.556 ± .1847
NH_3	.05	.99	.05	.82	.04	.13	.13	.32	.05	.09	.108 ± .0347	.330 ± .1990
NO_2	.003	.004	<.002	.002	.003	<.008	.003	.004	.006	.006	.005 ± .0014	.006 ± .0014
NO_3	.12	.16	.06	.06	.06	.08	.06	.08	.20	.24	.151 ± .0699	.220 ± .0948
TON	.47	.68	.51	.81	.52	.65	.43	.47	.49	.48	.463 ± .0426	.545 ± .0787
SP	.05	.06	.049	—	.051	.05	.039	.045	.028	.033	.037 ± .013	.0410 ± .0142
TP	.08	.14	.084	.124	.06	.124	.116	.116	.056	.124	.077 ± .0298	.096 ± .0263
MENDOTA												
TION	.282	.192	.293	2.642	.865	.183	.538	.479	.752	.672	.5794 ± .1818	.737 ± .459
NH_3	.10	.13	.25	2.6	.78	.06	.43	.37	.38	.38	.343 ± .1651	.504 ± .4849
NO_2	<.002	<.002	.003	<.002	.005	.003	.008	.009	.011	.012	.008 ± .0033	.008 ± .0027
NO_3	.18	.16	.04	.04	.08	.12	.10	.10	.361	.28	.229 ± .0924	.234 ± .0965
TON	.78	.56	.66	.59	.64	.66	.56	.62	.29	.28	.6140 ± .1312	.558 ± .0842
SP	.01	.48	.012	.26	.08	<.01	.119	.162	.10	.10	.0665 ± .0356	.140 ± .0902
TP	.066	.54	.06	.58	.53	.06	.152	.11	.148	.152	.1487 ± .0898	.1970 ± .1398
ROUND												
TION	.471	1.17	.639	2.40	.418	.458	.884	1.382	.883	.903	.788 ± .163	1.305 ± .334
NH_3	.07	.07	.05	.45	.07	.09	.11	.96	.28	.29	.165 ± .088	.345 ± .168
NO_2	.011	.10	.009	.055	.008	.028	.014	.102	.023	.033	.011 ± .0042	.044 ± .021
NO_3	.40	1.0	.58	1.90	.34	.34	.76	.32	.58	.58	.611 ± .137	.922 ± .317
TON	.45	.47	.45	.74	.45	.43	.49	.62	.50	.51	.495 ± .048	.533 ± .071
SP	.005	.008	.008	.009	<.002	.005	.007	.014	.006	.012	.014 ± .008	.015 ± .009
TP	.024	.04	.024	.066	.018	.034	.034	.054	.044	.04	.057 ± .0376	.066 ± .045
OCONOMOWOC												
TION	.192	1.032	.193	.774	.144	.564	.147	.207	.464	.435	.276 ± .105	.466 ± .0177
NH_3	.05	.84	.05	.57	.06	.46	.10	.16	.06	.07	.100 ± .0402	.274 ± .166
NO_2	.002	.022	.003	.024	.004	.004	.007	.007	.004	.005	.005 ± .0017	.009 ± .0082
NO_3	.14	.17	.14	.18	.08	.10	.04	.04	.4	.36	.156 ± .060	.192 ± .069
TON	.48	.61	.50	.52	.50	.56	.57	.55	.27	.28	.460 ± .0607	.510 ± .0788
SP	.12	.21	.09	.08	.07	.11	.78	.084	.072	.069	.129 ± .1464	.076 ± .0347
TP	.128	.274	.14	.12	.10	.24	.158	.104	.09	.086	.094 ± .0235	.119 ± .047

TABLE 4. MONTHLY NITROGEN–PHOSPHORUS CONCENTRATIONS (MILLIGRAMS PER LITER) FOR TWELVE WISCONSIN LAKES—1966—*Continued*

	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		MEAN & SD	
	E	H	E	H	E	H	E	H	E	H	E	H
CRYSTAL												
TION	.092	.05	.183	.192	.053	.073	.122	.222	.136	.103	.124 ± .0228	.131 ± .0413
NH_3	.05	.008	.02	.03	.01	.03	.04	.08	.05	.02	.051 ± .0184	.054 ± .0299
NO_2	< .002	.002	.003	.002	.003	.003	.002	.002	.006	.003	.0027 ± .00085	.0023 ± .0003
NO_3	.04	.04	.16	.16	< .04	< .04	.08	.14	.08	.08	.071 ± .0236	.071 ± .0296
TON	.19	.25	.17	.22	.17	.24	.16	.21	.14	.17	.162 ± .0236	.193 ± .0325
SP	.004	.008	.008	.011	< .002	.011	.010	.022	.011	.021	.018 ± .0156	.026 ± .0191
TP	.012	.024	.022	.052	.022	.042	.018	.04	.028	.042	.027 ± .0200	.065 ± .0495
GENEVA												
TION	.152	.253	.142	.244	.103	.215	.314	.176	.29	.178	.170 ± .056	.191 ± .0372
NH_3	.05	.05	.08	.10	.02	.03	.05	.07	.10	.03	.053 ± .0188	.064 ± .0239
NO_2	.002	.003	< .002	.004	.003	.005	.004	.006	.01	.008	.003 ± .0018	.004 ± .0014
NO_3	.10	.20	.06	.14	.08	.18	.26	.10	.18	.14	.114 ± .0523	.112 ± .0377
TON	.34	.30	.40	.38	.39	.37	.36	.35	.43	.38	.379 ± .0342	.343 ± .0567
SP	.02	.01	.009	.024	.026	.02	.04	.064	.012	.012	.018 ± .0079	.019 ± .0125
TP	.04	.04	.034	.056	.032	.06	.072	.104	.032	.032	.041 ± .015	.054 ± .0202
BIG GREEN												
TION	.174	.402	—	—	.162	.406	—	.474	.273	.343	.245 ± .070	.371 ± .053
NH_3	.07	.10	—	—	.06	.04	.03	.05	< .03	< .02	.047 ± .0127	.052 ± .0224
NO_2	.004	.002	—	—	< .002	.006	.002	.004	.003	.003	.003 ± .0011	.005 ± .0026
NO_3	.10	.30	—	—	.10	.36	.08	.42	.24	.32	.195 ± .073	.306 ± .0444
TON	.42	.76	—	—	.34	.36	.40	.36	.33	.76	.358 ± .0489	.443 ± .139
SP	.008	.033	—	—	.019	.052	.011	.012	.024	.052	.027 ± .0133	.037 ± .0108
TP	.022	.072	—	—	.04	.06	.028	.042	.062	.09	.051 ± .016	.067 ± .0191
TROUT												
TION	.132	.122	.313	.463	.083	.122	.132	.243	.188	.234	.176 ± .0957	.167 ± .079
NH_3	.07	.04	< .01	.02	.04	.02	.05	.04	.04	.05	.045 ± .0128	.0430 ± .0112
NO_2	< .002	< .002	.003	.003	.003	.002	.002	.003	.008	.004	.003 ± .0013	.002 ± .0005
NO_3	.06	.08	.30	.44	< .04	.10	.08	.20	.14	.18	.086 ± .0584	.124 ± .0894
TON	.34	.33	.24	.21	.52	.18	.21	.23	.22	.22	.251 ± .076	.221 ± .118
SP	< .002	.008	.014	.026	.005	.003	.007	.01	.011	.12	.018 ± .143	.029 ± .158
TP	.024	.036	.022	.06	.038	.028	.024	.04	.028	.032	.053 ± .038	.063 ± .045

*Epilimnion. †Hypolimnion. *TION—Total Inorganic Nitrogen ($NH_3+NO_2+NO_3$). *TON—Total Organic Nitrogen.
*SP—Soluble Phosphorus (Orthophosphates). *TP—Total Phosphorus.

four have a general algae nuisance during much of the summer. Interestingly, the lake with the highest mean inorganic nitrogen concentration (Round) was the lake without an algae nuisance problem. Of the seven lakes with less than 0.3 mg/l inorganic nitrogen, none has a general algae problem, although rare nuisance accumulations have been observed by residents on five of these lakes. Only Crystal and Trout Lakes are essentially free of algae nuisances.

Figure II represents the total inorganic nitrogen by month and suggests that the inorganic nitrogen fluctuates seasonally. The magnitude of the fluctuations apparently depends on the quantity of inorganic nitrogen available and the subsequent algae standing crop. This data suggests that samples of total inorganic nitrogen may be collected at any time of the year from oligotrophic lakes without interfering with interpretation. However, total inorganic nitrogen collections from eutrophic lakes must be interpreted with regard to season. Sawyer realized the seasonal sampling difficulties and suggested spring overturn as the most appropriate sample time. This may very well be, but stratification typically commenced within hours after spring overturn, and a homogeneous spring overturn sample normally could not be collected. The fall overturn (November sample) appeared to be most stable and representative for Round, Mendota, Delavan, and Pewaukee, but was less representative for Lake Winnebago.

Total Organic Nitrogen

Total organic nitrogen concentrations represent the nitrogen bound by biological processes. As such, it is a useful measure of the trophic condition. The three most eutrophic lakes by this parameter are Delavan, Winnebago, and Pewaukee. Trout, Crystal, and Big Green are the most oligotrophic.

As in the case of inorganic nitrogen, the concentration of organic nitrogen in a relatively oligotrophic lake (Geneva) has no apparent monthly variation (Figure III). Both eutrophic lakes revealed variability, but it was not seasonally oriented as in the case of inorganic nitrogen. The 2.76 mg/l observed on Pewaukee Lake in February was at a time of ice cover and no plankton sample was collected; however, considerable algae were noted in the water samples. The 2.26 mg/l observed on Delavan in June was at a time of high algae population, but the algae population in July, September, and October was just as high with substantially lower organic nitrogen levels.

The range of means was so well distributed on this parameter that it is one parameter in which annual means could offer a

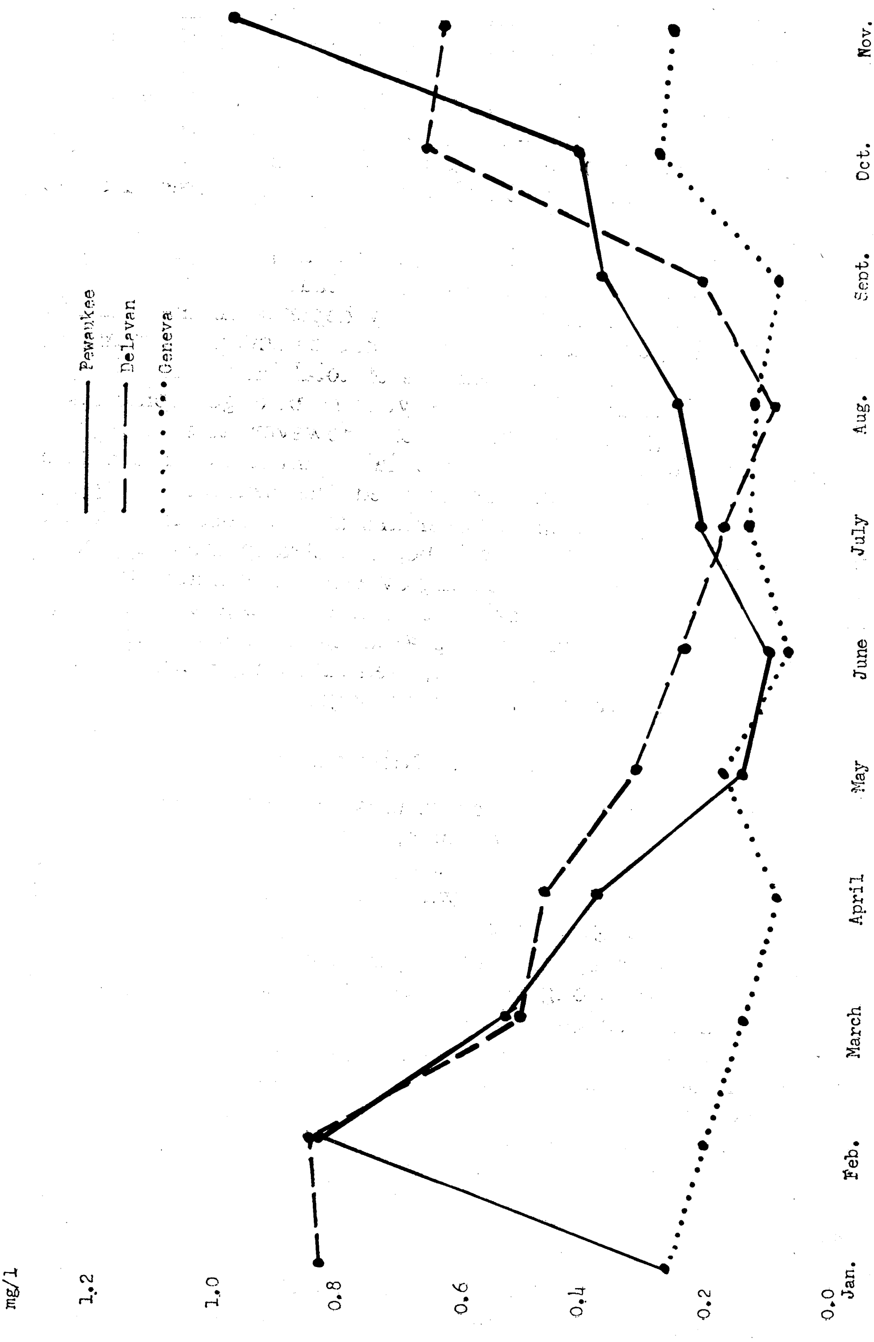

FIGURE 2. Total Inorganic Nitrogen in Surface Samples.

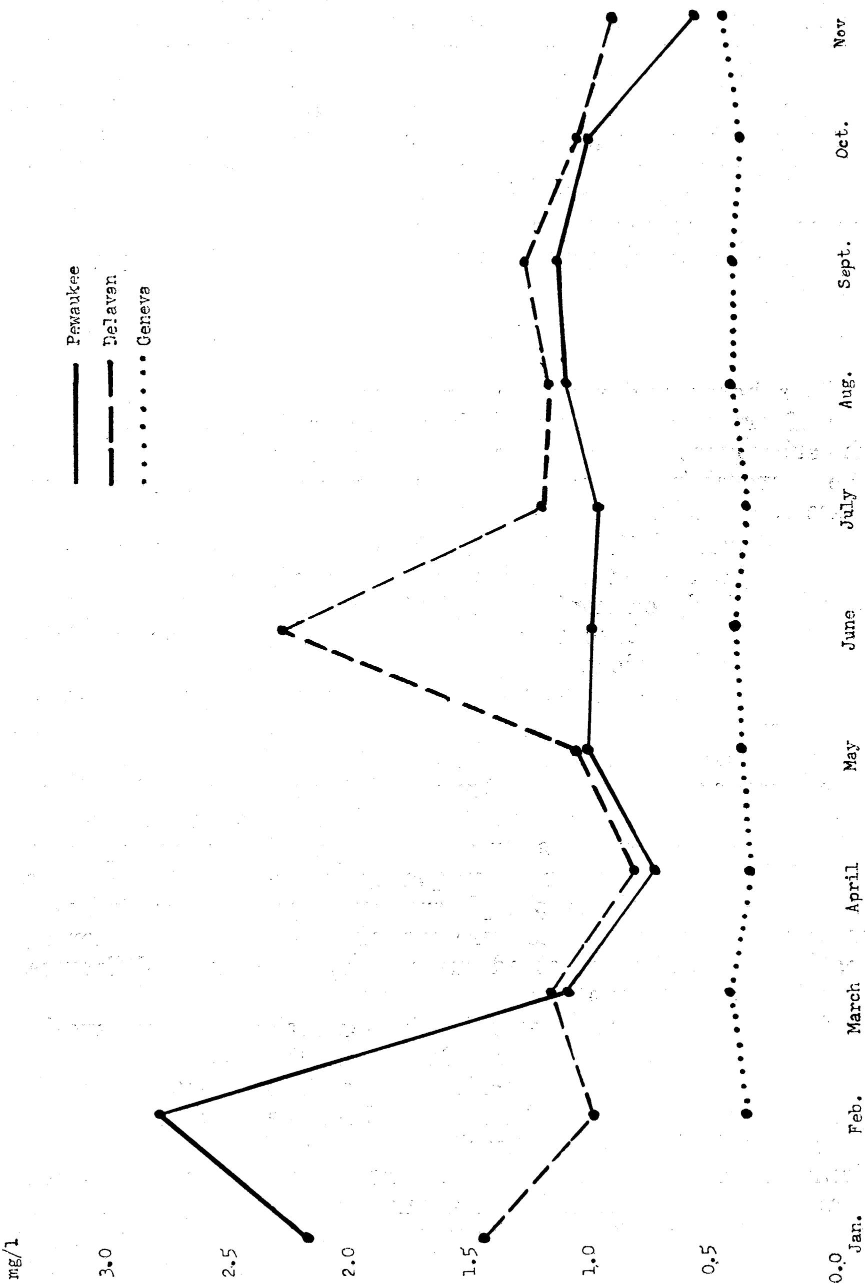

FIGURE 3. Total Organic Nitrogen in Surface Samples.

trophic description. A lake with an annual mean of less than 0.2 mg/l organic nitrogen probably would not have algae or other plankton nuisances. An annual mean of 0.2 mg/l to 0.4 mg/l would have rare algae nuisance conditions dependent on winds but not general nuisance conditions. A lake with an annual mean between 0.4 mg/l and 0.6 mg/l would probably experience periodic algae blooms or have substantial weed growths or both. A lake with an annual total organic nitrogen mean of more than 0.8 mg/l would probably experience numerous blooms during most of the growing season which would present a distinct impairment to recreational potentials.

Phosphorus

Phosphorus analyses were conducted on all lakes, but the past use of arsenics as an aquatic herbicide on four of the lakes and the subsequent interference of arsenic in the phosphorus test make the interpretation of phosphorus data on the four herbicide-treated lakes impossible.

The eleven-month soluble phosphorus mean on untreated Lakes Crystal, Trout, and Geneva was 0.018 mg/l on all three lakes. The lowest eleven-month phosphorus mean was 0.014 mg/l observed on Round Lake. The plankton catches from these four lakes were all relatively low.

Lakes Delavan and Mendota revealed substantially higher soluble phosphorus levels than the typically oligotrophic lakes. Big Green Lake and Lake Winnebago had remarkably similar soluble phosphorus means (0.027 and 0.026 mg/l). This similarity in phosphorus means and the apparent difference in plankton catches tend to suggest that the concentration of soluble phosphorus is not particularly useful in evaluating water quality and recreational potential of a lake. The soluble phosphorus could be a better indicator parameter if more samples were available. Nine to eleven monthly analyses were simply not adequate to evaluate small differences with the observed analytical variability.

The total phosphorus means for the eight lakes sampled revealed that Lakes Crystal, Geneva, Big Green, and Trout all had relatively low total phosphorus concentrations. This is consistent with plankton observations. Lakes Winnebago, Mendota, and Delavan revealed the highest total phosphorus levels, also consistent with plankton observations. From these monthly total phosphorus means, it appears that lakes with an annual mean total phosphorus of less than 0.03 mg/l would have essentially no aquatic nuisance development. Lakes with an annual mean total phosphorus between 0.03 and 0.05 mg/l experience rare aquatic nuisance development, but recreational potential of the water remains excellent. Lakes with an annual mean total phosphorus of over 0.1 mg/l would experience frequent aquatic nuisances during most of the growing season.

SUMMARY AND CONCLUSIONS

1. Table 5 summarizes the ranking of the twelve lakes based on annual means of selected parameters. The relationship between these parameters as indicators of eutrophication is shown by the generally similar placement for each lake in the various columns. A composite rating, based on assignment of a numerical value for position in each column, produces the following ranking. A value of one is given for first place, two for second and so on, so the lowest values represent the most oligotrophic lakes.

Composite Rating Based on Five Parameters

Crystal	8
Big Green	17
Geneva	17
Trout	19
Round	31
Pine	33
Middle	33
Oconomowoc	34
Mendota	45
Pewaukee	49
Delavan	52
Winnebago	52

Further examination of the table indicates that this composite rating would not be changed greatly if the phosphorus data were included.

2. The presence of dissolved oxygen in the hypolimnion during summer stagnation no doubt has an important effect on fish. However, as a measure of trophic index, it can be misleading since the volume of the hypolimnion tempers the effect of production and decomposition. Even the most oligotrophic lakes such as Crystal, Trout, and Geneva reveal dissolved oxygen levels one meter off the bottom that would be considered critical for fish. Lakes Pine and Oconomowoc, which have essentially no nuisance blooms of plankton, reveal no measurable dissolved oxygen in the hypolimnion in late summer. Classically eutrophic lakes such as Delavan and Pewaukee reveal no measurable dissolved oxygen in the hypolimnion during most of the summer.

TABLE 5. TROPHIC RANK OF TWELVE WISCONSIN LAKES BASED ON SEVEN PARAMETERS

	Dissolved Oxygen Hypolimnion	mg/l 1 M. Off Bottom	Plankton No. 20 Mesh Net	μg/l Total Solids	Transparency Secchi Disc	Seasonal Mean	Organic Nitrogen	Mo. Mean mg/l	Total Inorganic Nitrogen	Mo. Mean mg/l	Soluble Phosphorus	Mo. Mean mg/l	Total Phosphorus	Mo. Mean mg/l
Most Oligotrophic	Big Green....	8.1*	Round......	60.3	Crystal......	7.7	Crystal......	.162	Crystal......	.124				
	Crystal.......	3.15	Pine........	64.5	Big Green...	5.4	Trout.......	.251	Geneva.....	.170	Round......	.014	Crystal......	.027
	Trout........	1.9	Crystal......	68.0	Geneva.....	4.6	Big Green...	.358	Trout.......	.176	Crystal......	.018	Geneva.....	.041
	Geneva.......	1.0	Geneva.....	77.5	Middle......	4.4	Geneva.....	.379	Pine........	.210	Geneva.....	.018	Big Green...	.051
	Round.......	0.15	Trout.......	81.7	Oconomowoc	4.4	Oconomowoc	.460	Big Green...	.245	Trout.......	.018	Trout.......	.053
			Big Green...	83.4	Trout.......	4.1	Round......	.495	Middle......	.263	Big Green...	.027	Round......	.057
	Oconomowoc .	0.0	Middle......	252	Round......	3.9	Middle......	.545	Oconomowoc	.276	Winnebago..	.031	Winnebago..	.129
	Pine.........	0.0	Oconomowoc	426	Mendota....	3.1	Mendota....	.614	Winnebago..	.354	Mendota....	.066	Mendota....	.149
			Mendota....	751	Pine........	2.7	Pine........	.663	Pewaukee...	.421	Delavan.....	.075	Delavan.....	.170
	Mendota.....	0.0	Pewaukee...	1004	Delavan.....	1.6	Pewaukee...	.827	Delavan.....	.470				
	Middle.......	0.0	Delavan.....	1637	Pewaukee...	1.5	Winnebago..	.982	Mendota....	.579				
	Delavan......	0.0	Winnebago..	2118	Winnebago..	.7	Delavan.....	1.195	Round......	.788				
Most Eutrophic	Pewaukee....	0.0												

*Middle of hypolimnion.

3. The plankton sample collected with a No. 20 mesh net does not fully measure the standing crop of organic production since it ignores rooted or attached growths, and small algal cells may pass through the net. However, when 1,000 μg/l of blue–green algae are recorded, there are sufficient algae in the water to be distinctly noticeable. Often a recording of 500 μg/l in open water will be associated with wind-blown nuisance accumulation on specific shorelines. Diatoms and zooplankton did not develop nuisance conditions on any of the lakes considered, so that absolute nuisance concentrations cannot be established.

4. The monthly analysis for organic nitrogen produced a ranking of the lakes that was reasonably consistent with transparency and plankton recreational potential. Furthermore, it offered an opportunity to translate plankton nuisance conditions into absolute values. The lakes that had a total organic nitrogen annual mean of less than 0.2 mg/l had no algae or plankton nuisance. Lakes that had an organic nitrogen mean between 0.2 and 0.4 mg/l have had rare algae nuisances, and lakes between 0.4 and 0.6 mg/l had periodic algae blooms or substantial weed growths or both. Lakes with an annual total organic nitrogen mean of greater than 0.8 mg/l had nuisance algae during most of the growing season.

5. The monthly analyses for soluble phosphorus had a coefficient of variation which approached 100 per cent, indicating that the eleven monthly samples were insufficient to develop any reliable confidence interval about a mean.

6. The monthly analysis for total phosphorus suggested that lakes with an annual mean of less than .03 mg/l would be free of aquatic nuisances. Lakes with a total phosphorus annual mean between .03 and .05 mg/l would be essentially free of aquatic nuisances. Lakes with an annual mean total phosphorus more than 0.1 mg/l would experience nuisance weed growths or algae blooms during most of the growing season.

7. Eutrophication is not a simple process. It involves complex interrelationships between a variety of water quality parameters and an even greater variety of organisms. Although this study provides some insight into these relationships, a great deal more will need to be learned in order to cope successfully with the demands currently being made for lake management.

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ANNOTATED LIST OF THE FISHES OF WISCONSIN

Marlin Johnson and George C. Becker

In light of the increasing amount of work being done by state and federal agencies and by various state institutions on systematic and ecological as well as recreational and economic aspects of our fish fauna, the need has arisen for an up-to-date list, briefly noting the status of each species within the State of Wisconsin. Recent local studies on the distribution of fishes in various parts of the state have made possible the preparation of this list. Moreover, in recent years nomenclature for many species has been modified or clarified by national and international agencies; these changes have been incorporated.

Many significant changes in the distribution of certain Wisconsin fish species have occurred in recent years. These range changes have been brought about through fish rescue operations, crossover areas, canals, plantings by federal and state agencies, and the omnipresent fisherman's minnow bucket. Wholesale modification of the landscape, through forestry and agricultural practices as well as dam and industrial construction, has left its mark on streams and lakes and is reflected in widespread alterations in species' composition and numbers. These changes are pointed out in the annotations.

The list includes all the native fishes for Wisconsin and those exotic species planted with the intent that they become a characteristic part of the fish fauna. At the end of the paper, a separate list of problematical species includes those not known to be reproducing in the state and those found in nearby waters but not yet reported from the state. The status of each species is indicated by its general distribution and relative abundance within the state and by occasional reference to specific habitat.

The following scale was used for indicating distribution and abundance:

Rare—species which are taken at highly infrequent intervals with one or two specimens per collection.

Uncommon—species which are taken infrequently and in very small numbers.

Common—species which are taken frequently and in moderate numbers.

Abundant—species taken frequently and in large numbers.

The information has been compiled from the following sources: literature on Wisconsin fishes, personal communication with workers now actively engaged in fish research, fish collection records in the University of Wisconsin Zoological Museum and Biology Museum at Wisconsin State University–Stevens Point, and personal observations made by the authors. During the period from 1964–1966 the senior author, in conjunction with Field Zoology classes, has made extensive collections (350 stations) throughout southern Wisconsin. The junior author has made detailed surveys of several large watersheds in the state. Specimens of most species lie in the Zoological Museum, University of Wisconsin, Madison, and in the Museum of Biology, Wisconsin State University, Stevens Point.

The arrangement of orders and families follows the classification of Greenwood *et al,* 1966. Except where Dr. Bailey (see acknowledgements) has advised recent changes, nomenclature is according to Bailey *et al,* 1960. Certain synonomies have been included to facilitate cross reference to other literature dealing with fishes of our area (particularly Greene 1935, and Forbes and Richardson 1920). Pertinent literature on distribution, ecology, and taxonomy is cited.

Key rivers and lakes mentioned in the text are found on Map 1. The "lower Wisconsin River" refers to that section from the Prairie du Sac dam down to its juncture with the Mississippi River. The "lower Wolf River and its lakes" starts at the Shawano dam and includes Lake Winnebago.

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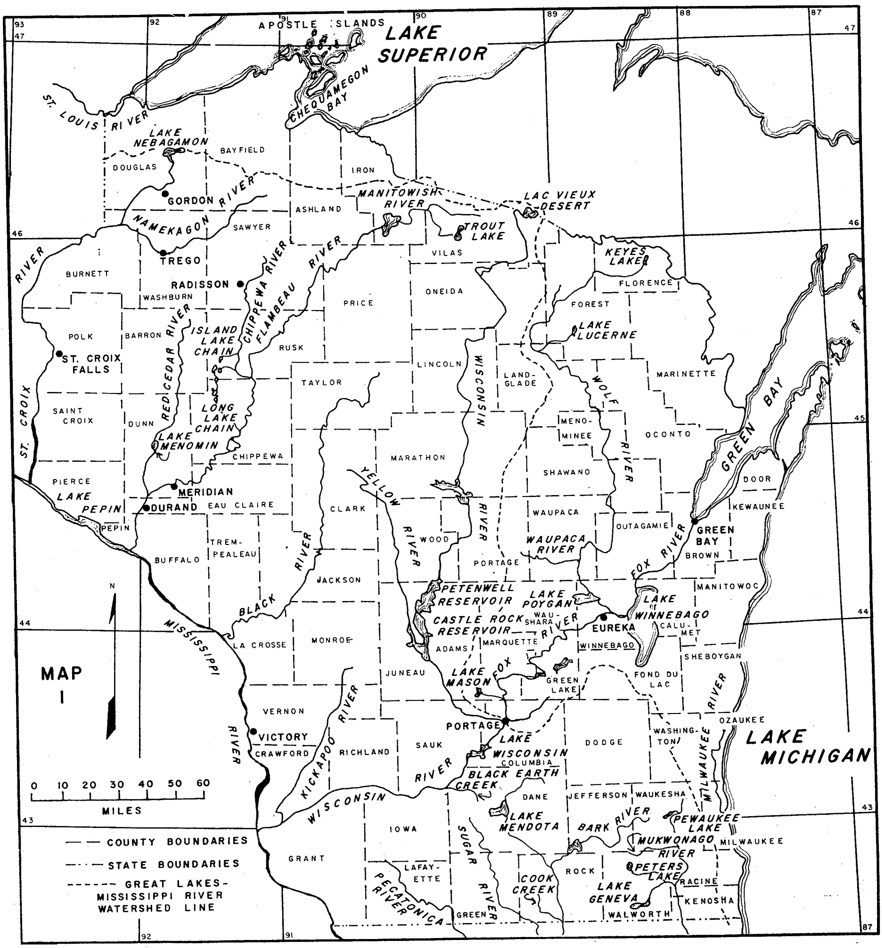
Superior: Evald Heinonen, Harvey Hadland, Wm. G. Bodin, Howard Weborg, Everett Marks, John Reynen, Bernard Moes, Norbert Swaer, Frederick Topel, and Walter Voight. Special thanks are due Reeve Bailey, Curator of Fishes, Museum of Zoology, University of Michigan, for verification of certain identifications and for help with nomenclatural changes, and Miss Peggy Brogan for drafting the map. Support for publication costs came from University of Wisconsin Center System.



Map 1. Map of Wisconsin showing major drainage units, counties, key rivers, and lakes and cities.

ORDER PETROMYZONTIFORMES

PETROMYZONTIDAE—LAMPREYS

Ichthyomyzon castaneus Girard—Chestnut lamprey

Uncommon to common in the lower Wisconsin, Yellow (Wood Co.), Mississippi, St. Croix and Nemakagon Rivers. In Great Lakes drainage present in the upper Fox R. at Eureka (Winnebago Co.) and reported from the lower Wolf R. and its lakes. 16, 65

Ichthyomyzon fossor Reighard & Cummins—Northern brook lamprey

Uncommon in Wisconsin R. and its tributaries. Common in small to medium-size streams of central Wisconsin flowing into L. Michigan. Distribution widespread in streams flowing into L. Superior. 7, 16, 25

Ichthyomyzon unicuspis Hubbs & Trautman—Silver lamprey
Ichthyomyzon concolor (Kirtland) F&R*

Uncommon in Mississippi and lower Wisconsin Rivers, Green Bay, and the large lakes of the lower Wolf R. basin. Common in streams flowing into L. Superior. 9, 13, 15, 16

Lampetra lamottei (Lesueur)—American brook lamprey
Entosphenus appendix (DeKay) G.†
Lampetra wilderi Gage F&R

Common in creeks of the Mississippi basin throughout southern and central Wisconsin. So far not reported from streams of Great Lakes drainage in the state, although reported as common in upper Michigan streams of eastern L. Superior. 7, 13, 16, 58

Petromyzon marinus Linnaeus—Sea lamprey

Recently abundant in L. Michigan. Common in L. Superior. Spawning and ammocete development occurring in streams in their watersheds. Exotic, invading L. Michigan in mid-1930's and L. Superior in the late 1940's. Currently subject to control with lampricides and other methods, but in last two years increasing in numbers (Moore, James D. 1969. Lake trout lamprey scarring in North Green Bay. Wis. Dept. Nat. Resources. Oshkosh. 5p. mimeo). 16, 69.

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* Forbes & Richardson, 1920.
† Greene, 1935.

ORDER ACIPENSERIFORMES

ACIPENSERIDAE—STURGEONS

Acipenser fulvescens Rafinesque—Lake sturgeon
Acipenser rubicundus Lesueur F&R

Common in the Menominee R. (Wis.–Mich. border) and in the lower Wolf R. and its lakes, particularly Poygan and Winnebago. Common in L. Wisconsin (Sauk & Columbia Cos.). Common in St. Croix R. to Gordon Dam and in Namekagon R. below Trego dam. Common in both the Chippewa and Flambeau Rivers. Present in Benson Lake, the widespread of Manitowish R. (Vilas Co.) and in the Clam R. (Burnett Co.). Verified report from Big Cedar L. (Washington Co.) in 1961, resulting from 1936 planting. Rare in Lakes Michigan and Superior. 9, 13, 65, 91.

Scaphirhynchus platorynchus (Rafinesque)—Shovelnose sturgeon

Uncommon to common in the main channels of the Mississippi and lower Wisconsin Rivers and in the lower Chippewa and lower Red Cedar Rivers. Presence reported up to St. Croix Falls dam on the St. Croix R. 13

POLYODONTIDAE—PADDLEFISHES

Polyodon spathula (Walbaum)—Paddlefish

Formerly abundant on the Mississippi R., now uncommon in the Mississippi and lower Wisconsin Rivers. 13, 23, 108

ORDER SEMIONOTIFORMES

LEPISOSTEIDAE—GARS

Lepisosteus osseus (Linnaeus)—Longnose gar

Common in most large lakes and quiet waters of larger rivers over lower two-thirds of Wisconsin. In northwestern Wisconsin common in Big Sissabagama, Big Court Oreilles, Grindstone, and Big Sand Lakes (Sawyer Co.). Common in the St. Croix R. below dam at St. Croix Falls; abundant in the Island Lake Chain (Rusk Co.) and the Long Lake Chain (Chippewa Co.). Uncommon in northeastern Wisconsin. 9, 10, 13, 65

Lepisosteus platostomus Rafinesque—Shortnose gar

Uncommon to common in lower Wisconsin and Mississippi Rivers and lower portions of their tributaries; in the St. Croix up to the St. Croix Falls Dam. Formerly reported from Lake Mendota (Dane Co.). Recently appearing in Lake Winnebago (Great Lakes drainage), possibly entering via the Fox–Wisconsin canal at Portage (Columbia Co.). Several specimens taken summer 1968 in southern third of Green Bay (L. Michigan). 9, 13, 67, 87

ORDER AMIIFORMES

AMIIDAE—BOWFINS

Amia calva Linnaeus—Bowfin

Uncommon to common in quiet waters of large rivers and large lakes. Wider dispersal and less common northward. 9, 10, 13, 65, 69

ORDER ANGUILLIFORMES

ANGUILLIDAE—FRESHWATER EELS

Anguilla rostrata (Lesueur)—American eel
Anguilla bostoniensis (Lesueur) G.
Anguilla chrysypa Rafinesque F&R

Rare in the Mississippi R. and its tributaries. Report from L. Neshonic (La Crosse Co.) about 1954 (letter from Lyle Christenson, April 25, 1969). Reports for 1966 from mouth of St. Croix (Burnett Co.) and Chippewa (Buffalo Co.) Rivers, and Lake Nebagamon (Douglas Co.). Taken regularly on Red Cedar R. upstream to L. Menomin (Dunn Co.). Single specimen collected from L. Superior (Beaver Lake Cr., Alger Co., Mich.). Single specimen collected at Red Banks in Green Bay of L. Michigan, summer 1968. Also collected in Lake La Belle, 1959, and Lake Nemahbin (Waukesha Co.), 1951. 46, 67, 69

ORDER CLUPEIFORMES

CLUPEIDAE—HERRINGS

Alosa chrysochloris (Rafinesque)—Skipjack herring
Pomolobus chrysochloris Rafinesque F&R G.

Probably extinct. Formerly found throughout the Wisconsin portion of the Mississippi R. and in the St. Croix up to St. Croix Falls. 23, 46

Alosa pseudoharengus (Wilson)—Alewife

Abundant recent (1952) addition to fauna of L. Michigan and has become a nuisance. Appeared in L. Superior in 1954, becoming common. 68, 79, 99

Dorosoma cepedianum (Lesueur)—Gizzard shad

Abundant in Mississippi and lower Wisconsin Rivers. Uncommon to common in lower portions of their larger tributaries. Common in

St. Croix R. upstream to St. Croix Falls Dam. Rare, southern L. Michigan. Uncommon in lower third of Green Bay of L. Michigan where collected by commercial fishermen summer 1968. 13, 22, 65, 68

HIODONTIDAE—MOONEYES

Hiodon alosoides (Rafinesque)—Goldeye
Amphiodon alosoides Rafinesque G.

Rare in Mississippi R. as far north as Lake Pepin. 23, 46

Hiodon tergisus Lesueur—Mooneye

Common in Mississippi, St. Croix R. upstream to St. Croix Dam, lower Wisconsin R., and uncommon in lower portions of their larger tributaries. Common in lower Wolf R. and its lakes (Great Lakes drainage). Rare in Green Bay and L. Michigan. 9, 13, 22, 65

ORDER SALMONIFORMES

SALMONIDAE—TROUTS, WHITEFISHES

Coregonus clupeaformis (Mitchill)—Lake whitefish

Common in L. Superior (up to 35 fathoms); common in L. Michigan but reduced in recent years by the sea lamprey. Reported from L. Lucerne (Forest Co.), Keyes L. (Florence Co.), and Trout L. (Vilas Co.). 29, 31, 34, 75, 91, 107

Leucichthys alpenae (Koelz)—Longjaw cisco

Formerly common in L. Michigan (20 to 60 fathoms), but becoming very rare in recent years. 96

Leucichthys artedii Lesueur—Cisco or lake herring
Argyrosomus artedi (Lesueur) F&R

Common but declining in Lakes Superior and Michigan. Common in many deeper inland lakes in northern tier of counties; rare to common in lakes of Waukesha Co. and in L. Geneva (Walworth Co.). Nearing extinction in Lake Mendota (Dane Co.). 20, 24, 31, 42, 53, 63, 96

Leucichthys hoyi (Gill)—Bloater

Abundant and dominant *Leucichthys* at 20 to 70 fathoms, but some found to greatest depths in both Lakes Superior and Michigan. Increased rapidly in numbers and extended range in L. Michigan during 1950's and early 1960's but declining in recent years as alewives increased. 31, 61, 96, 110, 111

Leucichthys johannae (Wagner)—Deepwater cisco

Perhaps now extinct, but formerly common in deeper waters of L. Michigan (30 to 90 fathoms). Last seen and taken in the early 1950's. 96

Leucichthys kiyi (Koelz)—Kiyi

Common in deep areas of L. Superior. Have become very rare in recent years in L. Michigan (60 to 100 fathoms). 31, 96

Leucichthys nigripinnis (Gill)—Blackfin cisco

Once common but now rare in L. Superior (15 to 100 fathoms). Formerly common in L. Michigan but now probably extinct—last records from the mid-1950's. 31, 96

Leucichthys reighardi (Koelz)—Shortnose cisco

Rare in western L. Superior (up to 50 and possibly 65 fathoms). Once common in L. Michigan (20 to 60 fathoms) but very rare in recent years. 31, 96

Leucichthys zenithicus (Jordan & Evermann)—Shortjaw cisco

Common in L. Superior (10 to 90 fathoms but most common at 30 to 70 fathoms). Once common in L. Michigan (20 to 70 fathoms) but decreasing to very rare in recent years. 31, 96

Prosopium coulteri (Eigenmann and Eigenmann)—Pygmy whitefish

Common in L. Superior (10 to 59 fathoms, but most common at 20 to 50 fathoms). 31, 37

Prosopium cylindraceum (Pallas)—Round whitefish
Prosopium quadrilaterale quadrilaterale (Richardson) G.

Common in L. Superior (shallows to 19 fathoms; rarer up to 40 fathoms). Uncommon to common in shallower areas of L. Michigan north of Sheboygan. Rare southwards. 31, 73

Salmo gairdneri Richardson—Rainbow trout

Introduced in late 1800's. Common locally in streams and lakes over the state. Continuously stocked in L. Superior and its tributaries; spawning successfully in some larger tributaries. Continuously stocked in recent years along Wisconsin shore of L. Michigan; natural reproduction insignificant. 19, 27b

Salmo trutta Linnaeus—Brown trout
Salmo fario Linnaeus G.

Introduced in late 1800's. Common in cold-water streams of southern and central Wisconsin, and in recent years playing a larger role in stream fishing of northern Wisconsin. Large brown trout are taken frequently in shore areas of Lakes Superior and Michigan, where they are maintained by extensive stocking. 18, 27c, 69

Salvelinus fontinalis (Mitchill)—Brook trout

Common in streams of central and northern Wisconsin; rare to uncommon in southern Wisconsin, except Richland, Columbia, Dane and Sauk Cos. where common in some streams. Coasters present along Wisconsin shores of Lakes Superior and Michigan (especially Door and Kewaunee Cos.); these populations sustained by stocking. 15, 17

Salvelinus namaycush namaycush (Walbaum)—Common lake trout
Cristivomer namaycush (Walbaum) G. & F&R

Common in L. Superior (10 to 39 fathoms). Uncommon in L. Michigan but returning in numbers. Inland waters with spawning trout: Trout and Black Oak L. (Vilas Co.), Big Green L. (Green Lake Co.). Recently introduced in Lac Court Oreilles (Sawyer Co.) 27a, 31, 35, 36, 48

Salvelinus namaycush siscowet (Agassiz)—Siscowet

Common in deeper waters (40 to 125 fathoms) of L. Superior. 33

Osmeridae—Smelts

Osmerus mordax (Mitchill)—American smelt

Common in L. Superior and Michigan and occasionally taken in large tributary streams. First taken off Wisconsin shores in L. Michigan in 1928 from 1912 stocking of Crystal R., Benzie Co., Michigan. Reached Wisconsin shores of L. Superior in late 1930's. Populations reproducing in L. Lucerne (Forest Co.); also reported from Sand Bar, Tomahawk and Big Diamond Lakes (Bayfield Co.). 26, 31, 106

Esocidae—Pikes

Esox americanus vermiculatus Lesueur—Grass pickerel
Esox vermiculatus Lesueur G. & F&R

Common in scattered localities in lakes and sluggish waters of southern one-third of state. Also found in Fishtrap and High Lakes and headwaters of Manitowish R. (Vilas Co.) and Minocqua Thoroughfare (Oneida Co.), where it was probably accidentally introduced during fish transfer operations in the early 1930's. 10, 64

Esox lucius Linnaeus—Northern pike

Common to abundant in lakes throughout state and in slow waters of large streams and rivers. Absent from the Chippewa R. and its lakes above Radisson (Sawyer Co.). 7, 9, 10, 12, 13, 69, 102, 103

Esox masquinongy Mitchill—Muskellunge

Common in the lakes and rivers in the headwater regions of the Chippewa, Flambeau, St. Croix (upstream to Trego Dam), and Wisconsin Rivers. Uncommon to rare in the middle one-third of the state. Stocked annually as far south as L. Wisconsin (Columbia Co.). Populations developed from stocking in Little Green L. (Green Lake Co.), Pewaukee L. (Waukesha Co.), and Lenwood L. (Washington Co.). Occasionally caught in L. Superior and in Green Bay (L. Michigan). 9, 10, 43, 64, 69, 81, 83

Esox masquinongy female X *Esox lucius* male—Tiger muskellunge

Natural crosses are reported in Lac Vieux Desert (Vilas Co.), Star, Big St. Germaine and Plum Lakes (Vilas Co.), and Tomahawk and Minocqua Lakes (Oneida Co.). Hybrids have been produced in Wisconsin hatcheries in 1940, 1946, 1947, 1963, 1965 and stocked frequently in landlocked bass lakes. This hybrid has a growth rate more rapid than either parent species. Experiments indicate that it will backcross with *Esox lucius*. 14, 65, 69

UMBRIDAE—MUDMINNOWS

Umbra limi (Kirtland)—Central mudminnow

Common to abundant in small streams and marshes throughout state except in southwestern quarter, where uncommon. 7, 9, 12, 13, 65, 69

ORDER CYPRINIFORMES

CYPRINIDAE—MINNOWS AND CARP

Campostoma anomalum pullum (Agassiz)—Central stoneroller

Abundant in small swift-flowing streams of southern Wisconsin. Occasionally taken in quiet pools. 13, 57, 80

Campostoma anomalum oligolepis Hubbs & Greene—Largescale stoneroller

Abundant in medium-size, swift-flowing streams in central and northern Wisconsin. 13, 57, 80

Carassius auratus (Linnaeus)—Goldfish

Common in some Milwaukee Co. lagoons. Occasionally found in southeastern Wisconsin streams and in Peters Lake (Walworth Co.). Introduced in part through a fish exchange program with the Nebraska Fish Commission in 1903, 1904, and 1908. 67, 78, 113

Cyprinus carpio Linnaeus—Carp

Abundant in large shallow waters of southern and central Wisconsin. Becoming common in some northern Wisconsin waters in recent years. Introduced through plantings by Wis. Commissioners of Fisheries, 1881–1895. 30, 41, 69, 74, 113

Chrosomus eos Cope—Northern red-belly dace

Abundant in small streams and in bog lakes of central and northern Wisconsin. 7, 12, 69

Chrosomus erythrogaster (Rafinesque)—Southern red-belly dace

Abundant in small to medium-size streams in southern Wisconsin. Rare to uncommon in central Wisconsin, apparently moving into a number of new localities in recent years. 13

Chrosomus neogaeus (Cope)—Finescale dace
Pfrille neogaea (Cope) G.

Uncommon to common in small streams and ponds in northeastern Wisconsin and in the streams of the L. Superior drainage. Rare in headwater streams of central Wisconsin. 12, 69

Clinostomus elongatus (Kirtland)—Redside dace

Uncommon in small to medium-size streams in widely scattered basins of southern, central and eastcentral Wisconsin. 7, 13

Dionda nubila (Forbes)—Ozark minnow
Hybognathus nubila (Forbes) F&R

Rare in medium-size streams of gentle current Platte R. basin (Grant Co.). Reported from streams in Barron, Lafayette, Iowa, Walworth, Rock, and Waukesha Cos. in late 1920's. 13, 46

Hybognathus hankinsoni Hubbs—Brassy minnow

Common in slow-flowing streams over state except northwestern portion where uncommon. Rare in large rivers. 7, 13, 46

Hybognathus nuchalis Agassiz—Silver minnow

Uncommon in the lower Wisconsin R. and the Mississippi and in the lower portions of their tributaries. 13, 46

Hybopsis aestivalis (Girard)—Speckled chub
Hybopsis hyostomus (Gilbert) F&R
Extrarius aestivalis (Gilbert) G.

Generally uncommon over shallow sand flats in lower Wisconsin and Mississippi R. and lower portions of their larger tributaries. 13, 46

Hybopsis biguttata (Kirtland)—Hornyhead chub
Hybopsis kentuckiensis (Rafinesque) F&R
Nocomis biguttatus (Kirtland) G.

Common in clear-water, medium-size streams of northern and central Wisconsin. Uncommon in the southwestern quarter of state except in the southern tier of counties where common. 7, 12, 13, 46

Hybopsis plumbea (Agassiz)—Lake chub
Couesius plumbeus (Agassiz) G.

Uncommon in shoal waters in the vicinity of stream mouths in Green Bay and L. Michigan. Common near mouths of streams in Bayfield and Douglas Cos. (L. Superior drainage). 45, 69

Hybopsis storeriana (Kirtland)—Silver chub

Uncommon in flowing sections of the lower Wisconsin R., in the Mississippi R., and in the lower portions of their tributaries. 13, 46

Hybopsis x-punctata Hubbs & Crowe—Gravel chub
Hybopsis dissimilia (Kirtland) F&R
Erimystax dissimilis (Kirtland) G.

Probably extinct in state. Taken only once from the Sugar R. (Green Co.) in the late 1920's. 46

Notemigonus crysoleucas (Mitchill)—Golden shiner
Abramis crysoleucas (Mitchill) F&R

Common to abundant in lakes, slow-flowing streams and rivers over the entire state. 7, 9, 10, 12, 13, 22, 69

Notropis amnis Hubbs & Greene—Pallid shiner

Rare. In recent years this minnow has been collected from the lower Wisconsin and from the Mississippi Rivers in water of moderate flow. 13, 46

Notropis anogenus Forbes—Pugnose shiner

Rare. Earlier reports from Burnett, Waupaca, Kewaunee, Marquette, Columbia and Dane Cos. In recent years this minnow has been collected only from Pewaukee Lake (Waukesha Co.) and L. Poygan (Winnebago Co.). 2, 9, 10, 46

Notropis atherinoides Rafinesque—Emerald shiner

Common to abundant in L. Michigan, Superior, Winnebago and other large inland lakes of central and southern Wisconsin. Present in Yellow Birch L. (Vilas Co.). A common minnow in the lower Wisconsin and Mississippi R. and lower portions of some of their tributaries. 9, 13, 22, 69

Notropis blennius (Girard)—River shiner
Notropis jejunus (Forbes) F&R

Common in the lower Wisconsin and the Mississippi R. and lower portions of some tributary streams. An isolated population in L. Winnebago of the Great Lakes Basin. 9, 13, 46

Notropis buchanani Meek—Ghost shiner

Rare or nearly extinct in the state. Last collected in 1944 (UW Museum of Zoology—Madison) from the Mississippi R. opposite Crawford Co. 46

Notropis chalybaeus (Cope)—Ironcolor shiner

Camm Swift, Dept. of Biological Sciences, Florida State University, Tallahassee, writes that two collections which Greene (46) catalogued originally as *Notropis texanus richardsoni* are *Notropis chalybaeus* (letter November 8, 1968). The two series follow: *From* UMMZ 66537 (7 of 41) Wisc., Collumbia Co., Fox R. opposite Lock 25. VIII:26:1925 Green and Jones. *From* UMMZ 74054 (2 of 75) Wisc., Waupaca Co., Blake Cr., 5 ml. W. Symco. VII:9:1926 Greene and Lo Criccho.

Notropis cornutus (Mitchill)—Common shiner

Abundant and one of the commonest of stream and river minnows found under a wide variety of conditions. Occasional in clear-water lakes over clean bottom. 7, 9, 10, 13, 44, 65, 69

Notropis chrysocephalus (Refinesque)—Stripped shiner

Common in the Saukville–Grafton sector of the Milwaukee R. (Ozaukee Co.). Single specimen (Museum WSU–Stevens Point) collected from Green Bay near the city of Sturgeon Bay. Older records indicate presence from Kenosha to Dane Cos. 44, 46

Notropis dorsalis (Agassiz)—Bigmouth shiner
Notropis gilberti Jordan and Meek F&R

Common over sand-bottom, medium-sized streams in the Mississippi drainage. Recently established in the east-central streams within the L. Michigan drainage of Wisconsin. 7, 13

Notropis heterodon (Cope)—Blackchin shiner

Uncommon in central and southern Wisconsin. Absent from southwestern quarter. Locally common northward in lakes and bog ponds. 9, 10, 12, 46, 65

Notropis heterolepis Eigenmann & Eigenmann—Blacknose shiner
Notropis cayuga Meek F&R

Rare in southwestern quarter of state. Elsewhere common in widely separated lakes and slow-moving streams, often in heavily-silted habitats. 7, 9, 10, 12, 46, 65

Notropis hudsonius (Clinton)—Spottail shiner

Common locally in very large inland lakes, in Lakes Michigan and Superior, and in large slow-moving rivers as the lower Wisconsin and Mississippi, and in the St. Croix R. upstream to St. Croix Falls Dam. 9, 10, 12, 13, 22, 46, 65, 69

Notropis rubellus (Agassiz)—Rosyface shiner
Notropis rubrifrons (Cope) F&R

Common in medium-sized, swift-flowing streams of central and southern Wisconsin. Uncommon northward—apparently absent from the extreme northwest corner of the state. 7, 12, 13, 46, 69

Notropis spilopterus (Cope)—Spotfin shiner
Notropis whipplii (Girard) F&R G.

Abundant in medium to large-sized streams and rivers. A common minnow in large lakes. Absent from the northern tier of counties. 7, 9, 10, 12, 13, 65, 69

Notropis stramineus (Cope)—Sand shiner
Notropis blennius (Girard) F&R
Notropis phenacobius Forbes F&R
Notropis deliciosus (Cope) G.

Abundant in medium to large-sized streams and rivers of central and southwestern Wisconsin. Elsewhere uncommon to common. 7, 9, 12, 13, 69

Notropis texanus (Girard)—Weed shiner
Notropis nux Hubbs & Greene G.

Uncommon in the lower Wisconsin and in the Mississippi Rivers and in the lower portions of their tributaries. Older records indicate presence from east-central Wisconsin (Great Lakes drainage). 13, 22, 46

Notropis umbratilis (Girard)—Redfin shiner

Locally common in slow-moving, turbid waters of southeastern Wisconsin. Older records show presence in widely isolated streams throughout the southern half of the state. 46, 54

Notropis volucellus volucellus (Cope)—Northern mimic shiner
Notropis blennius (Girard) F&R

Locally common in medium-sized streams and in lakes over the state except in the southwestern quarter, where rare. Distribution sites widely isolated. 7, 22, 65, 69

Notropis volucellus wickliffi Trautman—Channel mimic shiner

Rare in the Mississippi R. Seldom taken in recent years. 13, 46

Opsopoeodus emiliae Hay—Pugnose minnow

Uncommon in slow-water and sloughs of the Wisconsin R. upstream to Du Bay (Marathon Co.) and in the Mississippi R. In the Great Lakes drainage taken only from the west end of L. Poygan (Waushara Co.). 9, 13, 22, 46

Phenacobius mirabilis (Girard)—Suckermouth minnow

Uncommon to common in small and medium-sized tributaries to the lower Wisconsin and Mississippi Rivers. In the southwestern quarter of the state, from Vernon Co. southward. Uncommon in Rock R. drainage in southeastern quarter. 13, 46

Pimephales notatus (Rafinesque)—Bluntnose minnow
Hyborhynchus notatus (Rafinesque) G.

Abundant in streams and lakes over the entire state. Uncommon in the larger rivers. This species, from the standpoint of distribution and numbers, is perhaps the most successful Wisconsin fish. 6, 7, 9, 10, 12, 13, 22, 65, 69

Pimephales promelas Rafinesque—Fathead minnow

Locally common over the entire state. Frequently associated with turbid water. 7, 12, 13, 22, 46, 69

Pimephales vigilax (Baird & Girard)—Bullhead minnow
Cliola vigilax (Baird and Girard) F&R
Hypargyrus velox (Girard) G.

Common to abundant in the lower Wisconsin and the Mississippi. Rarely associated with other large streams in the southwestern quarter of state. A recent collection from the Fox R. (Marquette Co.) near the Portage Canal indicates a late crossover into the Great Lakes drainage basin. 7, 22

Rhinichthys atratulus (Hermann)—Blacknose dace
Rhinichthys atronasus (Mitchill) F&R. G.

Common to abundant in small cool headwater streams. Uncommon to common in medium-sized streams supporting trout. Distributed throughout the state. 6, 8, 12, 13, 69

Rhinichthys cataractae (Valenciennes)—Longnose dace

Common to abundant in fast water of medium-sized streams of the northern half of Wisconsin. Common in small fast-water streams of southwestern Wisconsin. Common in wave-swept shallows of Lakes Michigan and Superior. 6, 8, 12 ,13, 69

Semotilus atromaculatus (Mitchill)—Creek chub

Abundant in small and medium-sized streams and rivers over the entire state. Rare in large rivers and in lakes. One of our commonest fishes. 7, 12, 13, 65, 69

Semotilus margarita (Cope)—Pearl dace
Margariscus margarita (Cox) G.

Common in very small streams of central and northern Wisconsin except in streams of L. Superior drainage where rare. Uncommon in larger streams. 7, 12, 65, 69

CATOSTOMIDAE—SUCKERS

Carpiodes carpio (Rafinesque)—River carpsucker

Common in the lower Wisconsin R. and the Mississippi R., and their larger tributaries. 13, 22, 46

Carpiodes cyprinus (Lesueur)—Quillback
Carpiodes thompsoni Agassiz F&R
Carpiodes velifer (Rafinesque) F&R

Abundant in the lower Wisconsin R. and the Mississippi R. and their larger tributaries. Common Lakes Poygan and Winnebago. 9, 13, 65

Carpiodes velifer (Rafinesque)—Highfin carpsucker
Carpiodes difformis Cope F&R

Common in the lower Wisconsin R. and the Mississippi R. and in their larger tributaries. 13, 46

Catostomus catostomus (Forster)—Longnose sucker

Common in L. Superior and its tributaries during spawning. Formerly common, now rare in L. Michigan. 31, 46, 69

Catostomus commersoni (Lacépède)—White sucker

Abundant and generally distributed in lakes and streams over the state. One of the most widely distributed and abundant fish species in the state. 6, 7, 9, 10, 12, 65, 69

Cycleptus elongatus (Lesueur)—Blue sucker

Rare. Found only in the lower Wisconsin R., the Mississippi R., and the St. Croix upstream to St. Croix Falls Dam. 13, 46, 65

Erimyzon oblongus (Mitchill)—Creek chubsucker
Erimyzon sucetta oblongus (Mitchill) F&R

Rare. Taken only twice in the southeastern corner of Wisconsin during the late 1920's from the Des Plaines R. (Kenosha Co.) and a tributary. 46

Erimyzon sucetta (Lacépède)—Lake chubsucker
Erimyzon sucetta oblongus (Mitchill) F&R

Rare to uncommon locally in the larger rivers and the lower portions of tributaries to them in the southern half of Wisconsin. Report from White Clay L. (Shawano Co.) needs substantiation. Occasionally taken in larger lakes, especially in southeastern Wisconsin. 9, 10, 13, 46

Hypentelium nigricans (Lesueur)—Northern hogsucker
Catostomus nigricans Lesueur F&R

Common locally in riffle areas of medium to large streams and rivers. Generally distributed throughout the state. 7, 12, 13, 65

Ictiobus bubalus (Rafinesque)—Smallmouth buffalo

Uncommon in the lower Wisconsin R. and in the Mississippi. Recent record from Island L. (Vilas Co.), needs verification. 13, 22, 46

Ictiobus cyprinellus (Valenciennes)—Bigmouth buffalo
Megastomatobus cyprinella (Cuvier & Valenciennes) G.

Uncommon to common in medium to large rivers in southern Wisconsin. Reported from L. Delavan (Waukesha Co.), L. Koshkonong (Jefferson Co.), Beaver Dam L. (Dodge Co.), the Madison Lakes (Dane Co.) and Long Lake (Waupaca Co.). The last is the first Wisconsin record from the L. Michigan drainage. Present in the Mississippi R. and in the St. Croix up to St. Croix Falls Dam. Reports needing substantiation from Manitowish Chain and Big Lake (Vilas Co.). 13, 22, 46, 65, 67

Ictiobus niger (Rafinesque)—Black buffalo
Ictiobus urus (Agassiz) F&R

Rare on the lower Wisconsin R. Uncommon on the Mississippi R. 13, 45

Minytrema melanops (Rafinesque)—Spotted sucker

Common locally in the lower Wisconsin and in the Mississippi Rivers and their larger tributaries. Common in Lake Poygan; occasional in L. Winnebago. It has been reported from the upper Fox R. (Columbia to Winnebago Cos.) and from the lower Wolf downstream from the Shawano Dam (Shawano Co.). Recently collected in Des Plaines R. (Kenosha Co.). 9, 13, 22

Moxostoma anisurum (Rafinesque)—Silver redhorse

Common locally in large streams in the western half of Wisconsin and in streams in the L. Superior drainage. Uncommon in east-central Wisconsin (L. Michigan drainage). 7, 65, 68, 69

Moxostoma carinatum (Cope)—River redhorse

This species has not been collected by Wisconsin workers but is reported in boundary waters in Lake St. Croix on the St. Croix R. between Minnesota and Wisconsin. 82b

Moxostoma duquesnei (Lesueur)—Black redhorse

Probably extinct. Taken only once from Black Earth Creek (Dane Co.) in the late 1920's. 46

Moxostoma erythrurum (Rafinesque)—Golden redhorse
Moxostoma aureolum (Lesueur) F&R

Uncommon in northern half of state (absent from northern tier of counties). Common in medium to large rivers in the southern half of the state. 7, 9, 12, 13

Moxostoma macrolepidotum (Lesueur)—Northern redhorse
Moxostoma breviceps (Cope) F&R
Moxostoma aureolum (Lesueur) G.

Common statewide in medium to large rivers. A common species in large lakes of central and northern Wisconsin. 7, 9, 12, 13, 22, 65, 69.

Moxostoma valenciennesi Jordan—Greater redhorse
Moxostoma rubreques Hubbs G.

Rare and probably nearing extinction. Old records indicate general distribution in the state. A purported specimen recently reported from the lower Wisconsin R. misidentified as this species, actually *M. macrolepidotum*. 13, 46

ORDER SILURIFORMES

ICTALURIDAE—FRESHWATER CATFISHES

Ictalurus furcatus (Lesueur)—Blue catfish

Rare, probably extinct. Only two old records from the Mississippi R. (Crawford and Pepin Cos.). 46

Ictalurus melas (Rafinesque)—Black bullhead
Ameiurus melas (Rafinesque) F&R G.

Abundant throughout the state in lakes and warm-water streams of all sizes. 7, 9, 10, 12, 13, 22, 65, 68, 69

Ictalurus natalis (Lesueur)—Yellow bullhead
Ameiurus nebulosus (Lesueur) F&R. G.

Common throughout the state, generally in clear medium-sized streams and occasionally in clear lakes. 7, 9, 10, 12, 13, 22, 65, 69, 89

Ictalurus nebulosus (Lesueur)—Brown bullhead
Ameriurus nebulosus (Lesueur) F&R. G.

Uncommon in sloughs of rivers and in lakes. Discontinuous distribution throughout state. 7, 9, 12, 13, 22, 69, 89

Ictalurus punctatus (Rafinesque)—Channel catfish
Villarius lacustris (Walbaum) G.

Uncommon to common in the Mississippi R. and the lower Wisconsin R. (upstream to Castle Rock Dam) and their larger tributaries, and in the St. Croix R. to Gordon Dam and in the Namekagon to Trego Dam. Uncommon to common in the Wolf and Fox River system of the L. Michigan basin. Rare in L. Michigan and Green Bay. In the L. Superior drainage a single recent record from the St. Louis R. (Douglas Co.). 9, 13, 22, 65, 69

Noturus exilis Nelson—Slender madtom
Schilbeodes exilis (Nelson) F&R. G.

Rare in Bark R. system (Waukesha Co.). 20, 46

Noturus flavus Rafinesque—Stonecat

Uncommon to common in medium-sized streams of moderate current in southern two-thirds of state. Rare northward except in L. Superior tributaries (Bayfield and Douglas Cos.), where common. 7, 12, 13, 65, 69

Noturus gyrinus (Mitchill)—Tadpole madtom
Schilbeodes gyrinus (Mitchill) F&R. G.

Common statewide in medium to large rivers. Frequently found in lakes over debris-covered bottom. 7, 9, 12, 13, 22, 69

Pylodictis olivaris (Rafinesque)—Flathead catfish
Leptops olivaris (Rafinesque) F&R

Uncommon to common in Mississippi, lower Wisconsin and Pecatonica Rivers. In recent years reported occasionally from lower Wolf and upper Fox Rivers and their lakes (L. Michigan drainage). 9, 13, 22, 65

APHREDODERIDAE—PIRATE PERCH

Aphredoderus sayanus (Gilliams)—Pirate perch

Uncommon to rare in sloughs of the Mississippi R. and in the Wisconsin R. up to central Wisconsin. Occasionally found in lower portions of tributaries to these waters. Uncommon in Des Plaines R. (Kenosha Co.). 13, 22

ORDER PERCOPSIFORMES

PERCOPSIDAE—TROUT-PERCH

Percopsis omiscomaycus (Walbaum)—Trout perch
Percopsis guttatus Agassiz F&R

Uncommon in the Mississippi and Wisconsin Rivers. More common northward, in the Chippewa R. and connecting lakes of Sawyer Co., and in L. Superior and tributary streams. Reported from Trout L. (Vilas Co.). Rare to uncommon in L. Michigan drainage except in Lakes Winnebago and Poygan (Winnebago Co.), where abundant. 9, 13, 31, 86

ORDER GADIFORMES

GADIDAE—CODFISHES AND HAKES

Lota lota (Linnaeus)—Burbot
Lota maculosa (Lesueur) F&R. G.

Rare to uncommon in widely separated large rivers and lakes statewide. Common in dark water streams of the Flambeau R. watershed and tributary streams to L. Superior; common in Lakes Poygan and Winnebago (L. Michigan drainage). Young occasionally taken in small streams opening into large bodies of water. Decreasing in L. Michigan in recent years. 9, 12, 13, 31, 65, 69

ORDER ATHERINIFORMES

CYPRINODONTIDAE—KILLIFISHES

Fundulus diaphanus (Lesueur)—Banded killifish

Common in lakes of southeastern Wisconsin. Uncommon in widely isolated sites in northern half of state and absent from southwestern quarter. 9, 12, 46.

Fundulus notatus (Rafinesque)—Blackstripe topminnow

Uncommon in sloughs and lakes of the Mississippi drainage in the southeastern quarter of state. A single recent report from the Wisconsin R. at Woodman (Grant Co.). In L. Michigan drainage, present in the upper Fox R. (Columbia and Marquette Cos.). Recently collected from lower Wisconsin R. 13, 46

Fundulus notti (Agassiz)—Starhead topminnow
Fundulus dispar (Agassiz) F&R. G.

Rare. Recently collected from quiet water in Coon Creek (Rock Co.) and sloughs of the Wisconsin R. (Iowa Co.). The later is the first for the Wisconsin R. basin. Older records from Walworth and Waukesha Cos. (lower Fox R. system). 46

ATHERINIDAE—SILVERSIDES

Labidesthes sicculus (Cope)—Brook silverside

Common in lakes and quiet waters of rivers and large streams in southern half of the state. Distribution discontinuous northward where uncommon. Absent in L. Superior drainage. 10, 13, 20, 22

ORDER GASTEROSTEIFORMES

GASTEROSTEIDAE—STICKLEBACKS

Culaea inconstans (Kirtland)—Brook stickleback
Eucalia inconstans (Kirtland) F&R. G.

Abundant in dense vegetation of small to medium-size streams throughout state. Although taken most frequently in clear water, this species may be found in highly turbid waters. 4, 7, 12, 13, 69

Pungitius pungitius (Linnaeus)—Ninespine stickleback
Pygosteus pungitius (Linnaeus) F&R

Common in shoal areas of L. Superior and uncommon in streams of its drainage basin. Rare in shoal areas of L. Michigan. 31, 46, 69

ORDER SCORPAENIFORMES

COTTIDAE—SCULPINS

Cottus bairdi Girard—Mottled sculpin
Cottus ictalops (Rafinesque) F&R
Uranidea kumlieni Hay F&R

Common in cold headwater streams throughout the state. Occasionally in large lakes: L. Metonga (Forest Co.), L. Winnebago (Winnebago Co.), shoal areas of L. Michigan. 7, 9, 12, 13, 28, 69

Cottus cognatus Richardson—Slimy sculpin

Uncommon to common in streams tributary to and in L. Superior. Uncommon in L. Michigan. Recently taken from Citron Creek (Crawford Co.), Camp Creek (Richland Co.) and Big Green L. (Green Lake Co.). 13, 28, 31

Cottus ricei (Nelson)—Spoonhead sculpin

Uncommon in shallow to deep waters of Lakes Michigan (2 to 73 fathoms) and Superior (20 to 60 fathoms). 28, 31, 46

Myoxocephalus quadricornis (Linnaeus)—Fourhorn sculpin
Triglopsis thompsonii Girard G.

Common in deep water of Lakes Superior (40 to 200 fathoms) and Michigan (25 to 100 fathoms). 28, 31, 46

ORDER PERCIFORMES

SERRANIDAE—SEA BASSES

Roccus chrysops (Rafinesque)—White bass
Lepibema chrysops (Rafinesque) G.

Common in large lakes and rivers of southern half of the state and in the St. Croix upstream to St. Croix Falls Dam. Abundant in L. Winnebago. 9, 10, 13, 22, 117

Roccus mississippiensis (Jordan & Eigenmann)—Yellow bass
Morone interrupta Gill F&R G.

Uncommon to common in the Mississippi and lower Wisconsin Rivers; common and increasing in Lakes Poygan and Winnebago. Introduced into the Madison lakes (Dane Co.) and into lakes of the lower Wolf R. (L. Michigan basin) during fish transfer operations of the 1930's and 1940's. Abundant in L. Mason, Adams Co. Recently stocked in the Manitowoc, Sheboygan, and Milwaukee R. basins in eastern Wisconsin. 9, 13, 50, 51, 67, 99

CENTRARCHIDAE—SUNFISHES

Ambloplites rupestris (Rafinesque)—Rock bass

Common in clear, medium to large streams and in lakes throughout the state except in southwestern quarter where rare. 7, 9, 10, 22, 53, 65, 69

Chaenobryttus gulosus (Cuvier)—Warmouth

Rare to uncommon in southern third of state; in sloughs of rivers and impoundments. Common in the Long Lake Chain (Chippewa Co.). Reported in L. Nebagamon (Douglas Co.). 13, 46

Lepomis cyanellus Rafinesque—Green sunfish
Apomotis cyanellus (Rafinesque) G.

Common in lakes and medium-sized streams of southern one-third of state. Discontinuous distribution northward. Not reported from the L. Superior drainage. 10, 12, 13, 22, 60

Lepomis gibbosus (Linnaeus)—Pumpkinseed
Eupomotis gibbosus (Linnaeus) F&R. G.

Common in clear medium-sized rivers and in lakes throughout the state except in the southwestern quarter and in L. Superior drainage where uncommon. 7, 9, 12, 13, 22, 69

Lepomis humilis (Girard)—Orangespotted sunfish
Allotis humilis (Girard) G.

Uncommon to common in Mississippi R. (Vernon Co. southward) and lower Wisconsin R. Rare to uncommon in sloughs and backwaters of larger streams in Richland, Iowa, Green, and Lafayette Cos. Recently collected from Sugar River (Dane and Green Cos.) and lower Fox R. (Kenosha Co.).

Lepomis macrochirus Rafinesque—Bluegill
Lepomis pallidus (Mitchill) F&R
Helioperca macrochirus (Rafinesque) G.

Most abundant centrarchid in Wisconsin. Found in medium-sized streams to large rivers and in nearly all lakes throughout the state. 7, 9, 10, 12, 13, 22, 65, 69, 97

Lepomis megalotis (Rafinesque)—Longear sunfish
Xenotis megalotis (Cope) G.

Uncommon in southeastern quarter of state. Recently collected in the Milwaukee R. (Ozaukee Co.) and in the Mukwonago R. (Waukesha Co.). Reported rare from L. Geneva (Walworth Co.). 46

Micropterus dolomieui Lacépède—Smallmouth bass

Common in medium to large streams and large clear-water lakes throughout the state. Common in upper Green Bay area of L. Michigan and Chequamegon Bay of L. Superior. 7, 9, 10, 12, 13, 65, 69, 70, 71, 114

Micropterus salmoides Lacépède—Largemouth bass
Aplites salmoides (Lacépède) G.

Abundant in medium to large rivers and in lakes throughout the state. 7, 9, 10, 12, 13, 22, 65, 69, 71, 75, 76

Pomoxis annularis Rafinesque—White crappie

Common in the Mississippi and lower Wisconsin Rivers and their larger tributaries. Reported from L. Mendota (Dane Co.). Recently taken from the upper Fox and lower Wolf River basin in east-central Wisconsin (L. Michigan drainage). 9, 13, 22

Pomoxis nigromaculatus (Lesueur)—Black crappie
Pomoxis sparoides (Lacépède) F&R. G.

Common in lakes and larger rivers throughout the state. Introduced into many lakes in northern Wisconsin where it has become abundant. 7, 9, 10, 12, 13, 22, 65, 69

PERCIDAE—PERCHES

Ammocrypta asprella (Jordan)—Crystal darter
Crystallaria asprella (Jordan) F&R. G.

Rare in the Mississippi River. Collected recently on the lower Wisconsin R. near Orion (Richland Co.), on the lower Chippewa R. between Durand (Pepin Co.) and Meridian Ferry Landing (Dunn Co.). 13, 46

Ammocrypta clara Jordan & Meek—Western sand darter
Ammocrypta pellucida (Baird) F&R. G.

Common locally in shallow riffles over sand flats in the lower Wisconsin R., in the Mississippi R. and in the St. Croix upstream to the St. Croix Falls Dam. Recently collected in the Waupaca R. (Great Lakes drainage near its junction with the Wolf R. in Waupaca Co.). 11, 13, 65

Etheostoma asprigene (Forbes)—Mud darter
Etheostoma jessiae (Jordan & Brayton) F&R
Poecilichthys jessiae Jordan & Brayton G.

Rare to uncommon in sloughs of the lower Wisconsin and Mississippi Rivers and in the lower portions of tributaries to them. 13, 22

Etheostoma caeruleum Storer—Rainbow darter
Poecilichthys coeruleus (Storer) G.

Common locally in central and southeastern Wisconsin. Uncommon in southwestern Wisconsin. 6, 12, 13, 46

Etheostoma chlorosomum (Hay)—Bluntnose darter
Boleosoma camurum Forbes F&R

Rare. This southern darter has been collected as far north as the Root R., Houston Co., Minnesota. Records (Zoological Museum UW, Madison; University Museums UM, Ann Arbor, Michigan) from the Mississippi River come from small isolated ponds between New Albin and Minnesota slough on the Iowa–Minnesota border just across from Victory, Vernon Co., Wis. 33, 49

Etheostoma exile (Girard)—Iowa darter
Poecilichthys exilis (Girard) G.

Uncommon to common locally over the state but found primarily in glaciated areas, where it is taken in small streams and bog lakes. 7, 9, 12, 13, 22, 69

Etheostoma flabellare Rafinesque—Fantail darter
Catonotus flabellaris Agassiz G.

Abundant over rocks and gravel in the smaller streams of the state. Occasionally taken in medium to large rivers. 7, 12, 13

Etheostoma microperca Jordan & Gilbert—Least darter
Microperca punctulata Putnam F&R. G.

Uncommon. Although found in widely separated areas over the state, it has been collected most frequently from the southeastern counties. 7, 46

Etheostoma nigrum Rafinesque—Johnny darter
Boleosoma nigrum (Rafinesque) F&R. G.

Abundant in all waters from the smallest stream and pond to the largest river and lake over a wide variety of bottom types. It is the most successful member of its family. 7, 9, 10, 12, 13, 22, 65, 69, 105

Etheostoma zonale (Cope)—Banded darter
Poecilichthys zonalia Cope G.

Common locally but of spotty distribution over the lower two-thirds of the state. Rare to uncommon in northeastern Wisconsin. In clear-water streams of medium to large size. 7, 12, 13

Perca flavescens (Mitchill)—Yellow perch
Abundant in lakes, ponds, impoundments and large rivers. Common in Chequamegon Bay (L. Superior) and in L. Michigan. 5, 7, 9, 10, 12, 13, 22, 63, 65, 69, 98

Percina caprodes (Rafinesque)—Logperch

Common in medium to large streams and rivers and in large lakes. Distribution statewide. 7, 9, 12, 13, 22, 65, 69

Percina evides (Jordan & Copeland)—Gilt darter
Hadropterus evides (Jordan & Copeland) F&R. G.

Uncommon in the Black R. and in the St. Croix R. in the vicinity of St. Croix Falls. 46, 65

Percina maculata (Girard)—Blackside darter
Hadropterus aspro (Cope & Jordan) F&R
Hadropterus maculatus (Girard) G.

Common in streams and rivers of all sizes in clear to turbid water. Distribution statewide. 7, 9, 12, 13, 69

Percina phoxocephala (Nelson)—Slenderhead darter
Hadropterus phoxocephalus (Nelson) F&R. G.

Uncommon in the lower Wisconsin R., the Mississippi, and in the larger streams tributary to them. Also in the Pecatonica R. (Lafayette Co.) and Sugar R. (Green Co.). In Great Lakes drainage found in L. Winnebago and in waters of the Upper Fox R. 9, 13, 46

Percina shumardi (Girard)—River darter
Cottogaster shumardi (Girard) F&R
Imostoma shumardi (Girard) G.

Uncommon in the lower Wisconsin and in the Mississippi Rivers. Recently collected in Lakes Winnebago, Poygan, and the lower Waupaca R. (L. Michigan basin). 9, 13, 46

Stizostedion canadense (Smith)—Sauger

Common in L. Winnebago and in the lower Wisconsin and Mississippi Rivers. Uncommon to common in St. Croix R. up to St. Croix Dam. Elsewhere in state uncommon, rare or absent. 9, 13, 22, 65, 88

Stizostedion vitreum vitreum (Mitchill)—Walleye

Common locally in large rivers and almost all of the large lakes in the state. Introduced in many large lakes, especially in the north. Common in Chequamegon Bay area of L. Superior. 7, 9, 10, 13, 22, 65, 69, 77, 88, 90

SCIAENIDAE—DRUMS

Aplodinotus grunniens Rafinesque—Freshwater drum

Common in the lower Wisconsin R., the Mississippi, the St. Croix upstream to St. Croix Falls Dam. Sporadic in some large lakes of southern one-half of state. Abundant in L. Winnebago. 9, 10, 13, 22, 65

PROBLEMATICAL FISHES

The following list includes those fishes currently not found in Wisconsin waters but which may be expected in the future. Also listed are those species and hybrids planted by various agencies but which are not known to reproduce naturally.

SALMONIDAE

Oncorhynchus gorbuscha (Walbaum)—Pink salmon

Accidentally introduced in 1955 into L. Superior from the Port Arthur, Ontario fish hatchery. Several successive generations have been reported. Six adults observed in the Cross R. near L. Superior, Cook Co., Minnesota, on Sept. 20, 1963. Although reported to this date only from Ontario and Minnesota waters, on the basis of its past movements we may expect to find it in Wisconsin waters. 14, 69, 93, 95

Oncorhynchus kisutch (Walbaum)—Coho salmon

Unsuccessfully introduced into L. Michigan and Riley L. (Chippewa Co.) in 1951. Planted in May, 1966, in State of Michigan tributaries of Lakes Michigan and Superior and apparently spreading throughout these lakes. Large numbers netted by commercial fishermen from L. Michigan off Michigan City, Indiana, during April and May, 1967. In 1968, 25,000 stocked in Ahnapee R. at Algoma. Stockings planned for 1969 include Algoma, Kewaunee, Sheboygan, and Manitowoc. 15, 27c, 104

Oncorhynchus tshawytscha (Walbaum)—Chinook salmon

Introduced. Between 1876 and 1879 a number of plantings were made, among them L. Geneva (Walworth Co.), Devils L. (Sauk Co.), Wautoma L. (Waushara Co.), L. Mendota (Dane Co.), Wisconsin R. at Portage (Columbia Co.), tributaries to the Mississippi (Grant Co.). In 1881 a mature female was taken from L. Michigan off Cedar Grove (Sheboygan Co.). Unsuccessfully stocked in Sunset L. (Portage Co.) in 1951. The State of Michigan stocked this species in 1967 in streams tributary to Lakes Superior and Michigan. Merryll Bailey reports capture of a 5-lb. chinook off Ashland (L. Superior) in May, 1969. A 1969 Wisconsin release of 60,000 is anticipated for the Sturgeon Bay ship canal. 15, 33, 113

Salmo clarki Richardson—Cutthroat trout

Introduced. In the Report of the Commissioners of Fisheries of Wisconsin for 1895–96 an entry is made of "450 black-spotted trout (full grown) distributed in 1896." A later entry in the same report mentions 500 black-spotted trout having been planted in "Pike's Creek," with no further data. Stocked in Black Earth Cr. (Dane Co.) in 1942 and in Gould Stream (Walworth Co.) in 1943. In 1959 the Twenty-Five Sportsmen's Club of Hubertus planted 500 legal cutthroat trout in Friess L. (Washington Co.). 113

Salmo salar Linnaeus—Landlocked salmon

Introduced. In 1875 landlocked salmon were stocked in L. Mendota (Dane Co.), Oconomowoc L. (Waukesha Co.), and Devils L. (Sauk Co.). In 1876, 10,000 were planted in L. Geneva (Walworth Co.). In 1879, plantings were made in "Clear L., Silver L., Geneva

L., Nagawicka L., and Green R." In 1907, 10,000 were planted in Trout L. (Vilas Co.). Two purported specimens of this species were taken Nov. 12, 1937, from a stream entering L. Geneva. Conservation personnel who examined the fish in 1939 believe them to be misidentified brown trout (letter Jan. 6, 1939, from L. A. Woodbury to F. C. Hewitt on file with the Wis. Cons. Dept.). 84, 113

Salvelinus namaycush female X *Salvelinus fontinalis* male—Splake

This hybrid was produced in Wisconsin as early as 1884. It has been stocked experimentally in lakes of northern Wisconsin in recent years. According to Canadian workers some backcrossing with the lake trout occurs. 15, 113

Thymallus arcticus (Pallas)—Arctic grayling

Introduced. Reports of the Commissioners of Fisheries of Wisconsin from 1878 to 1881 refer to grayling held in the Madison Hatchery, but no stocking occurred. In 1902, 180,000 fry were distributed from the Bayfield Hatchery with no locales indicated. In 1906, 30,000 eggs or fry were distributed at Lake Nebagamon to N. Clay Pierce, who had an estate on the Brule R. (Douglas Co.). These may have been released in the Brule. In 1908, 50,000 fry were planted in the Namekagon R. at Cable (Bayfield Co.). Unsuccessfully introduced in Mosquito Brook (Sawyer Co.) in 1937 and Pine R. (Waushara Co.) in 1938. 113

CYPRINIDAE

Scardinius erythrophthalmus (Linnaeus)—Rudd

Introduced into Oconomowoc L. (Waukesha Co.) in 1917 by Wisconsin Conservation Department. Reported to have spawned successfully in the lake in 1918, but has not been seen since. 20

Notropis lutrensis (Baird and Girard)—Red shiner

Recent records from Menominee Cr., 3 mi. ENE of East Dubuque (Jo Daviess Co.), and from Winnebago Co. in northern Illinois place this minnow almost on the Wisconsin state line (letter from Philip Smith, June 6, 1967).

Semotilus corporalis (Mitchill)—Fallfish

Appearance of the fallfish in the Cedar Cr., Thunder Bay District of Ontario, Canada is explained through the use of northern Lake Superior as a migration route. Not yet reported from Wisconsin waters. 1

ICTALURIDAE

Noturus insignis (Richardson)—Margined madtom

Introduced population in Sylvania Tract, Upper Peninsula, Michigan. Since this population is only a few miles from Wisconsin, it may possibly spread into our waters (letter from Reeve Bailey, April 4, 1967).

PERCIDAE

Etheostoma spectabile (Agassiz)—Orangethroat darter

The Illinois Natural History Survey has records of this species from Lake and McHenry Cos. which are adjacent to the Wisconsin state line (letter from Philip Smith, June 6, 1967).

Etheostoma blennoides Rafinesque—Greenside darter

A recent record needing substantiation from Lake Co., Illinois (L. Michigan drainage), places this species next to the Wisconsin state line. 95

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PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN NO. 60 TILIACEAE AND MALVACEAE—BASSWOOD AND MALLOW FAMILIES

Fred H. Utech

The woody, mostly tropical Tiliaceae has only one native and two cultivated species in Wisconsin, while the Malvaceae, characterized by monadelphous stamens, is represented not only by several noxious Eurasian weeds as velvet-leaf *(Abutilon theophrasti)*, flower-of-an hour *(Hibiscus trionum)* and cheeses *(Malva neglecta* and *M. rotundifolia)* and showy exotics as hollyhock *(Alcea rosea)* and high mallow *(Malva sylvestris)*, but also by several rare, handsome natives : poppy mallow *(Callirhoë triangulata)*, rose mallow *(Hibiscus militaris)* and glade mallow *(Napaea dioica)*.

The present treatment is a revision of an earlier preliminary report on Tiliaceae and Malvaceae by Hagen (1932) and is based on specimens in the herbaria of the University of Wisconsin (WIS), University of Wisconsin–Milwaukee (UWM), Milwaukee Public Museum (MIL), University of Minnesota (MIN), University of Minnesota-Duluth (DUL), State University of Iowa (IA), Oshkosh State University, La Crosse State University, Northland College (Ashland, Wis.), Beloit College and the private herbarium of Katherine Rill (Clintonville, Wis.—RILL). Grateful acknowledgement is due the curators of these herbaria for the loans of specimens.

Map dots represent exact locations, triangles, county records. Some locations have been added from Thomas Hartley's unpublished "Flora of the Driftless Area" (1962), Paul Sorensen's unpublished range maps from his Glacial Lake Wisconsin studies (1966), Jones and Fuller's *Flora of Illinois* (1955) and stand records for *Tilia americana* from the UW Plant Ecology Laboratory The map inset numbers record Wisconsin flowering and fruiting dates. Plants with vegetative growth only, in bud or with dispersed fruit were not included. For introduced species the year of earliest collection within a county is also recorded. Nomenclature and order of genera and species follows that of Gleason and Cronquist (1963) and Fernald (1950).

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TILIACEAE A. L. DE JUSSIEU BASSWOOD FAMILY

1. TILIA [TOURN.] L. BASSWOOD, LINDEN, LIME, BEE-TREE.

Large deciduous trees with soft white wood, fibrous inner bark, and numerous deep lateral roots. Winter buds large, obtuse, with few scales, *the terminal bud lacking*. Leaves alternate (2-ranked), cordate, palmately veined, serrate, oblique to truncate, acute to acuminate; stipules deciduous. *Flowers fragrant, entomophilous, yellowish-white, in cyme-like clusters each on an axillary peduncle adnate to the middle of a short-petioled, thin, wing-like bract.* Flowers perfect, 5-merous, hypogynous. Stamens many, free or united into 5 bundles and then opposite petals; filaments often forked distally; anthers 2-celled, opening longitudinally. *Staminodes 5, petaloid, opposite petals, always present in native species* (and in some Eurasian cultivars). Drupes globular, dry and woody, indehiscent, l-locular, 1- to 3-seeded; seeds with endosperm; cotyledons broad, 3- to 5-lobed.

About 25 tree species, native to north temperate deciduous forests, from Japan and Siberia to Europe, eastern N. America and Mexico. The chromosome number of *Tilia* (x = 41) is the highest odd basic number known in higher plants (Derman 1932).

Tilia as a generic name is of special botanical interest, for it was from these noble trees that Carolus Linnaeus (Linné) acquired his surname.

> His ancestors were peasants. Several of his relatives, who had quitted the plough for the Muses, changed their family name with their profession and borrowed the name of Lindelius or Tiliander (Linden-tree-man) . . . , a custom not unfrequent in Sweden, to take fresh appellations from natural objects. The father of Linnaeus, as the first learned man of his family, could not withstand following the example which his kindred had set before him. He likewise borrowed of the same tree a name which his son rendered afterwards famous and immortal in every quarter of the guobe. (Stoever 1794)

In North America, *Tilia* is called basswood in forestry, linden in horticulture, while in Britain, lime, apparently an altered form of linden or lind. The Anglo-Saxon lind means shield, i.e., of linden wood. The white, light, diffuse-porous wood is used for domestic utensils. Leaves, both fresh and dried, were fed to cattle by the Romans, a contemporary custom in northern Europe. The flowers produce excellent honey, hence the local American "bee-tree", while the dried steeped flowers serve as linden tea. Ropes, mats, shoes and baskets are made from the tough, fibrous inner bark, morphologically phloem bast fibers or bass, hence basswood.

Leaf pubescence on flowering branchlets usually differs from that on sprout leaves. Most *Tilia* lower leaf surfaces have small tufts of simple trichomes in the principal vein axils; these barbulae, domatia or acaradomatia are supposed to be symbiotic adaptations for mites (Jones 1968).

KEY TO SPECIES

A. *Leaves* of flowering branchlets *glabrous beneath,* except for tufts of simple trichomes in lateral vein axils; fruit ribs obscure or lacking.

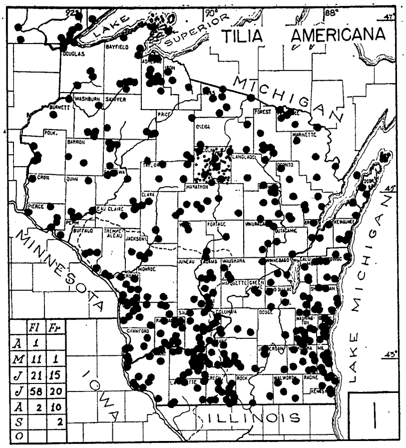
B. Staminodes 5; stamens 45–60; *axillary tufts whitish-gray,* lacking at petiolar leaf insert; cymes 6- to 15-flowered; common native forest tree __________1. *T. AMERICANA.*

BB. Staminodes lacking; stamens 25–30; *axillary tufts rusty brown,* well developed at petiolar leaf insert; cymes 5- to 7- (11-) flowered; commonly cultivated European tree ______________________________________2. *T. CORDATA.*

AA. *Leaves* of flowering branchlets *pubescent beneath and often above;* axillary tufts white; fruit strongly 3- to 5-ribbed; stamens 30–40; staminodes lacking; rarely cultivated European tree ______________________ 3. *T. PLATYPHYLLOS.*

1. TILIA AMERICANA L. American Basswood, Linden. Map 1.
Tilia glabra Vent.

Trees to 35 m tall, 1–1.5 m DBH, often clustered with two or more trunks, often with *several to many basal sprouts.* Bark on old trunks firm, dark gray with longitudinal furrows, young bark smooth, light gray. *Winter buds shiny, dark red,* ellipsoid–ovate, 2-ranked; terminal bud absent. Leaves broadly ovate–cordate, the blades of fertile shoots 8–20 cm long, 6–16 cm wide, cordate to truncate at base, abruptly acuminate, coursely serrate with gland-tipped teeth, glabrous beneath, with *tufts of whitish-gray hairs in vein axils, these lacking at petiolar leaf insert.* Petioles, pedicels and bracts of inflorescence glabrous. Cymes 6- to 15-flowered. Petals 5, yellowish-white, oblong to oblanceolate, 6–9 mm long. *Staminodes 5, oblanceolate, 5–7 mm long, opposite petals.* Stamens


TILIA AMERICANA
Fl Fr
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M 11 1
J 21 15
J 58 20
A 2 10
S 2
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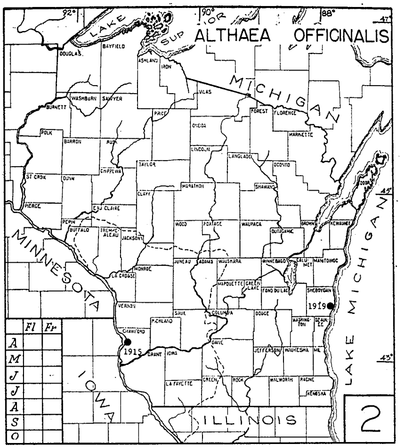
1


ALTHAEA OFFICINALIS
Fl Fr
A
M
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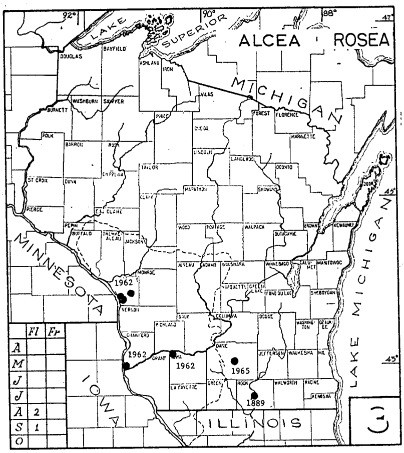
ALCEA ROSEA
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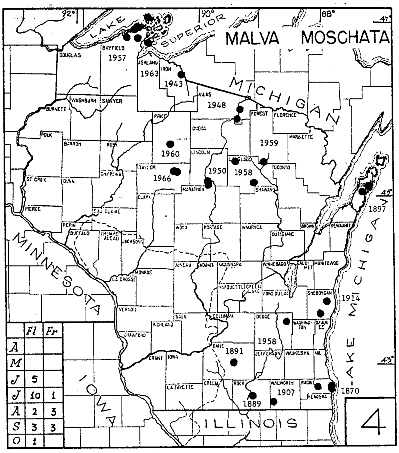
MALVA MOSCHATA
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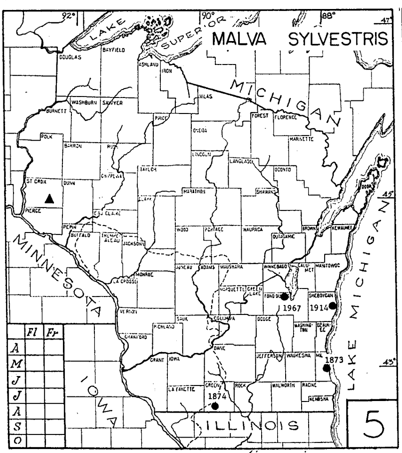
J 10 1
A 2 3
S 3 3
O 1
4


MALVA SYLVESTRIS
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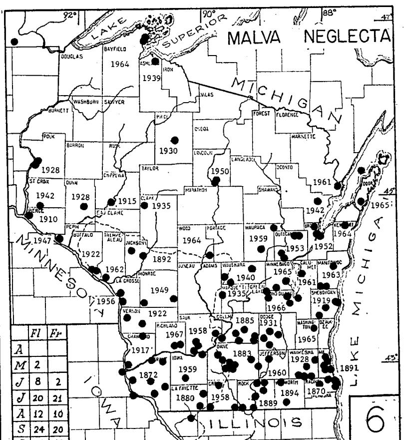
MALVA NEGLECTA
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A
M 2
J 8 2
J 20 21
A 12 10
S 24 20
O 4 10
6

45–60, free. Floral bracts 7–10 cm long, short stalked or sessile. Drupes globose, 6–12 mm wide, thick-shelled, without ribs. 2N = 82 (Derman 1932).

Native to deciduous forests of eastern North America (New Brunswick to southern Manitoba, southward to Penna. and Oklahoma), in its southeastern range partially sympatric along the glacial maxima with the Appalachian centered *Tilia heterophylla* Vent. (cf. maps Fowells 1965, Jones 1968), whence, Braun (1960) suggests, on vegetative characters, the putative "hybrid swarm" origin of *Tilia neglecta* Spach. However, according to Jones (1968) most specimens labelled *T. neglecta* consist of sprout leaves. The modern distributions suggest survival of *T. americana* in the Ozarks, *T. heterophylla* in the Appalachians, and post-glacial migration, overlap, and hybridization, a clinal pattern similar to that found between *Acer saccharum* ssp. *nigrum* and *A. s.* ssp. *saccharum* (Desmarais 1948, 1952), with *Tilia* the main deciduous forest co-dominant. Flowering from mid-May to late July, fruiting from early June to mid-August.

2. TILIA CORDATA Mill. Small-leaved Linden.

Cultivated trees to 25 m tall. Leaves orbicular-cordate, 2–7 (–10) cm wide, cordate, abruptly acuminate, the margin sharply serrate, *dark green and glaucous above, blue–green and glabrous beneath,* the axillary hair tufts rusty brown. Petioles glabrous, 1.4–3 cm long. *Cymes pendulent or upright, 5- to 7- (11-) flowered.* Stamens equaling petals, ca. 25–30, the filaments connate basally into 5 bundles alternating with petals; staminodes usually lacking. Floral bracts 3–8 cm long, glabrous. Drupes 1-seeded, globose–apiculate, thin-walled, slightly or not ribbed. 2N = 82 (Derman 1932).

Native from Siberia to England, Spain, Italy and the Balkans, commonly planted as lawn, street or park trees in many southern Wisconsin cities. Flowering in late June to early July.

3. TILIA PLATYPHYLLOS Scop. Large-leaved Linden.

Cultivated trees to 30 m tall. Leaves orbicular–ovate, 6–12 cm wide, obliquely cordate, abruptly acuminate, serrate, pubescent beneath and often above; *axillary tufts white.* Petioles densely pubescent, 2–5 cm long. *Cymes pendulent, 3- (rarely 4- to 6-) flowered.* Floral bracts 6–12 cm long, pubescent on lower midrib. Drupes 1-seeded, subglobose to pyriform, apiculate, densely pubescent, strongly 3- to 5-ribbed. 2N = 82 (Derman 1932).

Native in central and southeastern Europe (England to Spain, Asia Minor and Caucasus), rarely cultivated in Wisconsin as a shade tree: Milwaukee Co.: Milwaukee, 20 Sept. 1935, *Goessl s.n.* (WIS). Milwaukee, cultivated, 14 May 1938, *Shinners 12899* (UWM).

MALVACEAE A. L. DE JUSSIEU MALLOW FAMILY

Herbs (shrubs and trees in tropical regions), often *stellate-pubescent,* with simple alternate, mostly *palmately-veined and -lobed leaves.* Flowers solitary or cymose, 5-merous, regular, hypogynous and bisexual (unisexual in *Napaea*). *Calyx gamosepalous, persistent, often subtended by calyx-like bracts (paracalyx, epicalyx, involucre).* Petals separate, but slightly coalescent or frequently adnate to the base of the filament tube. *Stamens numerous, monadelphous* (filaments coalescent into a tube about ovary and style); anthers 1-celled. Ovary superior, bearing as many terminal style branches as there are carpels. Carpels 5-many, either *loosely coherent in a ring* around the base of the single style and then separating at maturity or completely *united into a compound ovary. Fruit a loculicidal capsule (Hibiscus) or carpels splitting ventrally and releasing seeds (Abutilon) or carpels separate, indehiscent, 1-seeded schizocarps (Malva).*

A large, predominately tropical family, only one-third of the Wisconsin species native, the majority naturalized from Eurasia, including obnoxious weeds (Cheeses, Velvet-leaf, Flower-of-an-Hour) and showy Eurasian garden cultivars (Hollyhocks, Mallows), of which some persist after cultivation, becoming locally established (Kearney 1951).

KEY TO GENERA

A. Carpels 5–20 or more, loosely united in a ring around a central axis, separating at maturity (schizocarps or mericarps); stamen-column antheriferous at summit. (Tribe MALVEAE)

- B. Carpels reniform, indehiscent, but not beaked, 1-ovulate; style-branches stigmatic along the inner face, slender-tipped.
  - C. Flowers perfect; involucre usually present.
    - D. Involucel of 6–9 distinct bractlets, united at base.
      - E. Plants 7–12 dm tall; petals 1.8–3.5 cm long; staminal tube terete, hairy; schizocarps 18–20, rounded on back, not keeled; rare escaped cultivar ________________________1. ALTHAEA.
      - EE. Plants 12–25 dm (or more) tall; petals 3.6–4.8 cm long; staminal tube 5-angled, glabrous; schizocarps 25–35 (or more), keeled on back; common showy garden escape ______2. ALCEA.

DD. Involucel of 3 bractlets or none.
F. Petals obcordate, white or tinted with blue, purple or red; bractlets 3; common weeds -- 3. MALVA.
FF. Petals truncate, rose red to purple; bractlets 3 or none; rare, dry prairie species - 4. CALLIRHOE
CC. Flowers white, small, dioecious; involucre none; large-leaved robust native prairie herbs ------ 5. NAPAEA.
BB. Carpels with long divergent beaks (3–3.5 mm), dehiscent, 3–8 seeded; stigmas terminal and capitate; flowers yellow; very common weed --------------------- 6. ABUTILON.
AA. Carpels 5, *united,* the fruit a loculicidal capsule without a central column; stamen-column antheriferous along much of its length; flowers 3 cm or more in diam. (Tribe HIBISCEAE) -- 7. HIBISCUS.

1. ALTHAEA L. MARSH-MALLOW.

1. ALTHAEA OFFICINALIS L. Marsh-mallow. Map 2.

Tomentose erect perennial 8–12 (–20) dm tall from an enlarged, knotty rootstock. Leaves triangular–ovate to cordate, crenate–serrate, gray to grayish-green, velvet-pubescent, the petioles 1.4–2.8 cm long. *Involucre united at base,* the 6–9 lanceolate bractlets densely stellate and hirsute, 4–5 mm long. *Petals obcordate, 18–28 (–35) mm long, white to pale pink. Staminal tube terete, hairy, commonly 12 mm long, bright violet;* anthers purplish-red. Carpels 18–20, densely short stellate, convex and not keeled on back, the lateral face not radially veined. *Seeds purplish black, 3.6–3.9 mm long.* 2N = 42 (Skovsted 1935).

Facultative salt-marsh plant, native to the drainage systems of the Caspian, Black and Baltic Seas, in North America as an escape along borders of saline or fresh water marshes. Formerly cultivated for the perennial root which yielded the original non-synthetic mucilaginous marshmallow paste; collected twice in Wisconsin: Crawford Co.: Lynxville, 11 Sept. 1915, *Davis s.n.* (WIS). Sheboygan Co.: Sheboygan, Aug. 1919, *Goessl s.n.* (WIS). Flowering in August to October.

2. ALCEA [Tourn.] L. HOLLYHOCK.

Linnaeus (Sp. Pl. 1753) followed Tournefort's distinction between *Althaea* (marsh-mallow) and *Alcea* (hollyhock), though Willdenow, De Candolle, Bentham and Hooker and others have fused the two genera into *Althaea*. Recent studies by Zohary (1963a, 1963b) in SW Asia have demonstrated the validity of readoption of this generic segregation: the staminal tubes in *Alcea* are 5-angled and glabrous, in *Althaea,* terete and hairy; the keeled schizocarps of *Alcea* are divided by an internal septum into an upper, empty cell and a lower one with a single seed, in *Althaea,* the schizocarps are rounded (on back), unilocular, one-seeded.

Alcea, an Old World genus with 60 species, is an Irano–Turanian element (mainly East Mediterranean, SW & central Asia).

1. ALCEA ROSEA L. Hollyhock. Map 3.
Althaea rosea (L.) Cav.

Robust biennial or perennial with *spire-like stems* to 2.5 m tall. Leaves cordate, shallowly 5- to 7- (9-) lobed, rarely dissected, densely stellate-pubescent, crenate; mid-stem leaves 5–11 cm long (blade petiole junction to lobe tip), 6–13 cm wide, the petioles (–3) 5–14 cm long. *Flowers showy, 7–10 cm wide, solitary or 2–4/leaf axil or in a terminal raceme.* Involucral of 6 (–9) lanceolate bractlets, united at base, densely stellate, the lobes 10–13 mm long. Calyx lobes 5, united, densely long-stellate, 11–16 mm long, *the involucre and calyx accrescent at maturity.* Petals 5 or double in horticultural forms, broadly obcordate, 3.6–5 (–6) cm long, white, yellow, pink, carmine-red to purplish-black or brownish-black, the claws bearded. *Staminal tube 5-angled, glabrous.* Peduncle stout, 1.8–2.3 cm long at maturity. Carpels 26–30, pale brown, ribbed, densely stellate–hirsute on tips, the lateral face radially veined. *Seeds light gray, 3–3.4 mm long.* 2N = 42 (Skovsted 1941).

Native to the north-eastern Mediterranean region (Aegean Islands, and adjacent Balkan Peninsula), and not, as customarily ascribed, to China (Linnaeus, *Sp. Pl.* 1753), which is beyond the natural range of the genus (Zohary 1963b); exact European introduction unclear, though long naturalized in SE Europe, Italy and S France; early herbalists Caspar Bauhin and Albertus Magnus noted that, like the tulip, introduction probably came in the 16th century from Turkey (Hegi 1925).

In Wisconsin frequently cultivated and persisting in the vicinity of gardens, dumps and waste places. Flowering from June to August or till frost.

The cultivated hollyhock is undoubtedly polymorphic (Zohary 1963b), consisting at least in part of hybrids of *A. pallida* (Willd.) Waldst. & Kit., *A. rosea* L. and *A. lavateraeflora* (D.C.) Boiss. In recent years its cultivated popularity has decreased due to a wide-spread Chilean fungal leaf infection *(Puccinia malvacearum* Bert.).

A horticultural variety, *ALCEA ROSEA* L. VAR. *SIBTHROPII* Boiss., differs from *A. rosea* in having large fig leaf-like leaves with 7-elongate lobes; carpels 35 or more, densely stellate at tips, deeply keeled; seeds reddish brown, minitely papillose, 3.8–4.2 mm long; in Wisconsin a rare and sporadic escape in dumps and rubbish piles, occasionally cultivated singly or mixed with *A. rosea*. Milwaukee Co.: Milwaukee, C. & N. R.R., on Locust St., one clump near patch of *A. rosea,* all probably sprouting from garden refuse, 3 July 1939, *Shinners 518* (WIS). Winnebago Co.: Oshkosh, dump at end of Oak St., probably escaped from soil scraped off a garden, 2 July 1966, *Harriman 924* (Oshkosh State Univ.). Flowering in July.

3. MALVA [Tourn.] L. MALLOW, CHEESES.

Annual, biennial or perennial herbs with *orbicular-reniform, palmately dissected or lobed, crenate leaves.* Flowers solitary or fascicled in leaf axils. Involucral bractlets (2–) 3, free, linear to obovate. Calyx 5-lobed. Petals 5, truncate, notched or obcordate. Anthers terminal on the staminal column. Styles as many as carpels, stigmatic on the inner surface. *Fruit of 8–20 radial carpels surrounding a central depression, these separating at maturity into as many one-seeded, indehiscent, round-reniform, laterally flattened schizocarps.*

Old World genus, native to Eurasia and North Africa, with 30 species, including several world-wide weeds and cultigens, such as the medical herbs *Malva sylvestris* and *M. neglecta,* which provide a leaf concoction (i.e. *Malvae folia*) that serves as an emollient and demulcent. *Malva* is an Old Latin name from the Greek *malache* or *moloche,* referring to the emollient leaves. The fruits are called cheeses since they resemble cheese wheels, and are eaten by children and poultry, and had been served on medieval tables. Reported hybrids (in *Flora Europaea,* Tutin *et al.* 1968) include *M. alcea* X *M. moschata, M. sylvestris* X *M. neglecta,* and *M. neglecta* X *M. rotundifolia.*

KEY TO SPECIES

A. Upper leaves deeply 5- to 7-parted to below the middle or nearly to the base; flowers chiefly solitary in the upper axils, showy; petals 2–3 cm long; escaped garden plants (Section BISMALVAE).

B. Pubescence of spreading simple hairs; carpels densely hirsute on back; bractlets linear-lanceolate -- 1. *M. MOSCHATA.*

BB. Pubescence of short stellate hairs; carpels glabrous; bractlets oblong-ovate ---------------------- *M. ALCEA*.

AA. Upper leaves reniform-cordate, with scalloped margins, only rarely lobed to the middle; flowers fascicled in the axils; petals 0.4–2.3 cm long (Section MALVA).

C. Bractlets oblong-ovate; *petals rose-violet, 1.4–2.3 cm long;* erect, escaped garden plant --------- 2. *M. SYLVESTRIS*.

CC. Bractlets linear or narrowly lanceolate; *petals white with pale blue or purple tinged tips, 0.3–1.2 cm long.*

D. *Carpels 12–15, when mature puberulent and not rugose on back;* lateral face of carels not radially veined; petals 6–12 mm long; common prostrate weed -- 3. *M. NEGLECTA*.

DD. *Carpels 8–11, when mature glabrous and rugose-reticulate on back* (Figs. 1 & 2); lateral face of carpels radially veined; petals 3.2–6 mm long.

E. Stems commonly prostrate to ascending; fruiting pedicels 10–45 mm long; bractlets 2.9–3.8 mm long; petals 3.2–4.5 mm long; common weed --- 4. *M. ROTUNDIFOLIA*.

EE. Stems erect; fruiting pedicels 8–15 mm long; bractlets 3.7–5.4 mm long; petals 4.8–6 mm long; rare garden escape ----------- *M. VERTICILLATA*.

1. MALVA MOSCHATA L. Musk-malow. Map 4.

Erect biennial to perennial, 3–8 dm tall, with knotty root-stocks, *pubescent throughout, chiefly of simple divergent hairs.* Leaves cordate, deeply 3- to 5- (7-) parted, the upper linear bipinnatifid, the lowest broadly 5-lobed, *faintly musk scented* (hence common name). Flowers solitary to 3 in upper axils, the fruiting pedicels 1.6–4 cm long. Bractlets 3, linear to oblanceolate, ciliate, glabrous on back, 5–6 mm long. *Calyx 5-lobed, with simple trichomes, inflated in fruit. Petals 5, triangular-obcordate, pale rose-violet, 2–2.4 cm long. Fruiting carpels 11–15, rounded not keeled and densely hirsute on back.* Seeds reniform, gray brown, glabrous, 1.8–2 mm long. 2N = 42 (Skovsted 1935).

Native of Europe to North Africa, (rail-transported) adventive over most of Europe, often cultivated as a garden plant for its showy flowers, in Wisconsin infrequent, escaping and persisting locally on sandy roadsides, dumps, waste places and beaches. Flowering and fruiting from mid June to mid September.

MALVA ALCEA L. Vervain mallow.

Erect robust perennial, 4–8 (–12) dm high, short stellate pubescent. Similar to *M. moschata*, but upper leaves more broadly divided. *Flowers solitary*, on short pubescent pedicels, these 1.6–2.6 cm long in fruit. Bractlets 3, oblong to ovate, 4.5–6 mm long, densely stellate on back. Calyx 5-lobed, stellate pubescent. *Petals 5, obcordate, notched, pale purple to white, 2–2.8 cm long. Carpels 18–20, when mature keeled and glabrous or sparsely pubescent on back*. Seeds reniform, dark gray brown, glabrous, 2–2.3 mm long. 2N = 82 (Skovsted 1935).

Native of Europe (Sweden to Spain, the Balkans and S Russia), a pontic-Mediterranean element of dry and calcareous sites, in Wisconsin escaping sporadically from gardens but not persisting: Calumet Co.: Roadside n of Stockbridge, 7 Aug. 1907, *Goessl s.n.* (WIS). Milwaukee Co.: Milwaukee, vacant lot on Hopkins St., ½ block s of Villard Ave., flowers light pink, garden escape, 15 July 1942, *Fuller F–42–86* (MIL). Flowering in late summer.

2. MALVA SYLVESTRIS L. High-mallow. Map 5.

Erect biennial to perennial, 4–8 dm tall from a shallow branched taproot, *the stems glabrous or very sparsely hirsute*. Leaf blades round–cordate or reniform, broadly 5-lobed, the terminal lobe obtuse to rounded, 2–9 cm long (petiolar leaf insert to lobe tip), 3–11 cm wide. *Petioles 6.5–9.5 cm long, pubescent in a single line on the upper surface.* Flowers fascicled in upper leaf axils; fruiting pedicels 2–3.5 (–5) cm long. *Bractlets 3, oblong to ovate or obovate, 3.8–4.7 mm long, subglabrous, ciliate.* Calyx 5-lobed, stellate–pubescent. Petals obcordate, notched, rose–violet, 1.4–2.3 cm long. *Mature carpels commonly 10, rugose–reticulate on the back,* glabrous. Seeds round–reniform, 1.9–2.1 mm long, blackish brown, subglabrous.

Native Euro–siberian element (Europe, N. Africa, Asia Minor to Siberia), world-wide adventive, in Wisconsin grown in old gardens, locally persisting as an escape: Green Co.: Monroe, 7 Aug. 1894, *Stuntz s.n.* (WIS). Fond du Lac Co.: Pea field near old homestead, 1 mi. w from hwy 175 on Cemetery Rd., 1 Oct. 1967, *Jeffers s.n.* (WIS). Ozaukee Co.: Port Washington, growing wild, 17 Aug. 1887, *Runge 137* (MIL). Sheboygan Co.: Sheboygan, July 1914, *Goessl s.n.* (WIS). St. Croix Co.: Baldwin, *Anderson s.n.* (WIS). Milwaukee Co.: Milwaukee, 1873, *Sherman 673* (IA). The Wisconsin specimens have glabrous or sparsely hirsute stems, obtuse-lobed leaves and dark flower color, thus belong to var. *mauritiana* (L.)

Boiss. (Fernald and Wiegand 1910). This is the common type grown in European farm gardens (Hegi 1925). Flowering from mid-July to early October.

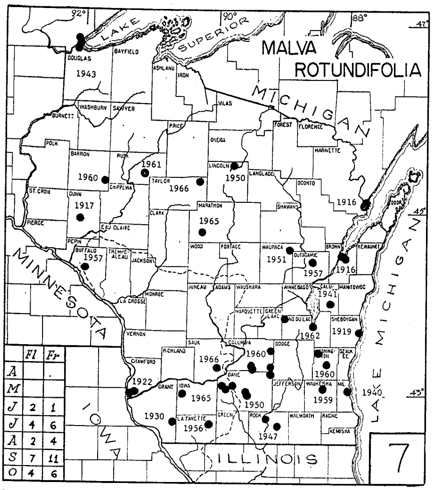
3. MALVA NEGLECTA Wallr. Common mallow, Cheeses. Fig. 1 & 2.
Malva rotundifolia of some American authors, not L. Map 6.

Biennial or perennial with prostrate to ascending stems, 1–7 dm tall, from a deep branching taproot. Leaves round–cordate, shallowly 5–9 lobed, crenate, 2–4 (5.5) cm long (petiolar leaf insert to lobe tip), 3–6 (–9) cm wide, long petiolate. Flowers 1–5 in leaf axils, pedicels slender, 1–5 cm long. Calyx 5-lobed, stellate–pubescent at anthesis. Bractlets 3, linear, ciliate, 3.6–4.6 mm long. Petals 5, triangular–obcordate, 6–12 mm long, white with pale blue or purplish tips, the claws bearded. Staminal tube ca. 6 mm long. Styles and stigmas purple. *Outline of carpel ring scalloped,* the depressed center ca. 1/3 the diameter of the head (Figs. 1 & 2). *Mature carpels 12–15, commonly 14, densely puberulent, not reticulate on back,* the lateral faces smooth. Seeds round–reniform, 1.7–1.9 mm long, laterally depressed, blackish brown, glabrous. $2N = 42$ (Mulligan 1961).

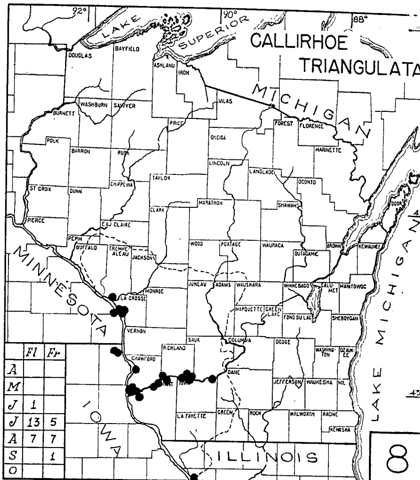
Native to temperate Eurasia (from England to L. Baikal) and N. Africa, widely adventive in Wisconsin mostly about dwellings, fields, lawns, roadsides, gardens and especially in highly nitrogenous waste places, becoming a noxious pest, most common south of the northern highlands, being limited by the colder climate, e.g. earlier frost, shorter growing season—cf. map of *Galium aparine* (Urban & Iltis 1957). Flowering continually from April to November, fruiting May to November.

4. MALVA ROTUNDIFOLIA L. Cheeses. Map 7, Figs. 1 & 2.
Malva borealis Wallm.
Malva pusilla Smith ex Withering

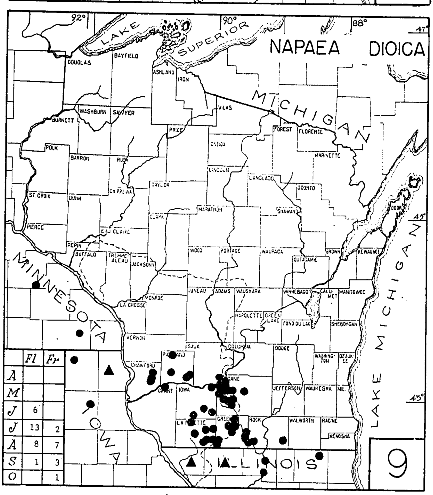
Procumbent to ascending, branched biennial to perennial, 1–5 dm tall, from a slender unbranched taproot. Leaves round–cordate with 5–9 shallow lobes, crenate, 1–5 (–6) cm long (petiolar leaf insert to lobe tip), 3–9 cm wide, long petiolate. Flowers 2–6 in leaf axils, the fruiting pedicels 1–3.5 (–4.5) cm long. Calyx 5-lobed, with simple pubescence at anthesis, accrescent at maturity. Bractlets 3, linear, ciliate, 2.9–3.8 mm long. Petals 5, oblanceolate–obcordate, 3.2–4.5 mm long, white with pale blue or purplish tips, the claws bearded. *Staminal column ca. 3 mm long.* Styles and stigmas purple. *Marginal outline of carpel ring circular,* the depressed center ca. 1/5 the diameter of the head (Figs. 1 & 2). *Mature carpels 9–11,*



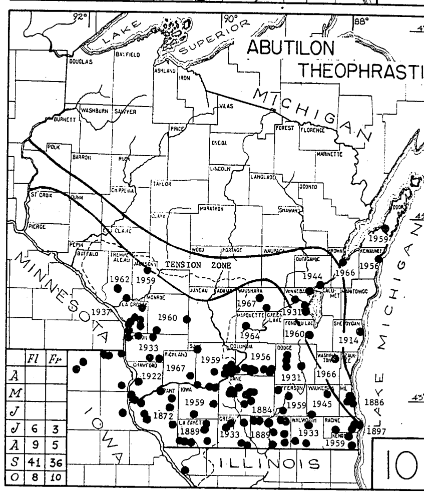
	Fl	Fr
A		
M		
J	2	1
J	4	6
A	2	4
S	7	11
O	4	6



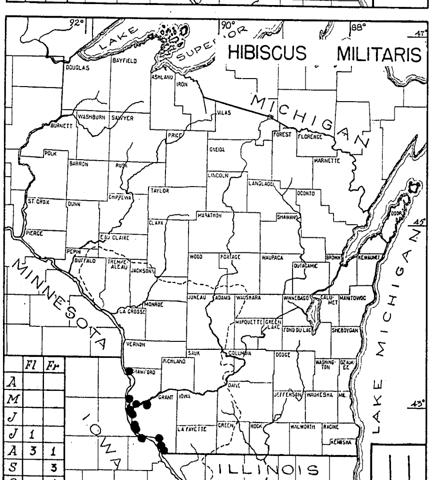
	Fl	Fr
A		
M		
J	1	
J	13	5
A	7	7
S		1
O		



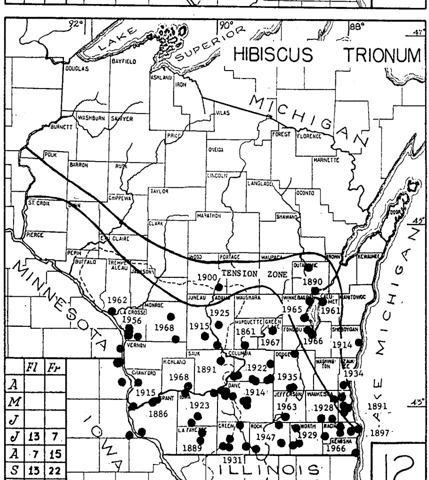
	Fl	Fr
A		
M		
J	6	
J	13	2
A	8	7
S	1	3
O		1



	Fl	Fr
A		
M		
J		
J	6	3
A	9	5
S	41	36
O	8	10



	Fl	Fr
A		
M		
J		
J	1	
A	3	1
S		3
O		1



	Fl	Fr
A		
M		
J		
J	13	7
A	7	15
S	13	22
O	4	8

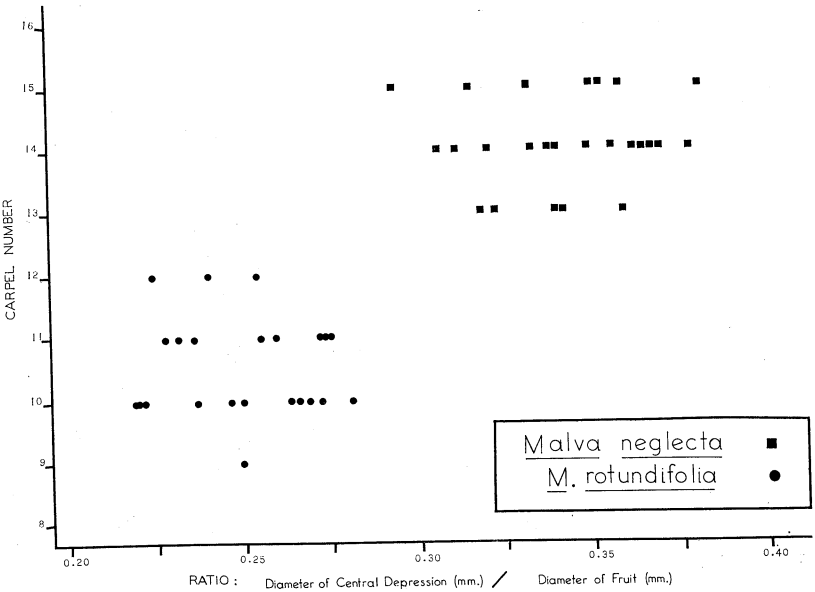
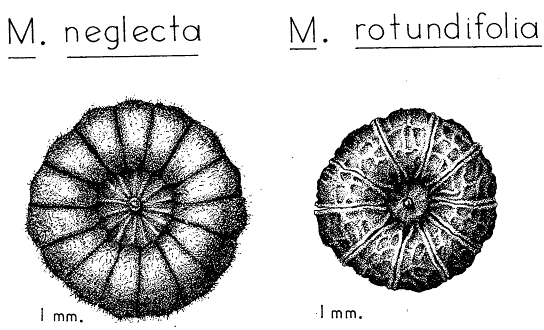


FIGURE 1. Scatter-diagram comparing the number of carpels per fruit and the width ratio of the central depression diameter divided by the fruit diameter of *Malva neglecta* and *M. rotundifolia.*



Length (mm)	Malva rotundifolia	Malva neglecta
Bractlets	2.9 - 3.8	3.6 - 4.6
Petals	3.2 - 4.5	6.0 - 12.0
Staminal column	ca. 3	ca. 6

FIGURE 2. Comparative carpel illustrations and floral measurements for *Malva neglecta* and *M. rotundifolia.*

commonly 10, when young tomentulose, glabrous with maturity, conspicuously rugose–reticulate on back, the lateral face radially veined. Seeds reniform, 1.8–2 mm long, laterally depressed, dark brown, glabrous.

Native of eastern Europe and western Asia (central Europe to Siberia and India), a world-wide adventive like *Malva neglecta* though not as frequent, a weed in southern Wisconsin in sandy, gravelly soils, about dwellings, waste and disturbed places, roadsides and railroad tracks. Similar in appearance to *M. neglecta*, but with fewer and glabrous carpels (Fig. 1) and shorter bractlets, staminal tube and petals (Morton 1937). Some European floras use *M. pusilla* Smith (ex Withering), because *M. rotundifolia* is considered a *nomen ambiguum.* Flowering and fruiting from April to November.

MALVA VERTICILLATA L. var. CRISPA L. Curled-mallow.

Erect perennial to 1 m (or more) tall, with large reniform leaves crenately 5- to 7-lobed, *the margins crisped. Petioles pubescent along a single line on the upper surface,* 5–11.7 (–17) cm long. *Flowers crowded in axillary fascicles, nearly sessile, the fruiting pedicels 8–15 mm long.* Bractlets 3, linear–lanceolate, 4.4–5.4 mm long, with simple trichomes. *Calyx 5-lobed, acuminate, with short stellate pubescence. Petals* 5, ovoid–obcordate, notched, *4.8–6 mm long,* white with pale blue tips, *Mature carpels 8–11, glabrous, obsurely reticulate near carpel margins.* Seeds ca. 2 mm wide, gray–brown, glabrous.

Native of China, naturalized from S Asia to SE Europe, introduced to European gardens with *Alcea rosea* in the 16th century, sporadically adventive in North America, now seldom grown as a salad green or garden plant (Hegi 1925), in Wisconsin rarely persisting after cultivation: Racine Co.: Racine, (ca. 1860), *Hale s.n.* (WIS). Sheboygan Co.: Sheboygan, waste land, *Goessl s.n.* (WIS). Walworth Co.: Darien, brought in from Pflaum garden, 31 July 1935, *Wadmond s.n.* (WIS). Flowering from July to August.

4. CALLIRHOE L. POPPY MALLOW.

Perennial herbs with *erect stems fascicled from a thick fusiform taproot.* Leaves triangular–cordate, crenate to deeply divided. Calyx 5-lobed, *either naked or with a 3-leaved involucre at its base.* Petals 5, triangular, broadly truncate, erose or fimbriate at summit, purple, red–purple, occasionally pink or white. *Staminal column antheriferous along more than half its length. Styles* slender, stigmatic along inner surface, *greatly elongated at anthesis*. Carpels 10–15, these separating at maturity into as many one-seeded, indehiscent, reniform schizocarps.

New World genus with 7 species of the Great Plains and northern Mexico.

KEY TO SPECIES

A. *Leaves triangular, crenate; involucre of 3 spatulate bractlets;* carpels keeled, strigose, the lateral faces not radially veined; native, dry sand prairies ----------1. *C. TRIANGULATA*.

AA. *Leaves deeply 5- to 7-parted, the segments incised; involucral bractlets lacking;* carpels strongly rugose, the lateral faces radially veined; rare, waif introduction -2.*C. ALCAEOIDES*.

1. CALLIRHOË TRIANGULATA (Leavenw.) Gray Poppy mallow. Map 8.

Erect perennial herbs with several stems to (2.5–) 6–8 dm tall, from a *stout fusiform taproot,* to 3 dm long. *Stems, leaves and calyx harshly stellate.* Leaves triangular–hastate, 6.5–13 cm long, 3.6–9.5 cm wide, coarsely crenate, truncate to cordate at base, with variable petiole lengths 3–17 cm. Stipules oblong, persistent, 6–11 cm long. *Flowers showy, panicled from axillary peduncels, 8.6–20 cm long, the pedicels 1.6–2.2 cm long at maturity. Bractlets 3, spatulate, ciliate, 6–9.5 mm long.* Calyx deeply 5-parted, the lobes 2.1–4.7 mm long at maturity. *Petals magenta–purple,* broadly truncate at summit, 1.9–2.6 cm long. Staminal column 10–13 mm long, *antheriferous laterally,* the anthers yellowish brown. Carpels 10–12, one seeded, indehiscent, short beaked, keeled, strigose, not rugose on back, the lateral faces not radially veined. Seeds reniform, laterally depressed, dark brown, 2.3–2.9 mm long.

Rare showy sand prairie species of the Ozarks and Great Plains, confined in Wisconsin to the dry and sandy valleys of the Wisconsin and Mississippi Rivers: in Prairie du Chien cemetery on Mississippi River sand terrace, (*Jones 416,* WIS); in Grant Co., Boscobel, prairie remnant along railroad, (*Musselman 2036,* WIS); sandy upland, Midway Prairie, La Crosse Co., (*Hartley 1404,* WIS); sandy *Pinus banksiana* woods E of Gotham, Richland Co., (*Nee 1068,* WIS). The preservation of this handsome species is insured by the inclusion of the Midway Prairie as one of the Scientific Areas of Wisconsin. Flowering and fruiting in July and early August.

CALLIRHOË ALCAEOIDES (Michx.) Gray

Perennial with numerous erect slender stems to 4 dm tall from a shallow, swollen taproot. Lower leaves triangular–cordate, shallowly 5–7 lobed, *the upper deeply 5–7 parted, these incised into numerous linear segments. Involucral bractlets lacking.* Calyx 5-lobed, the lobes acuminate, elongating to 1 cm at maturity. Flowers 2.5–4 cm wide, *the petals 1.4–1.8 cm long, pale rose to white,* fimbriate *or erose at summit.* Staminal column commonly 6 mm long, antheriferous along sides, the anthers dark red. *Styles exceeding staminal column by 1.5 cm at anthesis.* Carpels commonly 12, glabrous, strongly rugose on back, the lateral face radially veined. Seeds reniform, reddish brown, glabrous, 2.1–2.3 mm long.

Native of dry sand barrens, plains and prairies of south–central United States, where locally restricted. In Illinois limited to dry, gravelly or sandy, exposed soils, frequent along railroads (Jones and Fuller 1955), the only Wisconsin collection probably a waif introduction: Milwaukee Co.: Bay View, summer 1888, *Runge 140* (MIL).

5. NAPAEA [CLAYT.] L. GLADE MALLOW.

1. NAPAEA DIO|CA L. Glade mallow. Map. 9.

Napaea dioica L. forma *stellata* Fassett, *Torreya* 42:179–180. 1943. [Type: Dane Co.: Along a railroad 3.8 miles west of Cross Plains, Aug. 16, 1942, *Fassett 22057,* (WIS, Isotypes in US, NY, GH, and several other herbaria.)]

Robust, *white-Yowered, dioecious perennial,* 1–2 m tall from a stout taproot. Leaves 1–3 dm wide (basal leaves larger, to 6 dm), deeply 5–9 (–11) lobed or parted, the lobes coarsely toothed or incised, the lower surfaces strigose–pilose with or without admixture of short stellate hairs. *Flowers numerous, dioecious, without involucel, in large terminal panicles.* Calyx lobes 5, united, ovate to triangular, 5–8 mm long. Petals white, notched, those of the staminate flowers 5–9 mm long, those of pistillate shorter. Staminate flowers with 16–20 anthers, pistils lacking, the pistillate with a short column of (usually) antherless filaments, the styles stigmatic along the inner surface. *Carpels 8–10, when mature irregularly dehiscent into as many reniform, one-seeded schizocarps,* the back with stellate trichomes, rugose and ribbed. Seeds reniform, reddish brown, 3.5–3.8 mm long, glabrous. 2N = 30, N = 15 (Iltis & Kawano 1964).

The phytogeography, ecology and nomenclatural history of *Napaea dioica* have been reviewed by Iltis (1963) and Mickelson & Iltis (1966). The heliophytic habitat preference strongly suggests that it is a wet prairie, not a forest species, which was associated with the formation and extension of the prairie peninsula. Flowering late June to mid-August, fruiting July to early September.

Napaea is the *only* endemic *genus* confined almost completely to the glaciated north–central United States, and with its monotype *N. dioica* being the only strictly dioecious Malvaceae in the Western Hemisphere. The Californian *Sidalcea malachroides* with 2N = 20 appears to be the closest morphologically, but only as a putative relative. Based on karyotype analysis, Iltis and Kawano (1964) suggest that *Napaea* is an ancient allopolyploid hybrid between a 2N = 20 species of *Sidalcea* and another species (*Sidalcea* ?), now extinct, in which 2N = 10. The basic number would then be 5, not 7 as in all other members of the subtribe Malvinae. This would suggest segregation of *Napaea* and *Sidalcea* into their own subtribe.

Some plants have simple, straight appressed hairs and few stellate trichomes on the lower leaf surface. In others, these simple hairs are lacking, except on the larger veins, and are replaced by the short branched stellate trichomes (forma *stellata* Fassett, 1943). Frequently, the same plant will have upper leaves with mostly stellate trichomes, while the large basal leaves have mostly simple unbranched trichomes. Under the microscope these extremes are striking, yet there are numerous collections with both types mixed in various proportions (Iltis 1963). Though it might be useful to name these extremes, it is impossible to know whether the Linnean type specimen has stellate, simple or mixed pubescence. Fassett assumed, on the flimsy basis of Sprengel's (Syst. Veget. 3:122) statement that it is a "herba hirsuta", that the type had simple hairs. This conclusion is not warranted, since any plant may be hirsute with simple hairs. It seems best to ignore forma *stellata* until the Linnean type has been examined.

6. ABUTILON [Tourn.] Miller VELVET-LEAF.

1. ABUTILON THEOPHRASTI Medic. Velvet-leaf, Butter-print. Map 10.

Stout branched annual herb (2–) 5–18 dm tall, from shallow thick taproot 8–17 cm long, *softly velvet-pubescent throughout.* Leaves cordate, 4–12 (–19) cm long, 3.5–11 (–17) cm wide, acuminate, the margin entire or slightly toothed; petiole 4–11 cm long. *Peduncles 13–26 mm long, jointed above the middle. Bractlets lacking;* calyx 5, united at base, ovate–elliptic, persistent, 7–12 mm long. Flowers yellow, 14–28 mm across. *Carpels 12–15 (–17) with conspicuous, horizontally spreading beaks, 3.1–3.5 mm long, the* *"schizocarps" ventrally dehiscent and not separating readily from the central axis.* Seeds 3–6 (–8)/carpel, 3.1–3.4 mm long, dark brown with short scattered stellate pubescence. 2N = 42 (Skovsted 1935, Smith 1965).

Native of India and central Asia, a world-wide adventive, common below the tension zone in southern Wisconsin, climate-limited (Lindsay 1935), as a noxious weed in cultivated and fallow fields, especially corn, but occasionally in gardens, along fence rows and waste places. The seeds retain their viability for over 50 years and are not killed by siloing (Steyermark 1963). The arrangement of the carpels resembles the print-blocks used on farms for stamping rolls of butter. Flowering and fruiting continuously from July to October or till frost.

7. HIBISCUS [Tourn.] L. ROSE-MALLOW.

Annual or perennial herbs or shrubs with entire to palmately lobed or dissected leaves. Flowers large, showy, in terminal racemes or solitary in upper axils. *Involucral bracts linear, 7–15.* Sepals 5, broadly triangular, enlarged in fruit. *Stamen-column long, with numerous lateral anthers; stigmas 5, capitate.* Fruit a 5-locular, subglobose or prismatic loculicidal capsule, subtended or enclosed by the persistent, accrescent calyx.

World-wide, subtropical to tropical genus, with ca. 150 species; *Hibiscus esculentus* L., okra or gumbo, a garden vegetable grown for its soft immature edible pods and *H. syriacus* L., Rose-of-Sharon, a showy ornamental shrub, are common temperate economic species.

KEY TO SPECIES

A. Tall perennial herbs, 1–2 m; petals pink, 5–9 cm long; fruiting calyx not inflated about the capsule.

B. Leaves obovate-lanceolate, canescent beneath; involucral bracts 10–15; *seeds not pubescent*__1. *H. MOSCHEUTOS.*

BB. Leaves hastate, green on both surfaces, glabrous; involucral bracts 9–10; *seeds with reddish brown hairs;* Wisconsin and Mississippi River bottoms ____2. *H. MILITARIS.*

AA. Low annuals, 3–6 dm; petals pale yellow with purple center, 1.5–3.0 cm long; fruiting calyx inflated; common southern Wisconsin weed __________________________3. *H. TRIONUM.*

7. HIBISCUS [Tourn.] L. ROSE-MALLOW.

1. HIBISCUS MOSCHEUTOS L. subsp. PALUSTRIS (L) Clausen
Hibiscus palustris L.

Robust perennial to 2 m; stems densely to remotely stellate-pubescent. Leaves ovate to elliptic lanceolate, 8–20 cm long, 9–15 cm wide, serrate to crenate, rarely lobed, green above, with whitish to grayish pubescence beneath. *Petioles adnate to peduncle.* Involural bracts 9–14, linear, 1.4–2.5 cm long. *Petals pink, rarely white, lacking red band at base, 6.5–9 cm long.* Styles with spreading pubescence. Capsules abruptly contracted to a beak, glabrous or essentially so. *Seeds dark brown, papillose,* 3–3.2 mm long.

Saline, brackish or fresh water marshes of the northern coastal plain with inland extension to the Great Lakes region of southern Ontario, southern Michigan, northern Indiana and northeastern Illinois, in Wisconsin known from only one collection and now probably extinct: Rock Co.: Janesville, flowers pink, 25 Aug. 1889, *Gertil Skavlem s.n.* (WIS).

Radford *et al.* (1968) treat *Hibiscus palustris* L. as a subspecies of the sympatric and southern *H. moscheutos* L., as previously suggested by Fernald (1942, 1950).

2. HIBISCUS MILITARIS Cav. Rose-mallow. Map 11.

Robust, essentially glabrous perennial 1–2 m tall, with several erect stems arising from a crown root. *Leaves triangular to hastate,* 8–12 cm wide, 8–15 cm long, acute at apex, *basal lobes diverging,* green on both sides; petioles 7–13 cm long. Flowers showy, solitary in upper axils, the peduncles 2.3–5.8 cm long. Bractlets 9–12, glabrous and linear, 1.7–2.3 cm long. *Petals 5, pink with red-purple base, 6–8.5 cm long.* Carpels 5, dehiscent and beaked with 6–8 seeds carpel. *Seeds with stiff, brownish-red trichomes, 3–3.3* mm long. 2N = 38 (Nakajima 1936 ex Darlington 1955).

Native of marshes and muddy shores of pond and streams of the coastal plain, extending north of the Mississippi Embayment to Iowa, Minnesota, Indiana, Illinois and Wisconsin. The few Wisconsin stations are limited to the Mississippi and Wisconsin River bottoms where deposition and silting occur—levees, boat landings and alluvial forests. *Leersia lenticularia* Michx., *Sagittaria montevidensis* Cham. & Schlect. ssp. *calycina* (Engelm.) Bogin, and *Rorippa sessiliflora* (Nutt.) Hitchcock have similar distributions.

Dispersability and habitat preference suggest a recent northward migration. Dispersal is no problem, for the seeds are eaten by ducks and bobwhites (Steyermark 1963). Recent migration is noted for Indiana by Deam (1940): "I have known well the shores of the

Wabash River near Bluffton for a distance of 5 miles since 1880. The first colony of this species was noted in 1897 and is now common all along the muddy shores and on the muddy bars in the river. In the early history of the state our streams were clear and when the forests were removed the streams became muddy and sediment was deposited on the shores and on the gravelly and rocky bars which made a suitable habitat for this species." Wisconsin's earliest collection dates from 1914: Crawford Co.: Bridgeport, 6 Aug. 1914, *Denniston s.n.* (WIS). Later collections indicate sites where deposition and silting would occur and create suitable habitats. Apparently native, though its recent northward extension has probably been due to man's activity. Flowering late July to early August, fruiting August to September.

3. HIBISCUS TRIONUM L. Flower-of-an-hour. Map 12.

Low hairy annual, much branched at base, 3–6 dm tall; taproot slender. Leaves deeply 3-parted, 1.5–6 cm long, the segments oblong–obovate, irregularly incised; petioles 2–5 cm long. Bractlets 10–12, linear, ciliate with white trichomes, 7–12 mm long. *Calyx 5-lobed, membranaceous, ribbed. Flower sulfur yellow with a red–purple center, showy, but ephemeral* (hence common name); petals 1.5–3 cm long. Mature capsules 5-locular, black with long yellow trichomes, 5–7 seeds/carpel; the calyx surrounding it highly inflated, translucent, with many vertical dark green ribs, papillose and long hirsute. Seeds brown–black, papillose, 2–2.3 mm long. 2N = 28 (Medvedeva 1936, ex Darlington 1955) and 2N = 56 (Skovsted 1935).

Native of SE Eurasian agricultural center, found in the neolithic Aggtelek kitchen middens of Croatia (Yugoslavia), a *Kulturbegleiter* ("culture follower") now adventive throughout Europe, eastern Asia to China, N. Africa and N. America (Hegi 1925), its numerous seeds with unusual viability contributing to its spread (Deam 1940), a common weed in southern Wisconsin, in sandy soils of cultivated fields, gardens, roadsides, and disturbed or waste places. Flowering and fruiting from early July to late October or till frost.

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PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN NO. 61[1]. HYPERICACEAE—ST. JOHN'S–WORT FAMILY

Fred H. Utech and Hugh H. Iltis

The Hypericaceae, a natural group often segregated from the more polymorphic, woody, tropical Guttiferae, has 2 genera and 14 species in Wisconsin. All but the ubiquitous Common St. John's-wort *(Hypericum perforatum)* are native and occur either in dry, exposed sands or wet marly marshes or bogs, sandy swales and lake, river or stream-sides. A southern origin for the Great Lakes–Central Wisconsin endemic *Hypericum kalmianum* is suggested. Three species are reported here as new for the state: *Hypericum prolificum,* x *H. dissimulatum* and *Triadenum virginicum.*

The present treatment revises McLaughlin's (1931) preliminary report on Hypericaceae. Material from the following herbaria was intensively studied: University of Wisconsin (WIS), University of Wisconsin–Milwaukee (UWM), Milwaukee Public Museum (MIL), University of Minnesota (MIN), University of Minnesota–Duluth (DUL), State University of Iowa (IA), Oshkosh State University, La Crosse State University, Northland College (Ashland, Wis.), Beloit College and the private herbarium of Katherine Rill (Clintonville, Wis.–RILL). We are grateful to the curators of these herbaria for the loans of specimens.

Dots on the maps represent exact locations, triangles, county records. Some locations have been added from Thomas Hartley's unpublished "Flora of the Driftless Area" (1962), Paul Sorensen's unpublished range maps from his Glacial Lake Wisconsin studies (1966), Olga Lakela's *Flora of Northeastern Minnesota* (1965), Jones and Fuller's *Flora of Illinois* (1955) and Frank Seymour's Lincoln County sight record index (WIS).

The map inset numbers record Wisconsin flowering and fruiting dates; plants with vegetative growth only, in bud or with dispersed fruit were not included. For introduced species the year of earliest collection within a county is also recorded. Nomenclature and order of genera and species follows Gleason and Cronquist (1963) and Fernald (1950).

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HYPERICACEAE LINDLEY ST. JOHN'S–WORT FAMILY

Herbs or shrubs with opposite, simple, entire, often pellucid- or black-punctate leaves; stipules lacking. *Flowers perfect, regular, hypogynous, solitary, axilliary or in cymes.* Stamens 5 to over 100; filaments elongate, free or basally connate in 3 or 5 bundles, these opposite petals; anthers 2-celled, longitudinally dehiscent. Ovary superior; carpels 3–6; placentation parietal, pseudo-axile or axile (Fig. 1); styles distinct or united. Capsules septicidal, 1, 3 or 5 loculate. Seeds many, small, without endosperm.

A small family with 12 genera and 600 species, usually segregated from the tropical Guttiferae (Clusiaceae).

KEY TO GENERA

A. Petals yellow to orange, convolute in bud; stamens numerous to few, distinct or united at base into 3 to 5 clusters; hypogynous glands lacking .... 1. HYPERICUM.

AA. Petals pink to mauve-purple, imbricate in bud; stamens 9, strongly triadelphous; hypogynous glands 3, orange, alternate with the stamen bundles ....2. TRIADENUM.

1. HYPERICUM [Tourn.] L. ST. JOHN'S–WORT.

Annual or perennial herbs or shrubs; leaves simple, frequently pellucid or black-dotted, opposite, entire, frequently with axillary decussant branchlets; stipules lacking. Inflorescence cymose. Sepals 5, often unequal, persistent. Petals 5, yellow to orange, convolute in bud, often black-dotted. Stamens numerous or few (small fld. spp.); filaments free or basally connate. Ovary superior; styles united or separate and divergent; stigmas minute or capitate. Placentation parietal (1-celled), pseudo-axile by intrusion of placentae (partially 3- or 5-celled) or axile (completely 3- or 5-celled) (Fig. 1). Capsules septicidal, 1- to 5-carpellate. Seeds small (ours 0.5–3.0 mm), short-cylindric, aerolate.

The largest genus of the Hypericaceae, world-wide, throughout temperate and tropical montane regions, with ca. 300 species of annuals, perennials with persistent rhizomes, and woody shrubs.

Key to Species

A. Styles united at base into a single straight beak at anthesis, splitting at maturity; stigmas minute, never capitate; stamens many, distinct. (Sect. MYRIANDRA)

B. *Small woody shrubs;* leaves and sepals articulate at base; withered stamens deciduous soon after anthesis. (Subsect. Centrosperma).

C. Midstem leaves 2.6–4.5 cm long, sessile; styles and carpels 5; *cymes chiefly terminal, 3- to 7-flowered.* ---------------------------1. *H. KALMIANUM.*

CC. Midstem leaves 3.5–7 cm long, short-petiolate; styles and carpels 3; cymes terminal and axillary, *11- to 19-flowered; rare.* -----------2. *H. PROLIFICUM.*

BB. *Perennial herbs slightly suffrutescent at base;* leaves and sepals not articulate at base; withered stamens persistent long after anthesis. (Subsect. Pseudobrathydium).

D. Plants robust, 30–60 cm tall, rhizomatose, the rootstock often woody; leaves linear–elliptic, 30–58 mm long; seeds 2.0–2.7 mm long; rare, moist prairies, Green Co. and Rock Co. ------------------------3. *H. SPHAEROCARPUM.*

DD. Plants slender, 15–35 cm tall from horizontal rhizome, the bases herbaceous; leaves elliptic to ovate, 16–33 mm long; seeds 0.5–0.8 mm long; central and northern Wisconsin lakes and river margins.------4. *H. ELLIPTICUM.*

AA. Styles free to base, the capsules not beaked; stigmas capitate; stamens many to few, connate basally into 3 or 5 bundles (phalanges).

E. Stigmas and styles 5; capsules 5-celled, 8–15 mm wide; flowers 50–60 mm across; stamens 5-delphous, numerous (over 150); larger leaves 5–8 cm long; robust perennial of wet habitats. (Sect. ROSCYNA) ---5. *H. PYRAMIDATUM.*

EE. Stigmas and styles 3; capsules 1- or 3-celled, 1–5 mm wide; flowers 5–30 mm across; stamens 60–5; larger leaves less than 5 cm long.

F. Capsules 3-celled, with azle placentae; flowers 6–32 mm across; corolla black-dotted; stamens 60–27, weakly 3-delphous.

G. Capsules oblong-conic, 4.5–6.5 mm long; styles 4–5 mm long; flowers 15–30 mm across; petals black-dotted on margin only; stamens (45)–50–(60); common Eurasian weed. (Sect. HYPERICUM ----------------6. *H. PERFORATUM.*

GG. Capsules subglobose-ovate, 3.8–4.6 mm long; styles 1.5–2.5 mm long; flowers 6–10 mm across; petals and sepals marked with black dots and lines; stamens (27)–35–(40); native. (Sect. ELINEATA) ----7. *H. PUNCTATUM.*

FF. Capsule 1-celled, with parietal placentae; flowers 4–7 (–10) mm across; corolla yellow, lacking black dots; stamens 20–5, weakly 5-delphous: (Sect. BRATHYS)

H. Leaves linear to elliptic-ovate, 8–44 mm long, 1–15 mm wide, 3- to 7-nerved; inflorescence cymose.

I. Capsules broadly ellipsoid or oblongoid, the apex rounded to obtuse; inflorescence diffuse and leafy-bracted, not well defined, the angle between a pair of lateral peduncles 70° or more (Fig. 5); sepals oblong to elliptic, widest near middle.

J. Uppermost bracts highly reduced, setaceous; cauline leaves often over 20 mm long, deltoid to ovate, usually cordate-clasping; sepals acute, equaling capsule; plants often 3–5 dm tall; mostly Driftless Area. ------------------------------8. *H. MUTILUM.*[2]

JJ. Uppermost bracts foliaceous; cauline leaves 8–15 mm long (rarely longer), ovate to elliptic, sessile but not strongly clasping; sepals obtuse, shorter than capsule; plants usually 1–3 dm tall; widespread. ------------------------------9. *H BOREALE.*[2]

II. Capsules ovoid to conic, the apex narrowed; inflorescence rather compact and clearly defined, setaceous-bracted not leafy, the angle between a pair of lateral peduncles 70° or less (Fig. 5); sepals lanceolate to linear, acute or acuminate.

K. Leaves elliptic-lanceolate to oblong, the larger 5–12 mm wide, rarely narrower, the bases subcordate-clasping; sepals 4–6.5 mm long; capsules elliptic-ovate, 5–7.8 mm long; plants often 3–5 dm tall; common throughout state. ________________10. *H. MAJUS*.[2]

KK. Leaves linear to linear-elliptic or -oblanceolate 1–3 mm wide, 1–(3-)nerved, the bases sessile-attenuate; sepals 2.5–4.4 mm long; capsules conic, 3–5.2 mm long; plants usually 1–3 dm tall; mostly northern Driftless Area. __________11. *H. CANADENSE*.[2]

HH. Leaves minute, scale-like, 1.5–3 mm long, 0.5 mm wide, strictly 1-nerved; inflorescence racemose; branches wiry; dry sands, Driftless Area. _____________13. *H. GENTIANOIDES*.

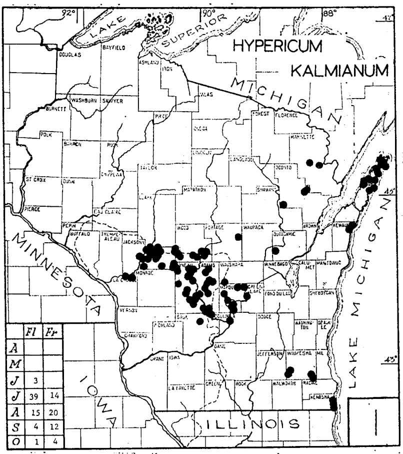
1. HYPERICUM KALMIANUM L. Kalm's St. John's-Wort. Map 1, Figs. 1–4.

Slender shrubs 2–6 (–10) dm high, with branches 4-angled, the branchlets 2-angled. *Leaves linear-elliptic to oblanceolate, revolute, coriaceous, sessile, obtuse, mostly 26–45 mm long, 4–8 mm wide* (Fig. 4). *Cymes 3- to 7-flowered (rarely more), restricted to terminal node* (Fig. 2). Flowers 20–35 mm across. Sepals oblong-elliptic, foliaceous, 6–8 mm long. Petals 5–14 mm long. Stamens numerous, distinct. *Ovary 1-locular, usually with 5 pseudo-axile intruding placentae* (Fig. 1); styles (3)–5–(6); stigmas never capitate. Capsules ovoid, 5-carpellate (rarely 3, 4 or 6), 7–10 mm long, 4–7 mm wide. Seeds light brown, 0.7–1.1 mm long. N = 9 (Hoar & Haertl 1932; Robson & Adams 1968).

Central Wisconsin sand plains and sphagnum-sedge meadows, in rocky shores, sandy swales, behind dunes, and calcareous low prairies about Lakes Michigan, Huron and Erie, to the Ottawa River, Quebec (Fig. 3: cf. maps McLaughlin 1930, Guire & Voss 1963, Adams 1959b), its Wisconsin distribution closely associated with the desiccated beds and outwash plains of Glacial Lakes Wisconsin, Oshkosh and Chicago. Flowering late June to early October; fruiting early July through October.

The history of *Hypericum kalmianum* is of particular interest, since all its stations are in glaciated territory (Adams 1959b, Guire & Voss 1963, McLaughlin 1931); this restriction suggests either a

[2] Hybrids between the species 8–11 are not uncommon (cf. Hybrids of Sect. *Brathys*, 12a, 12b, and 12c, pp. 29–32). Depauperate plants are common but can be keyed with help of full grown ones nearby.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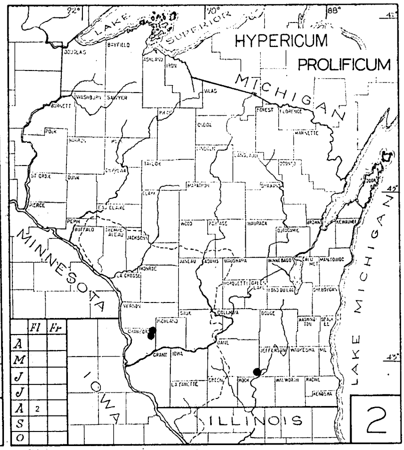
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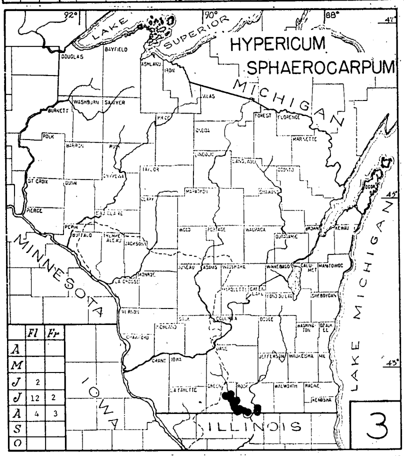
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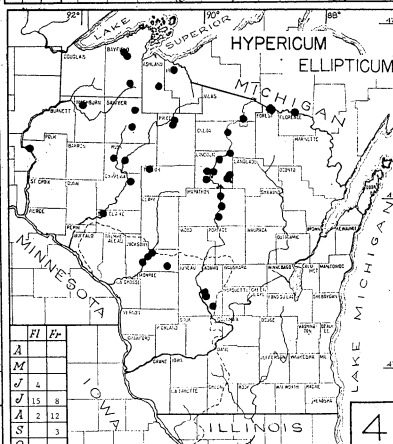
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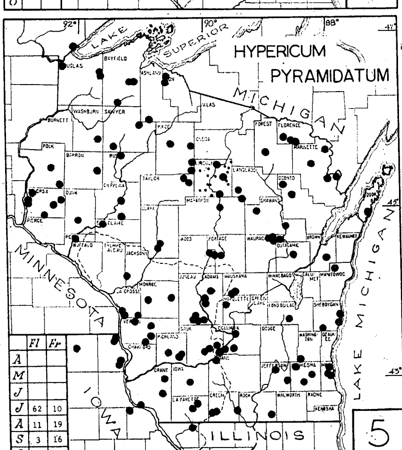
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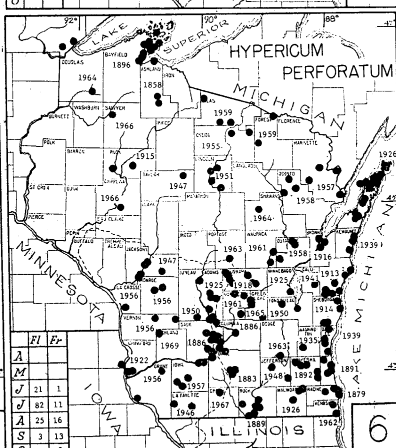
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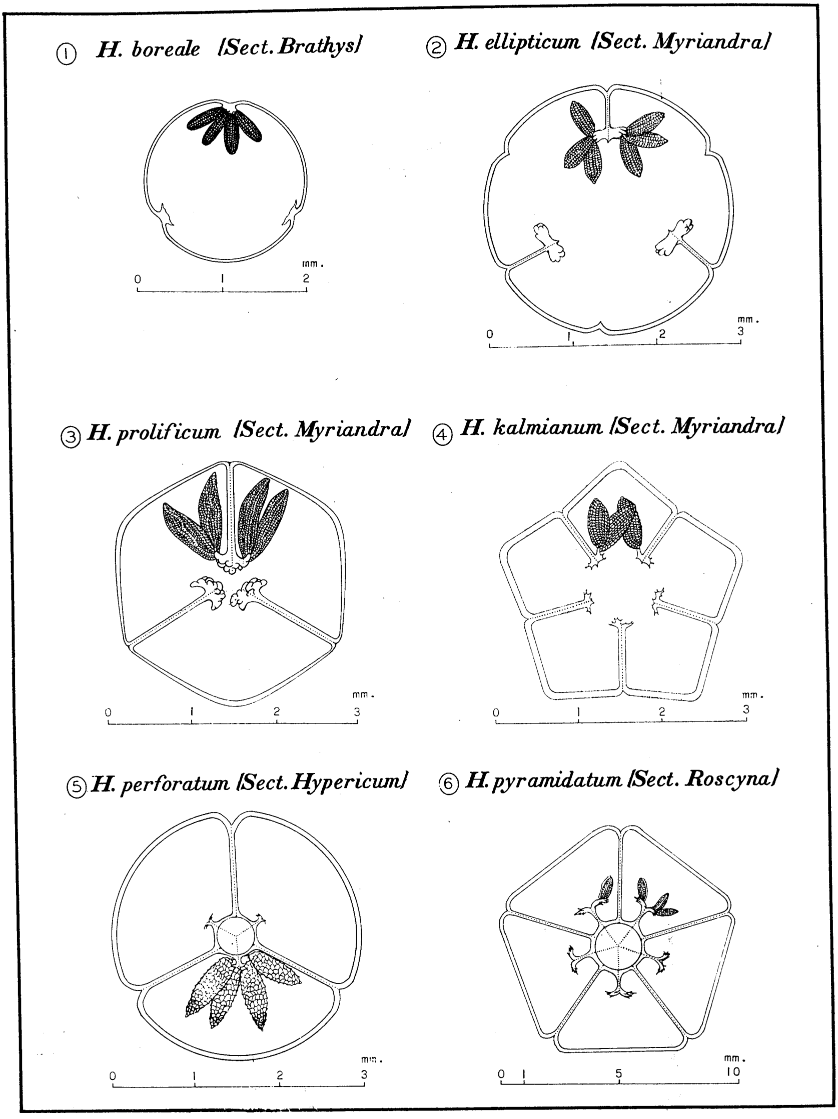
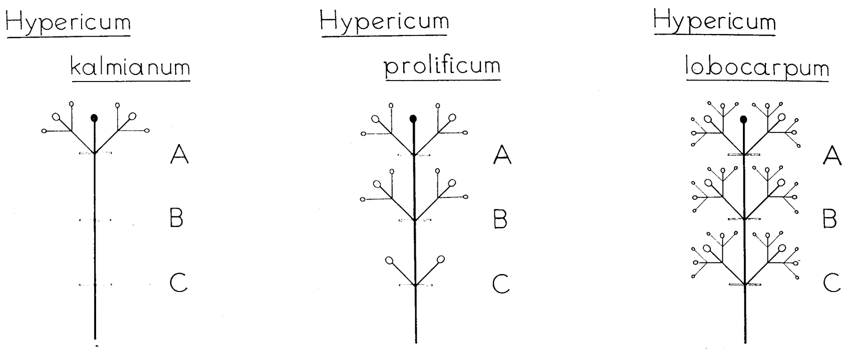
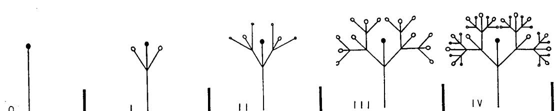


FIGURE 1. Diagrams illustrating the different types of placentation found in Wisconsin *Hypericum:* 1. *H. boreale* (Sect. Brathys)—parietal. 2. *H. ellipticum* (Sect. Myriandra)—pseudo-axile. 3. *H. prolificum* (Sect. Myriandra)—pseudo-axile. 4. *H. kalmianum* (Sect. Myriandra)—pseudo-axile. 5. *H. perforatum* (Sect. Hypericum)—axile. 6. *H. pyramidatum* (Sect. Roscyna)—axile.





H. kalmianum

	0	I	II	III	IV	Totals / Node	
A (terminal)	37 (7.8%)	168 (35.2%)	245 (51.4%) ★	23 (4.8%)	4 (0.8%)	477	(100 %)
B (axillary)		19 (3.9%)	19 (3.9%)			38	7.8
C ('')		3 (0.6%)				3	0.6
D ('')						0	0

H. prolificum

	0	I	II	III	IV	Totals / Node	
A (terminal)		32 (35.2%)	48 (52.7%) ★	11 (12.1%)		91	(100 %)
B (axillary)		28 (30.3%)	52 (57.1%) ★	10 (10.9%)		90	98.3
C ('')		28 (30.3%) ★	24 (26.3%)	8 (8.8%)		60	65.4
D ('')			6 (6.6%)			6	6.6

H. lobocarpum

	0	I	II	III	IV	Totals / Node	
A (terminal)		1 (1.6%)	18 (29.5%)	38 (62.3%) ★	4 (6.6%)	61	(100 %)
B (axillary)		3 (5.0%)	19 (31.1%)	28 (45.9%) ★		50	82.0
C ('')		1 (1.6%)	3 (5.0%)	22 (36.0%) ★		26	42.6
D ('')			3 (5.0%)			3	5.0

FIGURE 2. Statistical model and data comparing the inflorescences and degree of dichasial branching of *Hypericum kalmianum, H. prolificum* and *H. lobocarpum.*

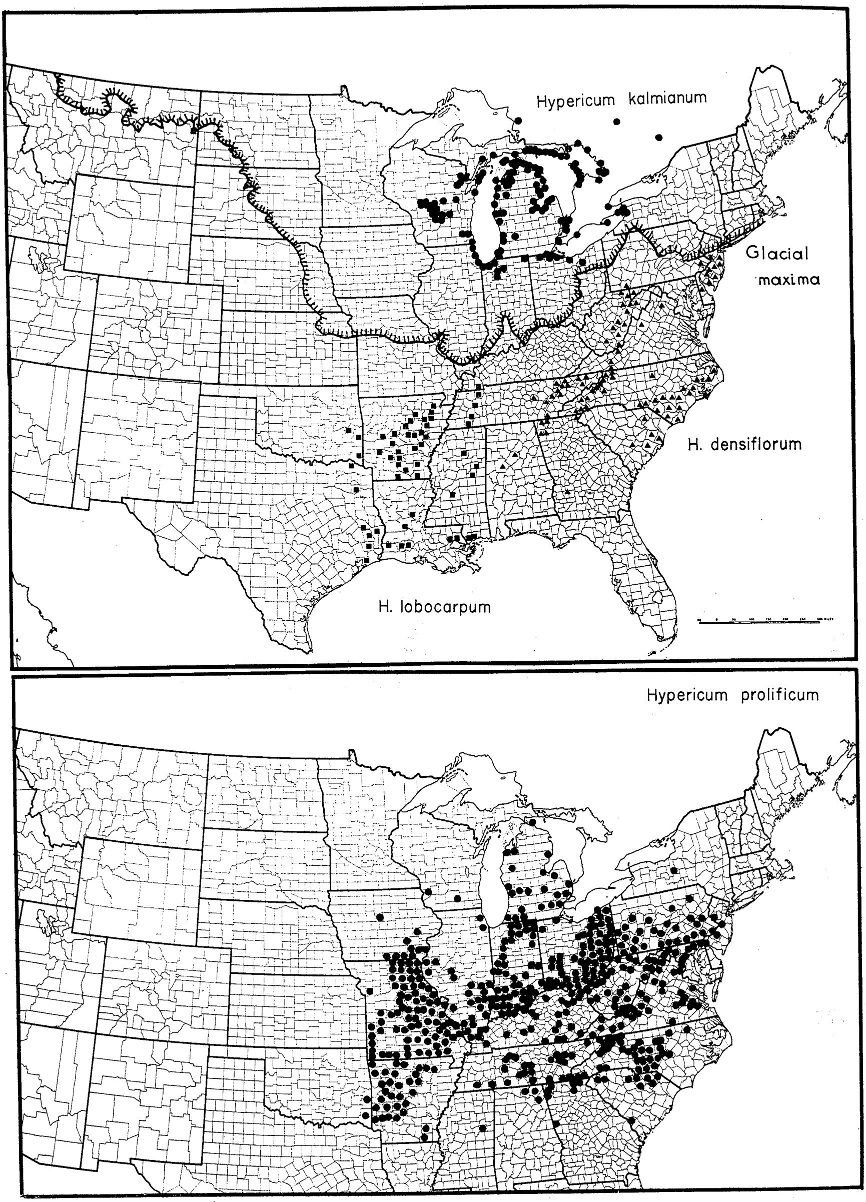


FIGURE 3. Distributional maps of *Hypericum kalmianum* L. *H. lobocarpum* Gatt., *H. densiflorum* Push and *H. prolificum* L., based in part on the unpublished map of Adams (1959b).

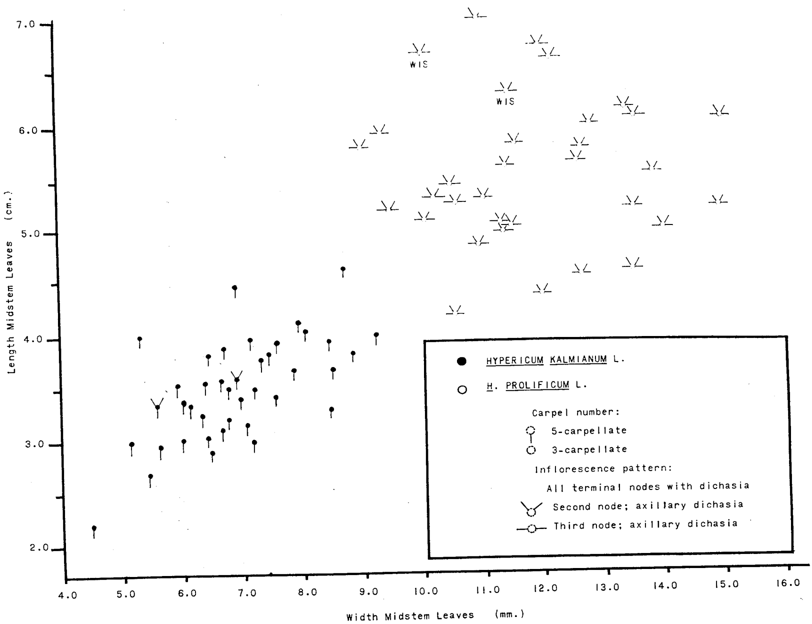


FIGURE 4. Scatter-diagram comparing leaf width and length and indicating number of carpels and degree of inflorescence branching of Wisconsin *Hypericum kalmianum* and Wisconsin and non-Wisconsin *H. prolificum.*

pre-glacial origin with subsequent survival either in unglaciated or in once-glaciated territory between differentially advancing glacial lobes, or a recent, post-glacial origin from a more wide-spread southern species. The last hypothesis seems to us the most reasonable. Adams (1959b, 1962) thinks this ancestor to be the Gulf Coastal and Mississippian Embayment *H. lobocarpum* Gatt. (= *H. oklahomense* Palmer), since this species and *H. kalmianum* both have mostly 5-carpellate ovaries, differing from the 3-carpellate, but otherwise similar and related *H. prolificum* L. The eastern coastal and inter-montane *H. densiflorum* Pursh is also commonly 3-carpellate: many authors de-emphasize carpel number and follow Svenson (1940) in considering *H. lobocarpum* as a variety of *H. densiflorum.* Carpel number is extremely variable even in well-defined species of section *Myriandra.* In any case, the fruits of both 5-carpellate taxa *(H. kalmianum* and *H. lobocarpum)* are very similar, except that those of *H. lobocarpum* tend to be smaller on the average and more deeply sulcate.

Comparison of degree of dichasial branching and flowers/inflorescence (Fig. 2) of *H. kalmianum, H. prolificum* and *H. lobocarpum* reveals a north to south increase, with the northern *H. kalmianum* usually fertile only in the uppermost node, the southern *H. lobocarpum* highly floriferous in many (3 to 5 or more) nodes. *H. prolificum* has the largest number of inflorescence combinations. Both *H. prolificum* and *H. kalmianum* have broad foliaceous sepals (4–8 mm long) and flowers to 30 mm wide; *H. lobocarpum* and *H. densiflorum* have usually shorter, narrower sepals (2–4 mm long) and often smaller flowers (to 20 mm across). Thus, while *H. kalmianum* was probably derived from *H. lobocarpum* (or *H. densiflorum*), the reduced inflorescence-branching, foliaceous sepals and larger flowers suggest some *H. prolificum* introgression into *H. kalmianum,* which would not be unlikely, considering the geographic proximity of the two populations.

2. HYPERICUM PROLIFICUM L. Map 2, Figs. 1–4.
Hypericum spathulatum (Spach) Steud. of ed. 8, Gray's Manual.

Erect bushy shrub 3–9 dm tall, diffusely branched; bark shreddy, gray, the branchlets sharply 2-angled. *Leaves oblanceolate-linear, obtuse and often mucronate, the margins strongly revolute, punctate,* the midstem leaves 3.5–7 cm long, 7–15 mm wide (Fig. 4). Petioles 1–4.6 mm long. *Cymes 11- to 19-flowered, terminal and axillary* (Fig. 2). Flowers 15–27 mm across. Sepals ovate, mucronate, 4.5–6 mm long. Petals obovate, bright yellow, 7–10 mm long. Stamens numerous, distinct. *Ovary 1-locular usually with 3 pseudo-axile intruding placentae* (Fig. 1); styles 3 (4); stigmas not capitate. Capsules ellipsoid-ovate, 3-carpellate (rarely 4 or 5), 10–13 mm long, 3.5–6 mm wide. Seeds black, 1.2–1.8 mm long. N = 9 (Nielsen 1924, Robson and Adams 1968).

A variable species in eastern and central United States (Fig. 3) on dry creek beds, sandy or rocky slopes, roadsides and old fields, occasionally cultivated, reported here for Wisconsin for the first time, Swezey's (1883) use of this name being based on collections of *H. kalmianum* (*Lapham s.n. and Hale s.n.,* WIS, MIL). All collections are recent, perhaps escapes from cultivation. Crawford Co.: town of Clayton, S. 11 SE ½, 9 July 1960, *Densmore s.n.* (WIS); sandy hillside E of Soldiers Grove on Co. E, with *Silphium perfoliatum, Corylus americana, Rhus radicans,* 4 Aug. 1960, *Schlising & Musolf 1749* (WIS). Dane Co.: Edgerton, Camp Hickory Hill, open, light sandy soil, 5 Aug. 1947, *Dorney s.n.* (RILL). Flowering late July and early August.

3. HYPERICUM SPHAEROCARPUM Michx. Map 3.
Hypericum cistifolium of authors, not Lamark

Erect perennials from woody branched rootstocks, the deep rhizomes with adventitious shoots. Stems herbaceous, 30–58 cm tall, 4-lined. Leaves linear-oblong to narrowly elliptic, acute to obtuse, sessile, 3–7 cm long, 4–15 mm wide. Cymes compact, compound, many-flowered; bracts lanceolate. *Sepals ovate-lanceolate,* 2.8–4.8 mm long. Petals yellow, 5.3–8.6 mm long. Stamens numerous. *Ovary 1-locular, with 3 intruding parietal placentae. Capsules globose to ovoid,* firm, few-seeded, 4.5–6.7 mm long; styles 3, united in sharp beak. *Seeds blackish-brown,* coarsely reticulate, pitted, *2.0–2.7 mm long,* the raphe developed into a keel.

Species of low or mesic prairies, limestone outcrops and cedar glades, Ala. to SW Ark., north to Iowa, Ill. and N Ind., rare in Wisconsin, confined to low wet prairies along the Sugar and Rock Rivers, as in low rich prairie (near Monticello, Green Co.), with scattered willows, dogwood, bur oak, *Potentilla arguta, Eryngium yuccifolium,* and *Ratibida pinnata.* The plants are almost always pulled up without the very deep slender horizontal rhizomes. Flowering late June to mid-August, fruiting mid-July through August.

4. HYPERICUM ELLIPTICUM Hook. Creeping St. John's-Wort.
Map 4, Fig. 1.

Erect unbranched perennial from a *reddish, spongy, slender, creeping rhizome.* Stems 15–35 cm tall, obscurely 4-angled. Leaves elliptic to elliptic-lanceolate, the larger 16–33 mm long, 4–13 mm wide, pellucid-punctate, not revolute, the midvein prominent. Cymes terminal, few-flowered; bracts linear to lanceolate. *Sepals narrowly obovate to oblanceolate,* 4–6 mm long. Petals oblanceolate, 4.6–8.6 mm long, often reddish in bud. Stamens numerous. *Ovary 1-locular with 3 intruding parietal placentae* (Fig. 1). Capsules subglobose to ovoid, 4–7 mm long, many-seeded; styles 3, united at base. *Seeds dark reddish brown,* striated, pitted, *0.5–0.8 mm long.* N = 9 (Hoar & Haertl 1932).

A "northern hardwoods" species, from NE Tenn. to Newfoundland, west to Lake Superior, in central and northern Wisconsin along stream banks, pond and lake shores, river flats and sand bars, as in cold streamside *Alnus* thickets in sunny *Carex* meadows, Brule River, Florence Co. The northern-most member of the 30 species of section *Myriandra* (Adams 1962) and the only Wisconsin *Hypericum* with prominent (oft-collected) rhizomes. Flowering late June to early August, fruiting July to latest October.

Submerged aquatic plants with simple sterile stems and round to ovate "feather-veined" leaves, resembling *Callitriche,* have been designated as forma *SUBMERSUM* Fassett (1939, 1960), while terrestrial plants with axillary branches overtopping the mature infructescence, as forma *FOLIOSUM* Marie-Victorin (Le Nat. Canadien 71: 201. 1944.)

5. HYPERICUM PYRAMIDATUM Ait. Giant St. John's-Wort.
Hypericum ascyron of Am. authors, not L. Map 5, Fig. 1.

Robust erect perennial herbs, 6–16 (–20) dm tall; branches 4-angled; root-crown woody. Leaves ovate-oblong to lanceolate, the larger 5.5–9.6 (–11) cm long, 2.5–4 (–5) cm wide, acute or obtuse, with sessile clasping bases. Stamens numerous (over 150), 5-delphous; anthers versatile. Sepals ovate-triangular, 6.5–8 mm long. *Petals broadly obovate, persistent, 1.8–2.8 cm long.* Styles 5, 6–10 mm long, halfway united, divergent above; stigmas capitate. Capsules conic-ovoid, completely 5-celled, septicidally dehiscent, 15–25 mm long, 8–15 mm wide (Fig. 1). Seeds brown, lustrous, reticulate, 1.1–1.4 mm long, the raphe keeled. N = 9 (Nielsen 1924).

Quebec to Minn., south to Penn., Ind., Mo. and Kansas, in Wisconsin in wet and open habitats as gravelly river banks, sphagnous sedge meadows, mesic forest edges and drainage ditches, as in low wet muck meadow near Mauston with *Carex, Polygonum, Physostegia virginiana,* or in a weedy floodplain prairie along Pine River, Richland Co., with *Napaea dioica, Artemisia serrata, Silphium perfoliatum, Urtica sp.,* (*Nee 1453,* WIS). Flowering late June to mid-September, fruiting mid-July to early October.

It is closely related to the true *Hypericum ascyron* L. of eastern Asia (E Siberia, Japan & China).

6. HYPERICUM PERFORATUM L. Common St. John's-Wort,
Klamath wed. Map 6, Fig. 1.

Erect branching perennials from a subligneous crown with short shallow rootstocks and deep branching taproot. Stems 2-angled, 4–6.5 (–8) dm tall, *with numerous sterile basal shoots and leaf axillary decussate branchlets.* Leaves linear-oblong to elliptic, pellucid-dotted, obtuse, sessile, 5-nerved, commonly 12–36 mm long, 3–9 mm wide, reduced on axillary branchlets. Cymes paniculate, flat-topped; flowers numerous, 15–30 mm across. Sepals linear-lanceolate, acuminate, 4–7 mm long. *Petals orange-yellow, black-spotted near margins, 9–14 mm long. Petals and stamens persistent.* Stamens (45)–50–(60). Ovary 3-loculate; styles 3, divergent, 3–4.5 mm long; stigmas capitate. Capsules completely 3-celled (Fig. 1) oblong-elliptic to conic, veiny, 4–7 mm long, 3–5 mm wide. Seeds blackish brown, lustrous, reticulate, 0.8–1.2 mm long. N =

16, 2N = 32 (Hoar & Haertl 1932, Mulligan 1957, Robson & Adams 1968).

A noxious world-wide weed, native to N Africa, W Asia and Europe (Hegi 1925), naturalized in E and W North America, in Wisconsin a common weed in open, sandy, poor or worn soils, chiefly on roadsides, railroads, neglected fields, beaches, sand plains, blowouts and barrens, occurring with such disturbance indicators as *Comptonia peregrina, Hieracium aurantiacum, Ambrosia artemisiifolia, Daucus carota, Asclepias syriaca* and *Euphorbia esula*. Flowering from early June to early September, fruiting from late June to early October.

This adventive is especially troublesome in the Klamath River Basin (N Calif. & S Ore.). The stem's numerous resin canals contain hypericin, which is poisonous to livestock, but probably not fatal (Marsh & Clawson 1930, Kingsbury 1964). Eradication is difficult due to deep perennial roots, vigorous leafy basal offshoots and numerous, highly viable, genetically similar seeds, megasporogenesis being 97% apomitic (pseudogamous) (Tutin *et al.* 1968).

The name "St. John's Wort" is derived from the belief that the plant's dew precented sore eyes on St. John's eve, June 24, when huge ceremonial bonfires of this plant blazed throughout Europe. Bouquets then gathered were hung in windows as talismans against thunder, witches and other misfortune, while in Switzerland, young women put them under their pillows believing they would marry the men of their dreams. The dark-red pellucid leaf dots supposedly appeared on August 29, the day John the Baptist was beheaded (Hegi 1925, Clohisy 1930).

7. HYPERICUM PUNCTATUM Lam. Map 7.

Sparingly branched perennial with terete stems 4–10 (–12) dm tall. Leaves oblong-elliptic to lanceolate, the larger 3–7 cm long, 1–2 (–3) cm wide, dark punctate, blunt or retuse, 5- to 7-nerved; base clasping to attenuate. Corymbs compact; flowers 6–10 mm wide, short-pedicellate. *Sepals ovate-oblong, broadly acute, black-spotted and -lined, 3.8–6.8 mm long.* Stamens (27)–35–(40), weakly 3-delphous; anthers black-dotted. Ovary 3-locular; styles 3, free, 1.5–2.5 mm long; stigmas capitate. *Capsules 3-celled, subglobose to ovoid, 3.8–4.6 mm long, 3.6–4.2 mm wide, with elongate oil vesicles.* Seeds yellowish-brown, 0.6–0.7 mm long. N = 8, 2N = ring of 16 at anaphase (Hoar 1931, Robson & Adams 1968).

Eastern North America, from Maine to Minn., south to Fla. & Texas, in Wisconsin along forest edges, open wooded slopes, floodplain thickets, wet prairies, abandoned fields and roadsides: in low, mesic woods (near Tomah, Monroe Co.), with *Trillium cernuum,* *Uvularia sessiliifolia, Mitchella repens, Aster macrophyllus* and in bottomland woods on floodplain terraces (Trempealeau Co.), with *Quercus bicolor, Fraxinus spp., Betula nigra, Carex spp.* Though widely distributed, it is never abundant, this possibly related to the *"Oenothera-like"* ring chromosome segregation pattern, producing various isolated and inbred populations. Flowering from early July to early September, fruiting August to mid-September.

8. HYPERICUM MUTILUM L. Map 8, Fig. 5.
H. mutilum var. *longifolium* Bob. Keller, in *Bull. Herb. Boiss.* (ser. 2) 8: 184. 1908, *ex char.* [Type: Visconsin (sic!), *Kumelien* (sic!), *113.*]

The variety *longifolium* is apparently nothing but a long-leaved plant, not taxonomically recognized here. There are no *Hypericum* specimens in the very fragmntary Kumlien Herbarium deposited at WIS. The type is presumably in G.

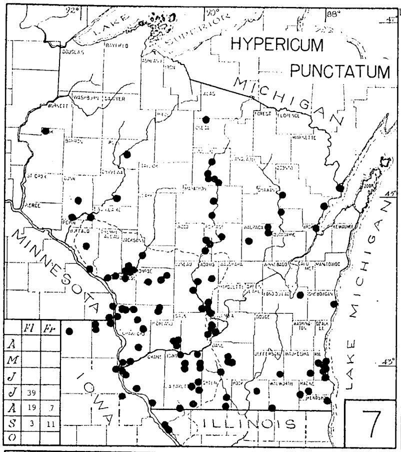
Erect slender annuals or perennials (1–) 2–6 dm tall, branched diffusely above, the leafy-bracted bases decumbent. Leaves deltoid-ovate to oblong-lanceolate, obtuse, cordate-clasping, 3- to 5-nerved, minutely punctate, the larger 1–2 (–3) cm long, (3–) 8–13 mm wide. *Inflorescences lax and diffuse, poorly defined, leafy-bracted, the pedicels very slender, unequal, the angle between a pair of lateral peduncles ca. 70–105°. Uppermost bracts setaceous, 1.5–3.8 mm long* (Fig. 5). Flowers 2.6–4.5 mm wide. Sepals linear-oblong, acute, 2–4 mm long, equaling capsule. Petals 2–3 mm long. Stamens 5–10. Ovary 1-locular, the styles 0.5–0.9 mm long; stigmas capitate. Capsules ovoid to ellipsoid, greenish at maturity, 2–4 (–5) mm long, 1.6–2.4 mm wide. Seeds yellow, striate, minutely rugose, 0.45–0.55 mm long. N = 8 (Hoar & Haertl 1932).

Eastern N. America, from Minn. to Newfoundland, south to Fla. and Texas, in Wisconsin mostly in the lower Wisconsin River valley and Driftless Area, on sandstone cliff ledges, sandy creek margins and river flats, moist sandy or black muck lowland meadows, swales and desiccated temporary pools, rarely in moist woods or abandoned fields. Flowering July to September; fruiting early August to late September.

A highly variable species with populations in Brazil, Hawaii and Europe.

9. HYPERICUM BOREALE (Britton) Bicknell Map 9, Figs. 1, 5, 6.
Northern St. John's–Wort.

Slender, rhizomatous and decumbent, branched perennial herbs with terete to obscurely 4-angled stems 1–3 (–4 in tall grass) dm tall, the bases often with leafy short-shoots. Leaves ovate to ellip-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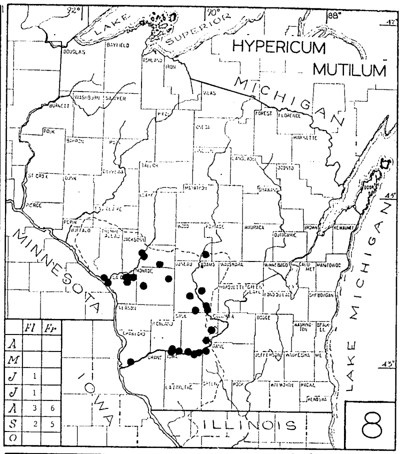
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S 2 5
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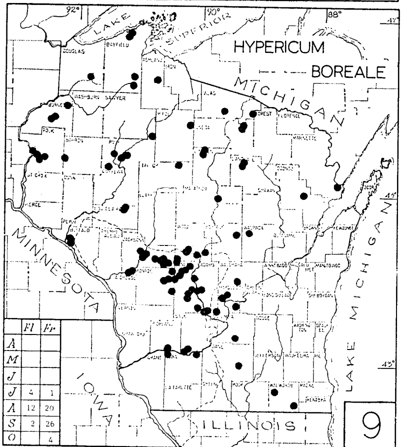
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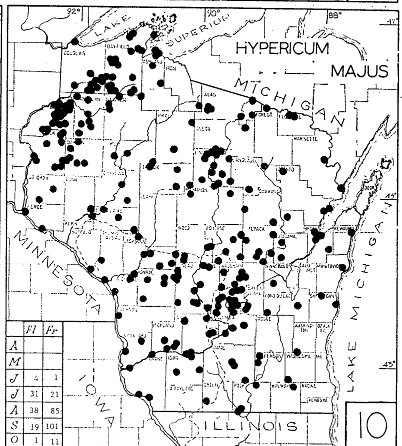
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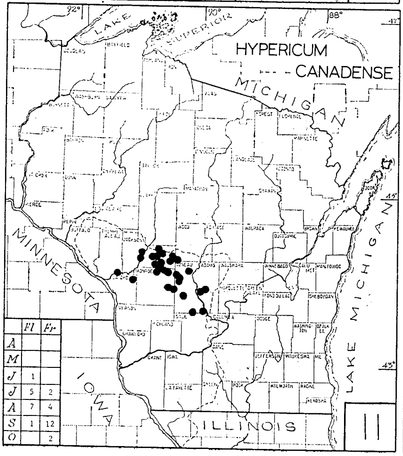
S 19 101
O 1 11
10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CANADENSE
LAKE SUPERIOR
MICHIGAN
MINNESOTA
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A 7 4
S 1 12
O 2
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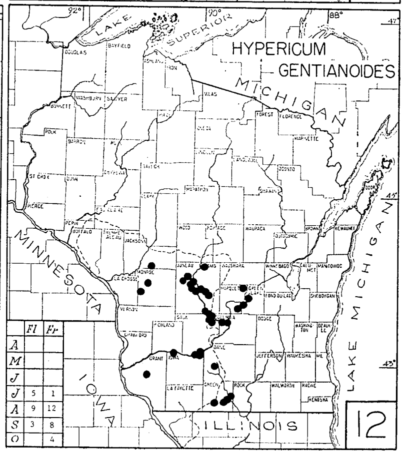
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GENTIANOIDES
LAKE SUPERIOR
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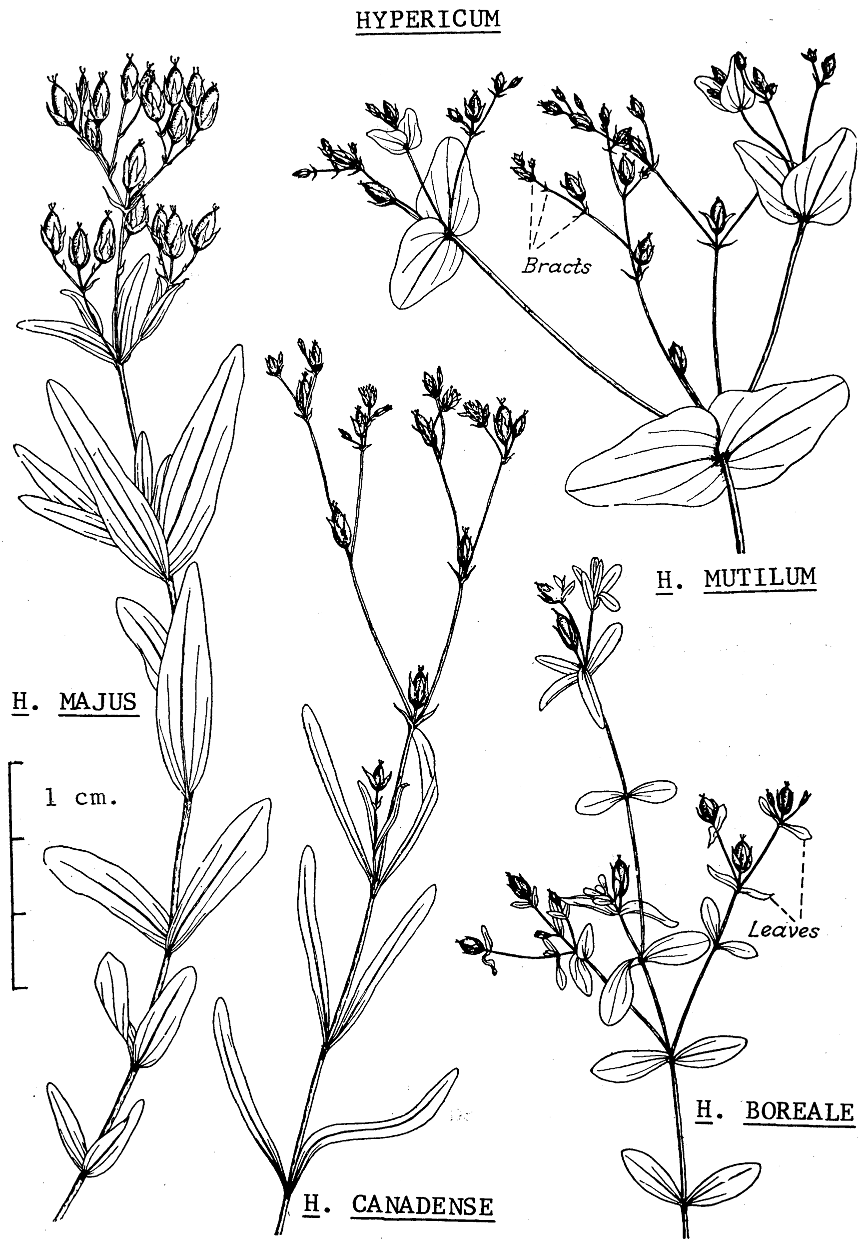


FIGURE 5. Line-drawings of several Wisconsin small-flowered *Hypericum* (Sect. *Brathys*), (From N. C. Fassett, 1960, p. 246, with permission).

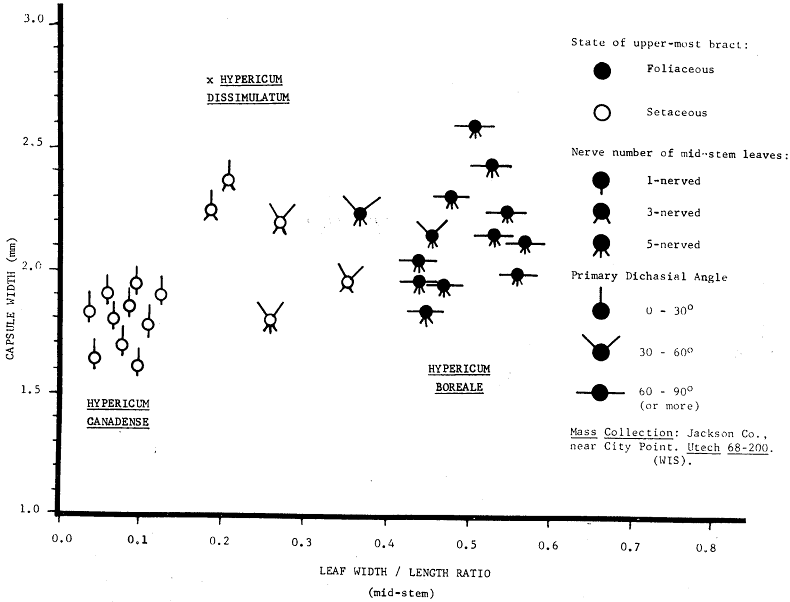


FIGURE 6. Scatter diagram of mass collection *(Utech 68–200)* clearly showing intermediates (x *Hypericum dissimulatum* Bicknell) between *H. boreale* and *H. canadense.*

tic, if aquatic suborbicular, obtuse to rounded, obscurely punctate, sessile, 3- to 5-nerved, the larger 8–15 (–25) mm long, 4–8 mm wide. *Inflorescence lax and diffuse, leafy-bracted, the angle between a pair of lateral peduncles ca. 85–110°. Uppermost bracts foliaceous, resembling small leaves, 2.5–4 mm long* (Fig. 5). Flowers 3.4–5 mm wide. *Sepals oblong-elliptic, 2.7–3.8 mm long, equaling petals but shorter than capsule.* Stamens 5–10. Ovary 1-locular; styles 3; stigmas capitate. Capsules ovoid to ellipsoid, 3–5 mm long, 1.5–3 mm wide. Seeds light brown, 0.6–0.75 mm long. N = 8 (Hoar and Haertl 1932).

Northeastern N. America, from Minn. to Newfoundland, south to N.Y., W Penna., N Ind. and E Iowa (disjunct to Tenn.?—Sharp *et. al.* 1960), apparently limited to glaciated areas, in Wisconsin common in moist acid habitats as rocky or sandy shores, mud flats, acid tamarack bogs, alluvial marches, floating sedge mats, damp swales and sandy fields, as Sphagnum—Cyperaceae wet meadows (Black River Falls, Jackson Co.) with scattered *Larix, Drosera intermedia, Eriophorum virginicum, Muhlenbergia uniflora, Spiraea tomentosa* and *Juncus spp.* Flowering mid-July to September, fruiting late July to early October.

Hybridizes in Wisconsin with *H. canadense* (pp. 26, 29–30; Fig. 6), these hybrids, called x. *H. dissimulatum* Bicknell (1913) and reported here for the first time for Wisconsin, represent the western-most station of this supposedly "unusually constant and recurring hybrid" (Fernald 1950).

9a. HYPERICUM BOREALE forma CALLITRICHOIDES Fassett

A sterile, submerged aquatic form with simple, flexible stems and small, 3-nerved leaves lacking pellucid-punctate dots, occasional in northern and central Wisconsin lakes (Adams, Bayfield, Jackson, Juneau, Langlade, Monroe and Oconto Counties) and grading shoreward into normal plants.

10. HYPERICUM MAJUS (Gray) Britton Map 10, Fig. 5.
Common St. John's–Wort.

Erect stout perennial with solitary or tufted stems, 1–4 (–6) dm tall, often with small leafy basal offshoots. *Leaves commonly ascending, lanceolate or elliptic to oblanceolate or broadly acute to narrowly oblong, acute to obtuse, subcordate-clasping, 5- to 7-nerved, the larger 1.5–4.4 cm long, 5–12 mm wide. Inflorescences well-defined, often compact, the angle between a pair of lateral peduncles only 25–50°*; bracts setaceous-subulate, 1-nerved, 1.8–3.8 mm long (Fig. 5). Sepals lance-acuminate, 4.2–6.5 mm long. Petals equaling sepals; stamens 15–20, weakly 5-delphous. Ovary 1-locular; styles 3, 1–1.5 mm long; stigmas capitate. Capsules narrowly ovoid to ellipsoid, obtuse, reddish-purple at maturity, 5–7.8 mm long, 2–4 mm wide. Seeds pale brown, lustrous, reticulate, 0.6–0.7 mm long. N = 8 (Hoar & Haertl 1932).

Western and northeastern N. America, from British Columbia, E Wash. and Colorado to Quebec and Penna. (2 disjunct stations in Tenn.—Gillespie 1959; Sharp *et. al.* 1960), frequent throughout Wisconsin, chiefly in open, moist, gravelly, sandy or sometimes muddy habitats, as shores and beaches, low wet prairies, shrub-carrs, black spruce and tammarack bogs, *Carex* swales, moist talus and cracks of sandstone cliffs, spring and marly marsh margins, and weedy in pastures, sandy fields, roadsides and cranberry bogs. Flowering late June through September; fruiting earliest July to mid-October.

Extremely variable in Wisconsin, especially as to size, hybridizing not infrequently with *H. boreale* and *H. canadense* (cf. page 32).

11. HYPERICUM CANADENSE L. Canadian St. John's-Wort.
Map 11, Figs. 5, 6.

Slender erect annual or perennial herbs, 1–3 (–4.6) dm tall; stems unbranched except above, sharply 4-angled. *Leaves linear-oblanceolate to linear, obtuse, sessile-attenuate, 1- or weakly 3-nerved, 6–25 (–40) mm long, 1–3 mm wide. Inflorescences well-defined but open, the angle between a pair of lateral peduncles ca. 30–65°; bracts subulate, 2–2.7 mm long* (Fig. 5). Flowers 4–7 mm wide. Sepals linear-lanceolate, acuminate, 2.5–4.4 mm long. Petals 2–5 mm long; stamens 5–10. Ovary 1-locular; styles 3, 0.7–1.0 mm long; stigmas capitate. *Capsules ovoid to conic, acute, reddish-purple at maturity, 3–5.2 mm long, 1.3–2.6 mm wide.* Seeds light yellow, reticulate, 0.5–0.6 mm long. N = 8 (Hoar & Haertl 1932).

Eastern N. America, from Ga. to Ala. to Newfoundland, west to Iowa, the Black Hills and SE Manitoba, in Wisconsin mostly in the northern Driftless Area, in sandy-peaty roadsides, along railroads, wet sandy meadows, swales and marshes, moist sandstone ledges, in *Sphagnum* of Ericaceae–Cyperaceae bog (near City Point, Jackson Co.) with *Ledum groenlandicum, Chamaedaphne calyculata, Larix laricina, Picea mariana, Rhynchospora alba, Carex oligosperma, Solidago uliginosa, Eriophorum virginicum, Betula pumila* and *Aronia melanocarpa.* Flowering early June to late August, fruiting mid-July to early October.

Of the 30 collections from Wisconsin, only 6 date from before 1930 and these from only 2 stations (McLaughlin 1931). The recent building of roads and flowages may have made the region's glacial lake beds more receptive to botanizing and to the establishment of pioneers such as *H. canadense* and its hybrids with*H. boreale* and *H. majus* (cf. below for citations).

HYBRIDIZATION IN *HYPERICUM* SECT. *BRATHYS* IN WISCONSIN:

Four Wisconsin members of section *Brathys (mutilum, boreale, canadense, majus)* are morphologically and ecologically similar, often two or three growing together in the same station in Wisconsin's Driftless Area, especially in the beds of glacial lakes (Maps 8–11), where all but the uncommon *H. mutilum* tend to hybridize. Hybrids are especially common in sandy, moist, flat, acid habitats. This region, at least post-glacially, has been a very suitable "open habitat" for the establishment of many Coastal Plain species (McLaughlin 1932, Peattie 1922), such as *Xyris spp., Bartonia virginica, Gratiola lutea, Drosera spp., Rhynchospora spp., Helenium flexuosum* (= *H. nudiflorum*) (Mickelson & Iltis 1966), and the microevolution of others (Johnson & Iltis 1963, pp. 267–8).

Potential for long range dispersal in this small-seeded group is probably very great: all four species occur in Europe, probably introduced by birds or in fodder (Heine 1962, Tutin *et al.* 1968). *Hypericum mutilum* L. also occurs in Brazil (Keller 1908) and Hawaii (Doty & Mueller–Dombois 1966).

Hybrids between these taxa are very common, both putative F_1's and backcrosses, which is one reason for the great taxonomic difficulties in this group. In addition, dwarf forms of each species are common and especially difficult to distinguish. Hybrids, being intermediate morphologically, are only briefly described below.

12. HYPERICUM BOREALE (Britton) Bicknell x H. CANADENSE L.
HYPERICUM x DISSIMULATUM Bicknell Fig. 6.

Similar to *H. canadense,* but more lax and branched, with smaller, lanceolate-elliptic leaves and shorter, reddish-green capsules (Bicknell 1913). *H. canadense* is evidently a southern species, which post-glacially overlapped the northern *H. boreale*. The latter species, confined as it is to glaciated territory, has a most anomalous distribution and its Pleistocene survival or origins is not clear. It may represent a "stabilized hybrid" between *H. mutilum,* a wide-ranging eastern species, and *H. majus,* a western element, which is now limited to glaciated territory of northeastern North America. Jackson Co.: Indian Creek, sand flats ca. 1 mi W of City Point, 22 Sept. 1968, *Utech 68–200* (WIS), a mass collection, represented by the hybrid analysis scatter diagram of Fig. 6.

12b. HYPERICUM BOREALE A*Britton*Q *Bicknell* x H. MAJUS (Gray) Britton

Hybrids of these dissimilar species are erect but shorter than *H. majus* and with diffuse-branched inflorescences and short, elliptic-ovoid capsules like *H. boreale*. *H. majus* is clearly a cordilleran (Pacific Northwest ?) element which, like so many other taxa, invaded NE N. America post-glacially to hybridized with an easttern vicarious element (Mason & Iltis 1965), in this case *H. boreale* (see above). Barron Co.: mud flat, edge of small lake, ca. 2 mi N of Turtle Lake, 21 Aug. 1956, *Iltis et al. 7280 B* (WIS). Juneau Co.: Sprague Flowage (T. 19 N., R. 2 E., Sec. 1), dry sandy-peaty, sedge-grass marsh, 23 Sept. 1967, *Iltis et al. 25,851 pro parte,* (WIS—mass collection).

12c. HYPERICUM MAJUS (Gray) Britton x H. CANADENSE L.

Two very similar species form hybrids of shorter stature than *H. majus* and with leaves of intermediate shape, vein number and width; sepals and capsules also intermediary. The parental species represent a vicarious pair (W. and E. North America) which postglacially became sympatric in glaciated northastern North America, where they hybridize freely. Clark Co.: Trow, moist ground, 15 July 1915, *Goessl 1303* (MIL). Jackson Co.: temporary sandy margined pool, (T. 20 N., R. 1 W., Sec. 22), 22 Sept. 1968, *Utech 68–300* (WIS—mass collection). Lincoln Co.: Wilson twp. (T. 35 N., R. 5 E., Sec. 4), ditch, 11 Sept. 1949, *Seymour 10,968* (WIS). Monroe Co.: NW of Warrens, railroad ditch, 15 Sept. 1935, *Fassett 17.686* (WIS). Oneida Co.: Rhinelander, Silver Bass Lake, on shore stump, 29 Aug. 1945, *Hein 34* (WIS). Wood Co.: swale and desiccated pond, ¾ mi W of Dexterville, 22 Sept. 1968, *Utech 68–100* (WIS—mass collection); Birch Bluff, S of City Point. (T 21 N., R. 2 E., Sec. 19), 31 May 1958, *Iltis & Koeppen 12,271a* (WIS).

13. HYPERICUM GENTIANOIDES (L.) B.S.P. Orange-grass, Pine Weed Map 13.

Erect, strict, very slender annual 1–2.5 dm tall; stems, 4-angled, punctate, with numerous ascending filiform branches. *Leaves subulate, appressed, acute, sessile, 1.5–2.8 mm long, 0.5 mm wide.* Inflorescence racemose; flowers minute, nearly sessile. Sepals linear–lanceolate, 1.6–2.2 mm long. Petals pale yellow, 2.8–3.6 mm long. Stamens.

5–10. Ovary 1–locular; styles 3, separate, 0.6–0.9 mm long; stigmas capitate. Capsules slenderly conic to lance-subulate, 4–4.8 mm long, 0.8–1.5 mm wide. Seeds yellowish brown, obscurely areolate, 0.3–0.4 mm long. N = 12 (Hoar & Haertl 1932).

Eastern United States (Maine to SW Ontario & Minn., south to Fla. and Texas), in open, dry, rock or acid outcrops, sand barrens and sand prairies in southern Wisconsin. At maturity, the entire plant turns copper or brick-color, hence called "orange grass." Flowering mid-June to mid-September; fruiting late June to late September.

2. TRIADTNUM Raf. MARSH ST. JOHN'S–WORT.

Erect glabrous perennial, stoleniferous herbs with simple, opposite, entire, often pellucid–punctuate leaves. Flowers 5-merous, regular, perfect, hypogynous, small, in axillary and terminal cymules. *Petals oblong, mauve or pinkish to greenish. Stamens 9, the filaments connate into 3 fascicles (3-delphous) and alternating with 3 conspicuous hypogynous glands.* Ovary superior, completely 3-loculate; styles 3, separate, divergent; stigmas capitate. Capsules septicidal, 3-carpellate. Seeds small, short-cylindric, reticulate.

Triadenum has 4 species in eastern North America and 1 in Asia (Japan, Korea, Manchuria, Ussuri & Amur, *Triadenum japonicum*

(Bl.) Makino; Ohwi (1965)), which are often considered as section *Elodea* (Juss.) Choisy [non section *Elodes* (Adans.) Koch] of *Hypericum*. Segregated by Rafinesque *(Fl. Tell.* 3: 78. 1836) on its pink petals and 3 hypogynous glands, it differs in addition (Holm 1906) by petals imbricate not convolute in bud, 9 stamens strongly 3-delphous into 3 fascicles alternating with 3 hypogynous glands, prominent veins repeatedly branched laterally to the blade margins, and tuberous subterranean stolons with paired scale-like leaves usually with one, rather than many adventitous roots above each bud. Chromosome counts of N = 19 (Hoar & Haertl 1932) do not suggest a relationship to *Hypericum,* but rather to *Cratoxylon,* a pan-tropical tree genus.

Key to Species

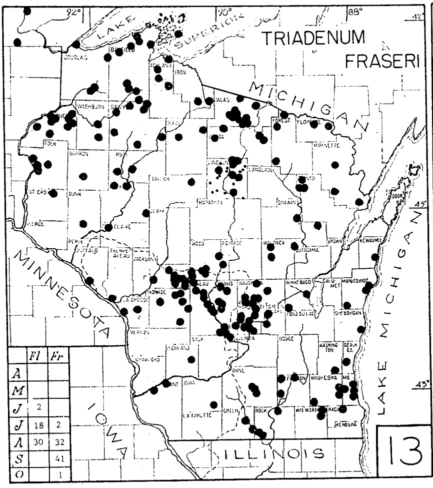
A. Sepals elliptic to spatulate, summit obtuse to rounded, 2.8–4.8 mm long; fruiting styles 0.6–1.5 mm long; common Wisconsin marsh and bog plant. ---------------1. *T. FRASERI.*

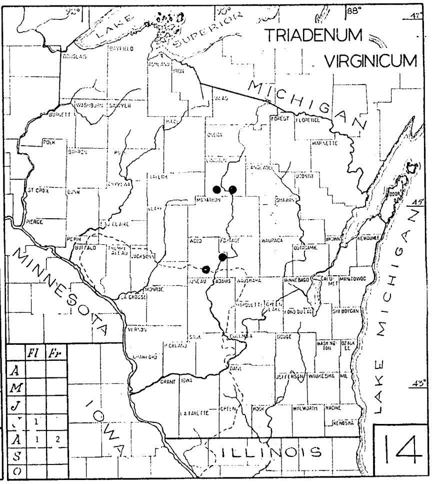
AA. Sepals oblong to lanceolate, summit acuminate to acute, 4.3–8 mm long; fruiting styles 2.1–3.6 mm long; rare, central Wisconsin. ---------------------------2. *T. VIRGINICUM*

1. TRIADENUM FRASERI (Spach) Gl. Marsh St. John's–Wort.
Hypericum Fraseri Spach May 13, Fig. 7.
Hypericum virginicum L. var. *Fraseri* (Spach) Fernald

Erect, glabrous, stoloniferous perennial herbs 2–6 dm tall, *mostly reddish-purple in age; internodes terete, without decurrent lines.* Leaves ovate-cordate to elliptic, 2.3–6.5 cm long, 1–3 cm wide, emarginate to obtuse, sessile and cordate-clasping. Cymules numerous, terminal and axillary, few-flowered. *Sepals 3–4.8 (–5.2) mm long, elliptic-oblong to spatulate, obtuse to rounded.* Petals mauve or pink, oblong, 5.4–8 mm long. Stamens 9, 3-delphous, persistent; hypogynous glands 3, oval, orange. Ovary 3-celled; *styles 3, free, 0.6–1.5 mm long at maturity;* stigmas 3, capitate. Capsules conic-ovoid, 7–10 mm long, 3–5 mm wide, abruptly narrowed to styles. Seeds cylindric, dark brown, reticulate, 0.9–1.1 mm long.

Native of northeast North America (NE Nebraska & SW Manitoba to Newfoundland & Labrador, south to Conn., Penna., N. Y., the mountains of W. Va., N. Ind. and Iowa), abundant in Wisconsin's wet acid habitats, as tamarack-black spruce- leather-leaf-sphagnum bogs, sedge meadows, shrub carrs, sloughs and peaty marshes: in Comstock Marsh, Marquette Co., an extensive quaking bog with abundant *Drosera rotundifolia, Sarracenia purpurea* and patches of *Phragmites communis, (Nee 1345,* WIS); along Turtle Lake, Marquette Co., with *Carex spp., Potentilla fruticosa* and *P.*





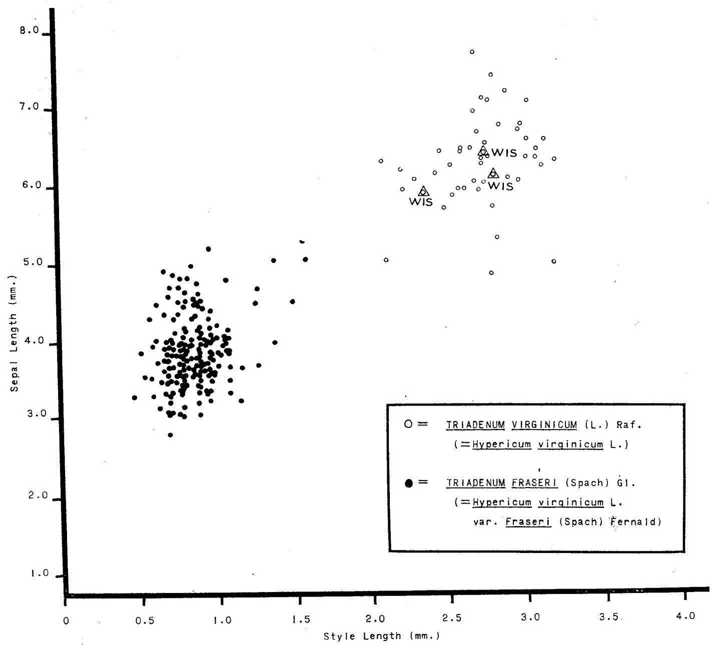


FIGURE 7. Scatter diagram comparing sepal and style length of Wisconsin *Triadenum fraseri* and Wisconsin and non-Wisconsin *T. virginicum.*

palustris, Chamaedaphne calyculata, sedge meadow and adjoining thickets; in Vilas Co., along Lac Vieux Desert, in shallow acid waters of slow stream draining sphagnum bog with *Larix laricina, Picea mariana, Ledum groenlandicum, Sarracenia purpurea, Calopogon pulchellus, Nuphar rubrodiscum, Utricularia, Hippurus,* etc., *(Iltis 18,149,* WIS). Flowering from early July to latest August, fruiting mid-July till late September.

2. TRIADENUM VIRGINICUM (L.) Raf. Map 14, Fig. 7.
Hypericum virginicum L.

Similar to above, but *sepals oblong–lanceolate, acuminate to acute, 4.3–8 mm long.* Petals obovate, 6.3–9.8 mm long. Ovary 3-celled; *styles 3, divergent, 2.1–3.6 mm long;* stigmas capitate. Capsules ovoid-cylindric, 7.6–13.4 mm long, 3–5 mm wide, gradually tapering to styles. Seeds cylindric, dark brown, reticulate, 0.9–1.1 mm long. N = 19 (Hoar & Haertl 1932).

An Atlantic coastal plain element, *Triadenum virginicum* extends inland to S. N. Y., S. Ontario, and disjunct to N. Ind. and central Wisconsin: Lincoln Co.: Merrill, dry sandy field along Prairie River with *Comptonia peregrina, Hieracium aurantiacum* and *Robinia pseudoacacia,* 19 Aug. 1956, *Iwen 419* (WIS). Bagga Marsh, among cranberry beds along Copper River, 25 Aug. 1957, *Schlising & Peroutky 660* (WIS). Wood Co.: burned over sphagnum bog, 5 mi NW of Babcock, 20 Aug. 1937, *Catenhusen s.n.* (WIS). Biron township, Huffman farm, 16 July 1953, *Dana s.n.* (WIS). It is noteworthy that all collections are recent, since 1937.

In Wisconsin, *T. Fraseri* is quite common and easily separatable from both Wisconsin and non-Wisconsin *T. virginicum* (Fig. 7). Taxonomically and morphologically, Gleason (1947) distinguished them on sepal and style length. Fernald (1936), using var. *Fraseri* to indicate this difference, notes that, where sympatric, they usually show clear segregation into a southern or lowland and a northern or upland series.

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PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN NO. 62. COMPOSITAE VI. COMPOSITE FAMILY VI. THE GENUS AMBROSIA—THE RAGWEEDS[1, 2]

Willard W. Payne

Ambrosia (including *Franseria*) is one of several genera of the Compositae which are distinguished by exceptional modification for wind pollination or anemophily. All of these genera (*Iva*, *Euphrosyne*, *Dicorea*, *Hymenoclea* and *Xanthium*, in addition to *Ambrosia*) are characterized by similarities in vegetative morphology, chemistry, cytology, and pollen and inflorescence structure that suggest evolutionary affinity. They have been variously classified as a distinct family, the Ambrosiaceae (Small, 1913; Rydberg, 1922), as a distinct tribe, the Ambrosieae (Cassini, 1834; Delpino, 1871; Benson, 1957; Payne, Raven and Kyhos, 1964), and as a subtribe, Ambrosiineae, of the tribe Heliantheae (Bentham, 1873; Fernald, 1950; Cronquist, 1952; Keck, 1959; Solbrig, 1963). There is growing evidence to support the derivation of this evolutionary group from helianthoid progenitors, of particular interest in this respect being the pollen wall ultrastructural studies of Larson and Skvarla (1966). At the same time, however, these plants have certain chemical and structural attributes more characteristic of the Anthemideae (Payne, 1963; Miller, 1967), and it is possible that they have been derived from a progenitor group intermediate between the Anthemideae and Heliantheae. Because of this, and taking into account the array of morphological features common to all of the genera, I believe they are best treated, for the present at least, as members of the tribe Ambrosieae.

Ambrosia is distinguished from other closely related genera of the Ambrosieae by capitulescences of wholly staminate and wholly pistillate capitula, the staminate with saucer-shaped, lobed involucres of connate phyllaries, the pistillate with hard, spiny, burlike fruiting involucres. The usual arrangement of head types is that in which staminate capitula are produced in racemose or

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spicate groups at the tips of the main stems and branches, while pistillate capitula are clustered in the axils of leaves and bracts below the staminate racemes (see Figs. 1, 2, 3). Close similarity and extreme floral reduction in *Ambrosia, Xanthium* and *Hymenoclea* suggest that these genera constitute the terminal evolutionary branch of the Ambrosieae, with *Xanthium* and *Hymenoclea* independently derived from primitive forms of *Ambrosia.*

The genus *Ambrosia* is predominantly American; approximately 31 species are native to North America, eight to South America; two species, closely allied to and probably derived from American progenitors, are found in the Old World. All available evidence suggests that the genus originated in and diversified from arid and semi-arid regions in southwestern North America, where primitive species are still abundant (Payne, 1964).

All of the ragweeds are found in open habitats. Primitive, shrubby species occupy natural sites in deserts and semi-desert areas, being particularly adapted for stream banks, exposed arroyos, and the like. Such species produce fruiting involucres with many straight or hooked spines (often identical to those of the cockleburs) and are adapted for animal dispersal. In addition, involucres of the majority of the species commonly fall into streams or are carried to streams by runoff water, and dissemination by flowing water is probably important in their local distribution. Advanced species of ragweeds occur most abundantly today as weeds in association with man. The physiological characteristics that have allowed primitive members to survive in open and primary sites in arid regions are undoubtedly those which have been refined to permit derived species to successfully exploit pioneer habitats created by the agricultural and urban practices of present American cultures. Fruiting involucres of most advanced, weedy species have few or no vestigial spines, and the reduced spines appear to play no significant role in fruit dispersal (Gebben, 1965). When individuals grow along streams or river banks, or when they occur on slopes, water flow is probably important for local down-stream or down-slope transport of fruits and seeds. Studies of introduced populations of the short ragweed *(A. artemisiifolia)* in Oregon (G. H. Moose, personal communication) indicate that seeds of this species may be carried short distances by water flow, and temporary colonies of the species often flourish on sand bars and flood plains. I have obtained evidence from experiments with a captive English sparrow (Payne, 1962) that a small proportion of ingested seeds of *A. artemisiifolia* can pass unharmed through birds' alimentary canals and still germinate. In addition to these factors man is a potent, long-distance transport agent for species that occur as weeds of cultivation. Regardless, most seeds of derived species fall and re-

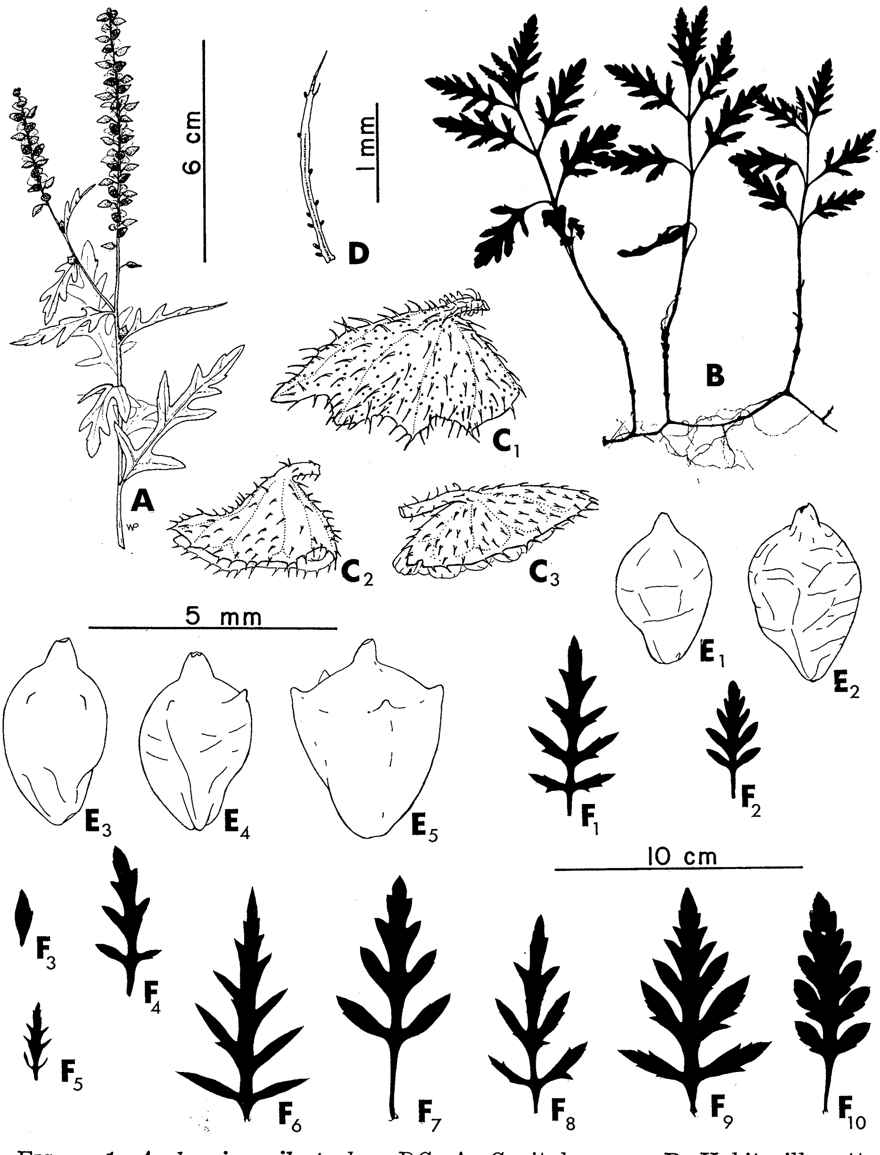


FIGURE 1. *Ambrosia psilostachya* DC. A. Capitulescence. B. Habit silhouette showing several young, adventitious shoots developed from runner-like root. C. Representative staminate heads. D. Pale. E. Representative fruiting involucres with vestigial spines or without spines. F. Leaf silhouettes from representative specimens; each silhouette from different specimen, all from median, cauline nodes.

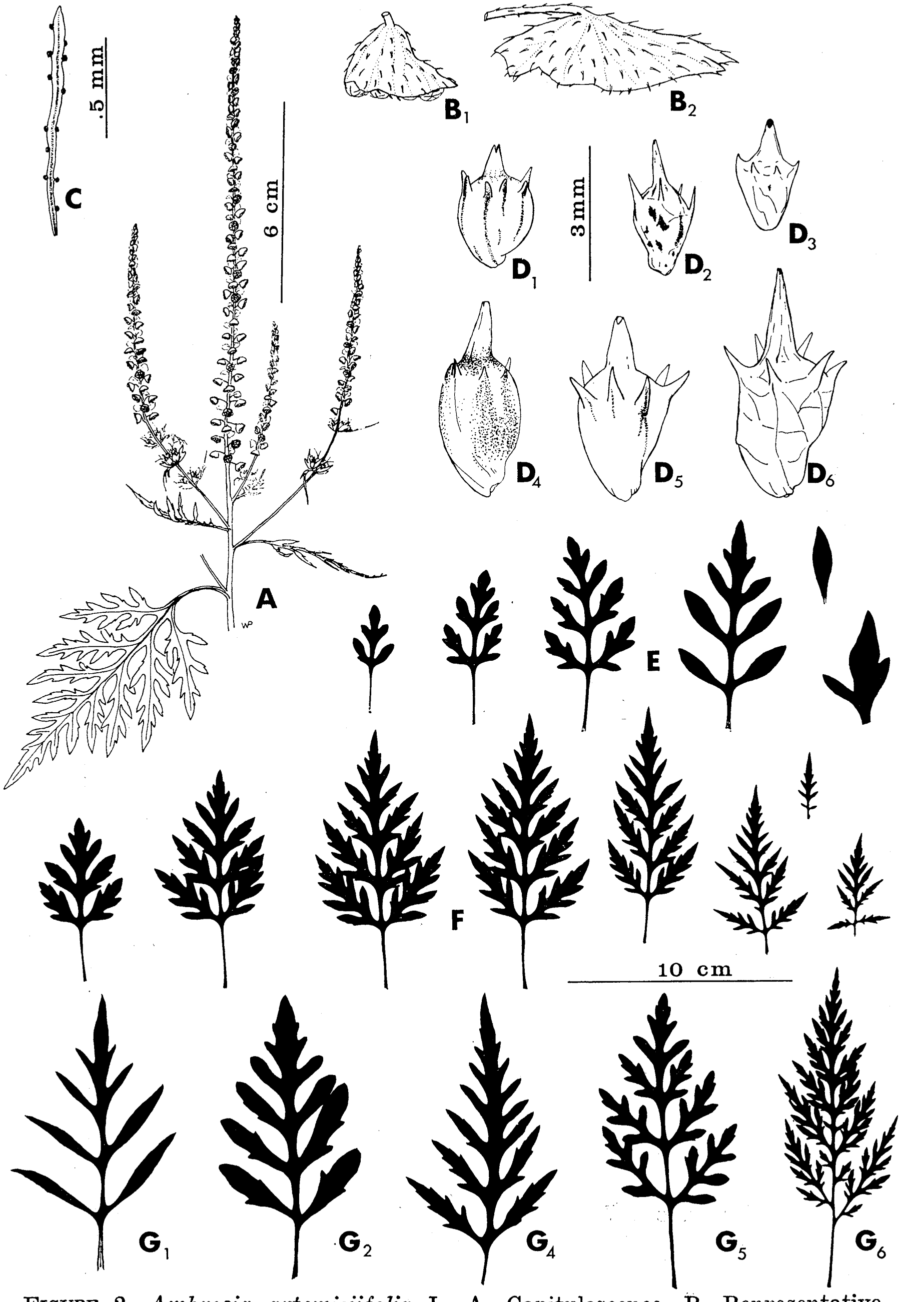


FIGURE 2. *Ambrosia artemisiifolia* L. A. Capitulescence. B. Representative staminate heads. C. Pale. D. Representative fruiting involucres. E. & F. Heteroblastic leaf series representing leaves of two frequently encountered forms; lowest nodes toward left. G. Population sample, each leaf from a different specimen; all leaves from node five above cotyledonary node.

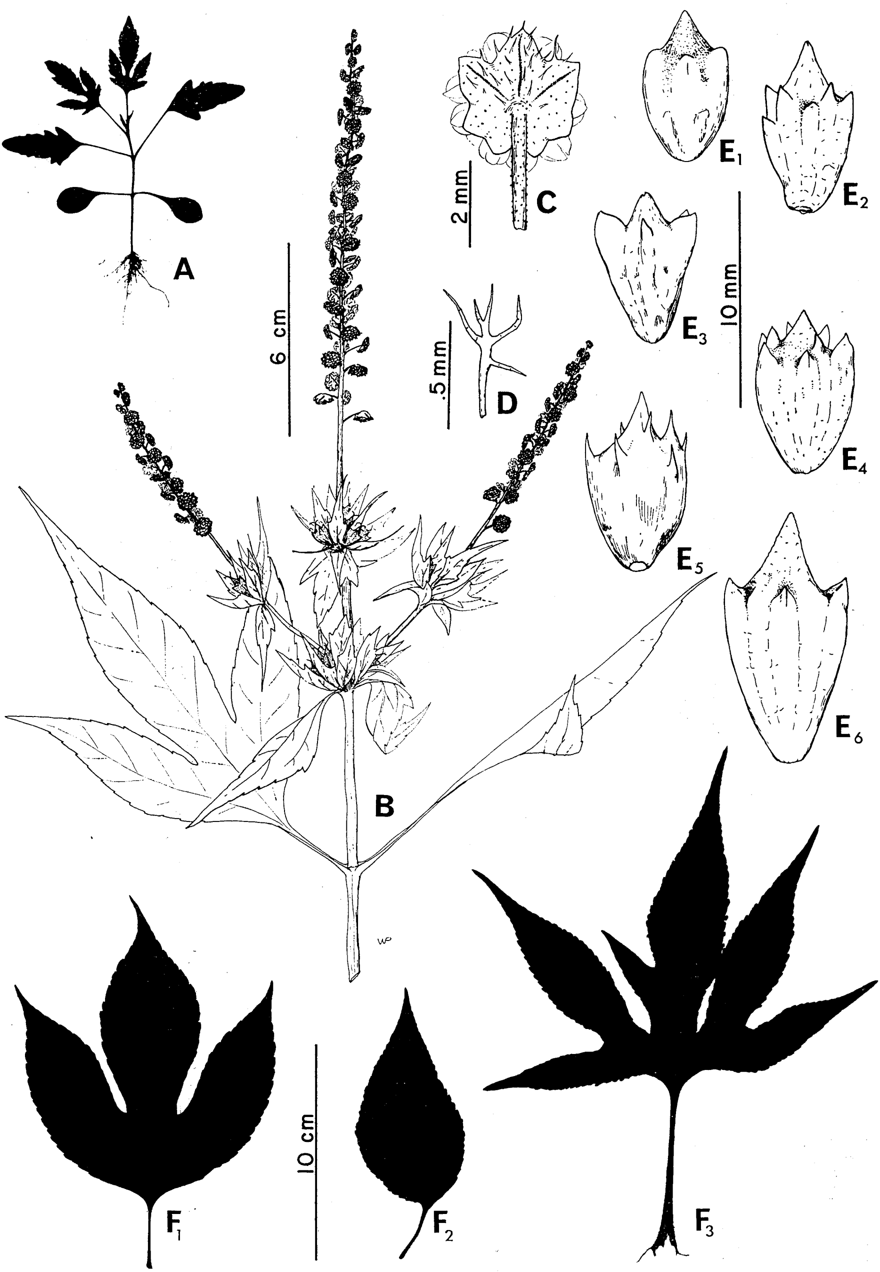


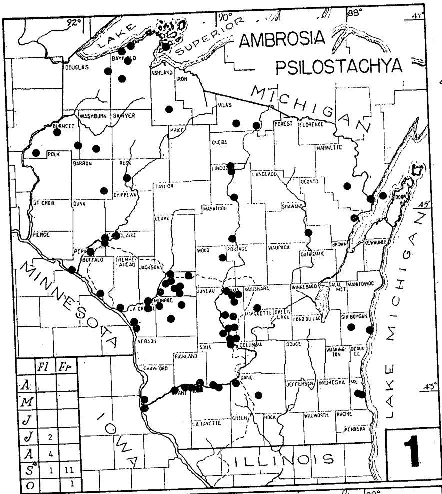
FIGURE 3. *Ambrosia trifida* L. A. Silhouette of seedling. B. Capitulescence. C. Staminate head; note distal striations. D. Pale. E. Representative fruiting involucres. F. Representative leaf silhouettes.

main in proximity to the parent plants, where they augment seed reserves present in soils that have previously supported the species. All of these factors are important in understanding the development and nature of the population structure of advanced species.

The three ragweeds found in Wisconsin are among the most specialized in the genus. They are widespread in the eastern and central United States (Maps 2, 4, 6), and are well known as sources of allergenic, air-borne pollen that constitutes the most serious natural air pollutant in North America, being the major cause of "hay fever" (cf. Wagner, 1959). An outstanding feature of all Wisconsin ragweed species is their morphological variability. Although this is particularly striking when the species are examined throughout their ranges, variability is also a pronounced attribute of the members of genetically restricted populations, such as the progeny grown from seeds developed by a single, self-pollinated plant (Jones, 1936). I have suggested (Payne, 1962, 1965) that for the short ragweed, heterogeneity may have been originally developed or strongly reinforced by fusion ("subspecies amalgamation") of once more distinct, subspecific groups. This hypothesis is compatible with present species structure and with the probable Pleistocene and post-Pleistocene history of the species. It may also provide at least a partial explanation for the similar attributes of Wisconsin perennial ragweed *(A. psilostachya)* and giant ragweed *(A. trifida)*.

Although this paper deals specifically with only the ragweeds of Wisconsin, there is presently no treatment covering other genera of the *Ambrosia* tribe (Ambrosieae) of the Compositae with which the ragweeds are often confused. Therefore, the keys below include all of the members of the Ambrosieae found in the state. Treatment of the genus *Iva* follows that of Jackson (1960), and of the genus *Xanthium* that of Löve and Dansereau (1959).

AMBROSIEAE—Wind pollinated shrubs, perennial herbs and annuals distributed principally in desert and disturbed habitats in the Americas. Leaves alternate to opposite, usually petiolate, often lobed. Pubescence various but always including simple, uniseriate trichomes which are dead at maturity, and biseriate, glandular colleters. Capitulescences paniculate to racemose or spicate, typically maturing acropetally; capitula paleaceous, perfect or unisexual, often nodding. Perfect heads with few, free or connate phyllaries, sterile disc florets, and fertile ray florets. Unisexual heads usually with connate phyllaries (phyllaries lacking in staminate heads of *Xanthium*), the phyllaries of pistillate heads united to form winged or spiny burs with prominent beaks through which the stigmatic lobes project. All florets reduced and specialized for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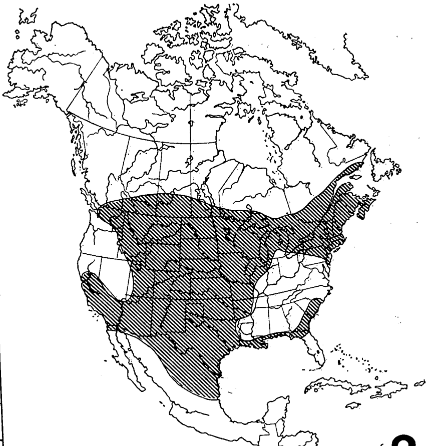
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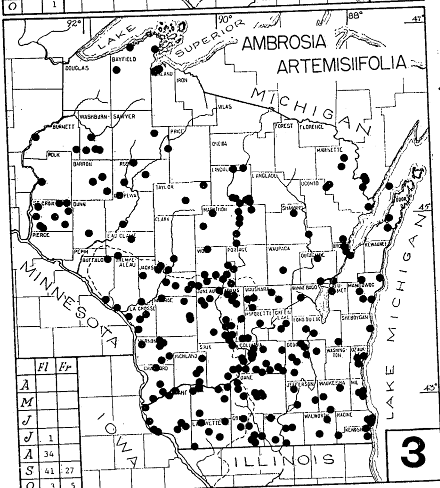
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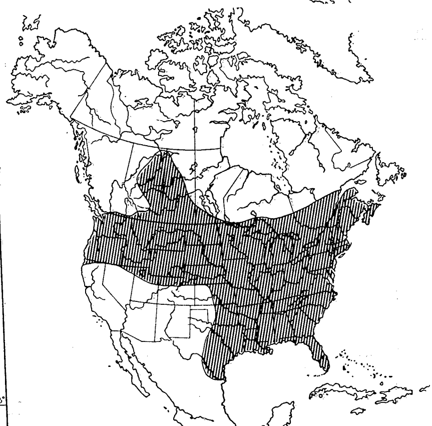
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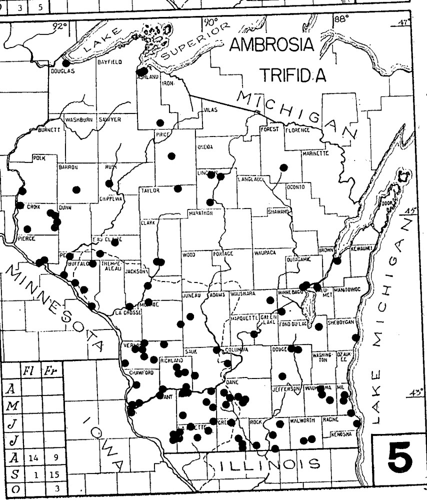
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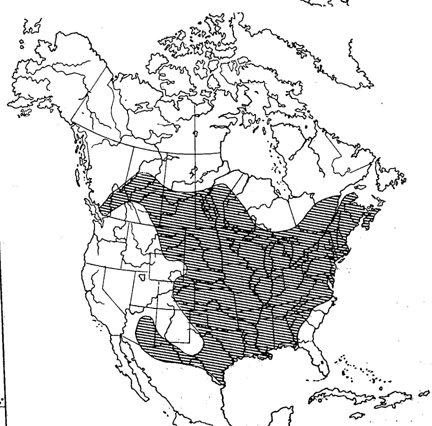
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anemophily; pappus vestigial or lacking; pistillate florets with reduced corollas or the corollas wanting, without androecia, the stigma lobes elongate and minutely papillose; staminate florets with anthers weakly connate and often separating during anthesis, lacking ovaries, and with capitate, penicillate pistillodia which elongate after anthesis to push pollen from the anther cylinders. Pollen oblate, tricolporate, the colpae mostly vestigial, echinulate, cavate, the cavae enlarging to form bladder-like chambers by pronounced shrinkage of the protoplast and invagination of the inner wall layers of the grains after shedding. Base chromosome number $x = 18$.

Key To Wisconsin Ambrosieae

a. Staminate and pistillate florets in common heads; ray florets fertile, disc florets sterile *(IVA)* ---------------------------b.

 b. Plants annual; phyllaries free ---------------------------c.

  c. Leaves ovate, coarsely serrate; heads subtended by prominent bracts; phyllaries 3–4 ----------------*I. annua L.*

  c. Leaves subcordate to ovate, usually coarsely lobed and toothed; heads ebracteate; phyllaries 5 ----------------------------------*I. xanthifolia* Nutt.

 b. Plants perennial; phyllaries basally connate ----------------------------------*I. axillaris* Pursh

a. Staminate and pistillate florets borne in separate heads -----d.

 d. Staminate heads lacking phyllaries, pistillate heads 2-flowered and with many, hooked spines *(XANTHIUM)* ------e.

  e. Leaves pinnately lobed; stems bearing long, golden, three-rayed, axillary spines ------------------*X. spinosum L.*

  e. Leaves coarsely palmately lobed; stems unarmed ----------------------------------*X. strumarium* L.

 d. Staminate heads with involucres of connate phyllaries, pistillate heads 1-flowered and with few vestigial spines or none -----------------------*(AMBROSIA)* See following key.

Genus 15. AMBROSIA L. Ragweed.

In Wisconsin, perennial or annual herbs with petiolate, lobed leaves opposite below or throughout. Staminate heads in terminal, racemose clusters, nodding on short stalks, many-flowered, paleaceous, with few-lobed involucres of connate phyllaries. Pistillate heads clustered in axils of upper leaves, sessile, 1-flowered, turbinate, with few sharp or blunt spines localized near the beaks or without spines.

Key To Species

A. Leaves pinnately or bipinnately lobed or parted; staminate involucres lacking dorsal striations; upper cauline leaves usually alternate -- B.

B. Plants perennial with horizontal runner-like underground roots; involucral spines blunt or absent; leaves usually coarsely lobed ---------------------- 1. *A. psilostachya.*

B. Plants annual with taproots; involucral spines usually sharply pointed; leaves usually delicately lobed and parted ---------------------------------- 2. *A. artemisiifolia.*

A. Leaves palmately lobed or unlobed; staminate involucres marked with dorsal striations; all cauline leaves usually opposite; plants annual --------------------------- 3. *A. trifida.*

1. *Ambrosia psilostachya* DC. Prod. 5: 536. 1836. *(non A. psilostachya* Grisebach. 1861.) Perennial Ragweed, Western Ragweed (Maps 1, 2; Figs. 1, 4P.) Type: *Berlandier 2280* G; Isotype NY.

A. hispida Torr. Ann. Lyc. Nat. Hist. N.Y. 2: 216. 1828. *(non A. hispida* Pursh. 1814).

A. coronopifolia T. & G. Fl. N. Am. 2: 291. 1842.

A. glandulosa Scheele, Linnaea 22: 157. 1849. *(non A. glandulosa* Rydb. 1922).

A. lindheimeriana Scheele, *l.c.* 22: 157. 1849.

A. coronopifolia var. *asperula* Gray, Bost. Jour. Nat. Hist. 6: 226. 1857.

A. coronopifolia var. *gracilis* Gray, *l.c.* 6: 227. 1857.

A. psilostachya var. *lindheimeriana* Blank. Rep. Mo. Bot. Gard. 18: 173. 1907.

A. californica Rydb. N. Am. Fl. 33: 20. 1922.

A. psilostachya asperula (Gray) Blank. ex Rydb. *l.c.* 33: 19. 1922.

A. psilostachya californica (Rydb.) Blake, *in* I. Tidestrom. Fl. Utah & Nev. 580. 1925.

A. psilostachya var. *coronopifolia* (T. & G.) Farwell ex Fern. Gray's Man. Bot., ed. 8, 1470. 1950.

Erect, perennial herb, 0.5–10 dm high; proliferating from runner-like roots. Stems unbranched or branched; pubescent, hirsute to pilose to hispidulous, minutely glandular; light green to yellowish, occasionally blotched or suffused with red. Leaves opposite below, alternate above, occasionally opposite nearly to staminate portion of capitulescence. Median cauline leaves short-petiolate to subsessile, the petiole usually broadened with decurrent blade tissue. Blade ovate to ovate-lanceolate in outline; pinnately to bipinnately lobed (rarely nearly unlobed), lobes with entire margins or sparsely serrate; lamina somewhat coriaceous, often densely gray-green pubescent; veins prominent on under surface; pilose to scabrous. Capitulescence usually little branched or unbranched, gradually blending with vegetative portion of axis. Staminate heads paleaceous; 10–40-flowered; stalked to subsessile; ebracteate. Staminate involucre campanulate, often prominently eccentric; shallowly toothed, the distal teeth usually larger; persistent after anthesis; pubescent, often minutely glandular-punctate. Staminate florets narrowly campanulate; corolla hyaline, five-lobed. Pistillate capitula sessile; often borne singly in axils of bracts and leaves subtending staminate raceme, usually clustered. Fruiting involucre obovate; spines 0–7, terete, usually bunt, often lacking; body to 6 mm long and 3.5 mm broad, reticulate-rugose, rarely striated; beak short, blunt to vestigial. Haploid chromosome number, n = (18), 36, 54, 72.

Ambrosia psilostachya is the least abundant of the Wisconsin ragweeds. It is a plant of sandy soils, commonly found on sandy prairies, often along ancient lake shores, sandy, glacial outwashes, and near the Great Lakes. Typical collection data include references to sandy beaches, sandblows, sandy prairie openings, and dry, sandy, open, upland forests. It is distributed fairly generally through Wisconsin (Map 1) but because of its habitat preferences is seldom abundant in comparison with short and giant ragweeds, and it is of minor economic importance as a weed of cultivated land. Reproduction is principally vegetative, and individuals well adapted for a particular site commonly produce large, clonal populations. The tendency for vegetative reproduction is correlated in this species with production of smaller, fewer-headed capitulescences. Comparative seed production by individual, well-grown shoots, raised in experimental garden plots at the University of Michigan Botanical Gardens in 1960, gave the following results: *A. artemisiifolia* (annual)—38,800 fruits; *A. trifida* (annual)—4,700 fruits; *A. psilostachya* (perennial)—80 fruits. In contrast, 24 perennial ragweed seedlings planted in similar plots in 1960 produced 3,175 vegetative shoots the succeeding spring (Payne, 1962). This difference in capitulescence development among the species indicates that, even where relatively abundant, *A. psilostachya* is a comparatively minor contributor to the atmospheric ragweed pollen load.

Like the other Wisconsin ragweeds, *A. psilostachya* is quite variable. This morphological variability is probably related, at least in part, to the presence in this species of a polyploid series, although no close correlation between particular ploidal levels and particular morphological expressions has yet been demonstrated. While Wisconsin perennial ragweed has not been intensively investigated cytologically, the most common ploidal level is probably $n = 36$ (tetraploid, based upon $x = 18$). Octoploid ($n = 72$) and diploid ($n = 18$, this count not yet verified in my laboratory) plants have been reported only from California and eastern Texas, respectively. Hexaploid plants ($n = 54$) are common west and south of Wisconsin, and it is possible that this ploidal level is represented in the state. Studies of the comparative sesquiterpene lactone chemistry of *A. psilostachya* clones and populations, currently in progress, indicate that the morphological variability of this species is paralleled by chemical variability (Miller, 1967; Miller, *et al.*, 1968).

2. *Ambrosia artemisiifolia* L. Sp. Pl. 2: 988. 1753. Short Ragweed, Common Ragweed. (Maps 3, 4; Figs. 2, 4A.) Lectotype: *Linnaeus 1114–4*. LINN. (I select this specimen from the Linnaean Herbarium as lectotype because it is representative for the species, is clearly labeled "artemisifolia" (sic) by Linnaeus, and is readily available as a photograph in the microfilm edition of the *Linnaean Herbarium* by the International Documentation Center AB, Tumba, Sweden.)

A. *elatior* L. Sp. Pl. 2: 987. 1753.
Iva monophylla Walt. Fl. Carol. 232. 1788.
A. *elata* Salisb. Prodr. 175. 1796.
A. *simplicifolia* Raeusch. Nomen. Bot. 274. 1797.
A. *absynthifolia* Michx. Fl. Bor. Am. 2: 183. 1803.
A. *paniculata* Michx. *l.c.* 2: 183. 1803.
A. *heterophylla* Muhl. ex Willd. Sp. Pl. 4: 287. 1805.
A. *artemisifolia elatior* (L.) Desc. Fl. Ant. 1: 239. 1821.
A. *longistylis* Nutt. Trans. Am. Phil. Soc. N.S. 17: 344. 1841.
A. *artemisiifolia* vars. α, β, δ, γ. T. & G. Fl. N. Am. 2: 291. 1842.
A. *artemisiifolia* L. α *quadricornis* Ktze. Rev. Gen. Pl. I. 305. 1891.
A. *artemisiifolia* L. β *octocornis* Ktze. *l.c.* 305. 1891.
A. *artemisiaefolia* ssp. *diversifolia* Piper, Contr. U. S. Nat. Herb. 11: 551. 1906.
A. *artemisiaefolia* L. var. *paniculata* (Michx.) Blank. Rep. Mo. Bot. Gard. 18: 173. 1907.
A. *media* Rydb. Bull. Tor. Bot. Club, 37: 127. 1910.
A. *elatior* L. var. *artemisiifolia* (L.) Farw. Rep. Mich. Acad. 15: 190. 1913.
A. *elatior* L. var. *heterophylla* (Muhl.) Farw. *l.c.* 190. 1913.
A. *diversifolia* (Piper) Rydb. N. Am. Fl. 33: 18. 1922.
A. *monophylla* (Walt.) Rydb. *l.c.* 17. 1922
A. *artemisiifolia* var. *elatior* f. *villosa* Fern. & Grisc. Rhodora 37: 185. 1935.

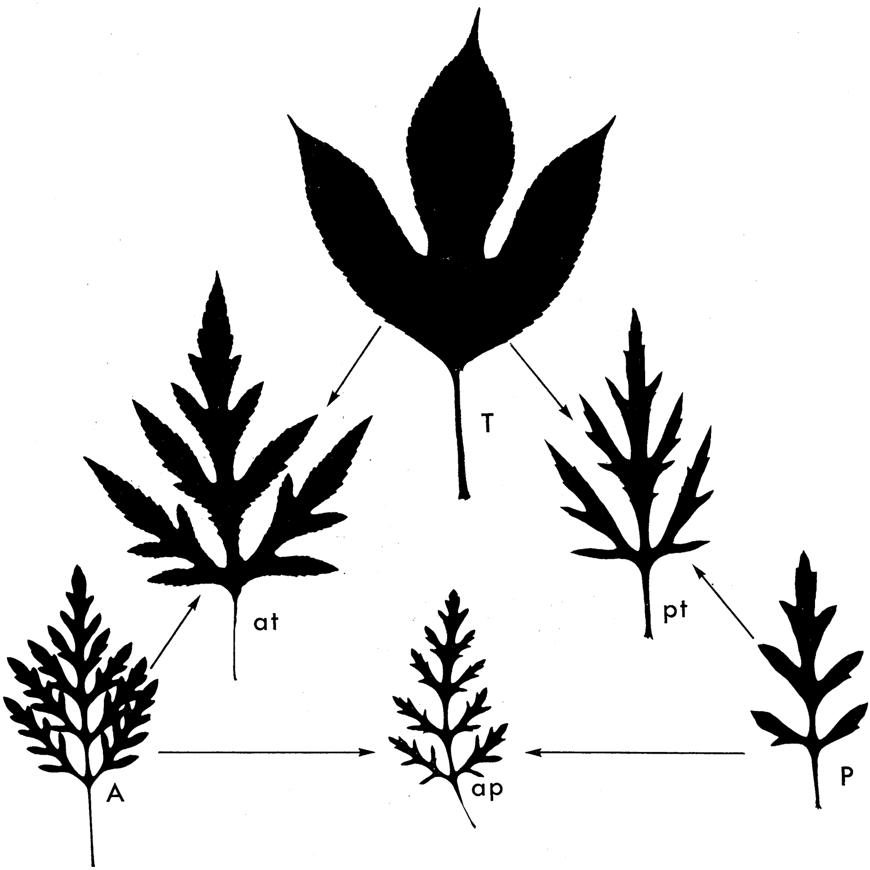

FIGURE 4. Leaf silhouettes representative for the Wisconsin ragweeds *A. artemisiifolia* (A), *A. psilostachya* (P), *A. trifida* (T), and their hybrid progeny.

Erect, annual herb, 1–7 (–20) dm high. Stems unbranched to much branched; glabrous to villous, often streaked with reddish to black longitudinal markings. Leaves petiolate, opposite below, alternate above. Lamina of median cauline leaves pinnatifid to tri-pinnatifid, frequently less lobed above and below, blades of upper-most cauline leaves occasionally unlobed; margin sparsely serrate, serrations blending with lobes; ovate in outline. Capitulescence much branched, occasionally wholly or predominantly staminate or pistillate, more or less abruptly differentiated from vegetative stem. Staminate heads paleaceous; 10–100 (–200) flowered; stalked, stalks to 4.5 (–15) mm long, seldom bearing more than a single, terminal head; ebracteate. Staminate involucre campanulate to cupulate to flattened; lobed, with 5–10 short-deltoid, marginal lobes, the sinuses normally extending less than ⅓ the distance to the stalk, terminal lobes usually largest; unmarked above; sparsely pubescent, sometimes obviously glandular; remaining attached after anthesis is complete. Pales linear, usually with marginal or terminal, simple or glandular trichomes. Staminate florets narrowly campanulate; corolla hyaline, 5 lobed; stamens 5, the tips of the claws usually long-attenuate; anthers connate. Pistillate heads sessile, 1 flowered; clustered in axils of bracteal and foliage leaves below the staminate racemes; all but the terminal one bracteate. Fruiting involucres obovate, the body to 2.5 mm broad and 3.5 mm long, with one beak to 2 mm long; supplied with 4–12 straight, terete spines, to 1 mm long (rarely longer, or completely vestigial and lacking), arranged in one or a few close whorls above center; glabrous or with few to abundant, short to long hairs, frequently glandular punctate, particularly below the beak; somewhat rugose; commonly with reddish-brown to black mottling or striations, sometimes suffused with pigment. Haploid chromosome number, $n = 18$.

Short ragweed is by far the most abundant and economically important of the ragweed species of Wisconsin. It is distributed generally throughout the state (Map 3), being uncollected from only a few counties in the northwestern and west-central portions of Wisconsin, where the species begins to reach the northern limits of its range at these longitudes. It is most frequently a weed of cultivated and ruderal habitats, roadsides, railroad embankments, and similar sites, and may also become abundant in overgrazed and sterile soils. Because urbanites most often encounter *A. artemisiifolia* as a roadside weed, it is popularly believed that roadside habitats support a major proportion of the plants in an area, and are, thus, the sources for most ragweed pollen production; this belief is defended by manufacturers of chemicals used to spray roadsides in weed control programs. However, three studies carried out in southeastern Michigan in 1958, 1959 and 1960 (Harrington, *et al.*, 1960; Gebben, *et al.*, 1962; Gebben, 1965) clearly demonstrate that, in areas encompassing both rural and urban land use, the great majority of plants are found in cereal grain fields, of which wheat fields lead the list.

An outstanding attribute of this species is its variability, usually with considerable distance between extremes in expression of virtually all characters (see, for example, Fig. 2, D and G). It is probable that genomes and populations capable of producing variable progeny are selected and maintained in this species. Such a mechanism enhances the ability of the species to survive with man by providing a continually varying supply of genotypes, some of which are capable of exploiting nearly any available primary site. The selective advantage for such a mechanism is obvious when one considers the variable nature of man-created primary habitats, viz., those associated with crop rotation, frequent interruption of different successional stages in different ways, and so on. A possibly significant factor in this mechanism has to do with seed longevity. The longevity experiments initiated by Beals (Darlington, 1922) and others demonstrate that seeds of *A. artemisiifolia* may remain viable in the soil for periods of 40 years or more. Thus, it is possible for plants developed from seeds produced the preceding season to interbreed with plants developed from seeds produced many ragweed generations in the past, bringing together and intermixing genomes from populations which may have been selected under quite different site conditions. Similar factors influencing population dynamics are probably also important in the biology of *A. psilostachya* and *A. trifida.*

3. *Ambrosia trifida* L. Sp. Pl. 2: 988. 1753. Giant Ragweed, Great Ragweed, Horse Cane. (Maps 5, 6; Figs. 3, 4T.)

Lectotype: *Linnaeus 1114–1.* LINN. (As for the previous species treated, this specimen is appropriately labeled and preserved, and a photograph is available from the International Documentation Center.)

A. simplicifolia Walt. Fl. Carol. 231. 1788.
A. integrifolia Muhl. ex Willd. Sp. Pl. 4: 375. 1805.
A. aptera DC. Prod. 5: 527. 1836.
A. trifida var. *integrifolia* (Muhl. ex Willd.) T. & G. Fl. N. Am. 2: 290. 1842.
A. trifida L. var. *β texana* Scheele, Linnaea 22: 156. 1849.
A. trifida L. *a normalis* Ktze. Rev. Gen. Pl. I. 305. 1891.
A. trifida L. *a normalis* var. *aptera* Ktze. *l.c.* 305. 1891.
A. trifida L. *a normalis* var. *heterophylla* Ktze. *l.c.* 305. 1891.
A. striata Rydb. Brittonia 1: 96. 1931.
A. variabilis Rydb. *l.c.* 97. 1931.
A. trifida L. f. *integrifolia* (Muhl.) Fern. Rhodora 40: 347. 1938.
A. trifida var. *polyploidea* Rousseau, Nat. Canad. 71: 215. 1944.
A. trifida var. *trifida* Cronquist, Rhodora 47: 396. 1945.

Erect, annual herb, 2–50 dm high. Stems unbranched to much branched; hispid-hispidulous to scabrous or nearly glabrous, sometimes tuberculate; somewhat angular and ridged; often with fine, black longitudinal striations, frequently suffused or blotched with red. Leaves opposite throughout or becoming alternate in the capitulescence; petiolate, the petiole often more or less winged with decurrent blade tissue. Blade ovate-lanceolate to broadly ovate or ovate-deltoid in outline; upper, bracteate blades often becoming narrowly lanceolate; unlobed or palmately lobed, the 3–7 primary lobes occasionally bearing pinnately arranged secondary lobes; margin serrate, the abaxial surface of each tooth often with a single, black striation; adaxial surface hispidulo-scabrous. Capitulescence little or much branched. Staminate heads minutely paleaceous; 10–125 flowered; stalked, stalks 2–8 mm long, rarely subsessile; ebracteate. Staminate involucre shallowly campanulate to saucer-shaped; crenulate or toothed at the margin, the three distal teeth usually more pronounced and marked on the upper surface with prominent, black striations; abcissing after anthesis is complete. Staminate florets narrowly campanulate; corolla hyaline, five-lobed, marked with longitudinal striations; stamens with short-attentuate claws. Pistillate capitula sessile, 1 flowered; clustered in axils of bracteal leaves below the staminate racemes; all but the terminal bracteate. Fruiting involucres obovate; spines terete to radially flattened, 3–11 in one or a few close-set whorls below the beak; body to 17 mm long and 10 mm broad usually ridged and somewhat rugose, frequently marked with black or red, somewhat pubescent. Haploid chromosome number $n = 12$.

Giant ragweed is the second most abundant species in Wisconsin, being distributed principally in the southern two-thirds of the state (Map 5). Although ordinarily less abundant regionally than short ragweed in terms of absolute numbers of specimens the greater stature and larger capitulescences make it a heavy pollen producer, and in areas of abundance it may contribute as much or more pollen to the local atmospheric pollen load. It is essentially a floodplain species and is most abundant in moist soils of drainage ditches, low fields, open stream banks, and the like.

Like short ragweed, *A. trifida* is quite variable, outstanding variability being associated with fruit size and shape, leaf shape, and pubescence. In the southern and southwestern United States the fruiting involucres are often scarcely larger than those of *A. artemisiifolia,* while in the Appalachian region fruits 10–20 times this size may be found (Payne and Jones, 1962). Similar fruiting involucre variation is common in local populations, and may also apply to different fruits taken from the same plant. Forms with unlobed leaves, or with both lobed and unlobed leaves are common, this aspect of leaf morphology being partially related to ecological conditions. Such plants have played a prominent role in the taxonomic history of the species, generating such epithets as *simplicifolia, integrifolia,* and *variabilis.* It is probable that, as with short ragweed, greatly increased population size, mixing of geographic races once more distinct, and variable selection pressures associated with modern agricultural practices and urbanization, have contributed to local variability.

The black striations distributed on all parts of the plant are related to sub-epidermal canals (resin canals?) which contain a deep red pigment. When cut, the plant bleeds red "blood," a fact that figured prominently in the "doctrine of signatures" medical practices of some American Indians, and which actually led to reverence and fear of the plant by certain tribes (Payne and Jones, 1962).

The most unusual characteristic of *A. trifida* is its chromosome compliment of $n = 12$. With the usual base of $n = 18$ in the genus, this presents the possibility of a progenitor genome of $n = 6$. Pairing behavior studies by K. L. Jones (1943) of the hybrid *A. artemisiifolia* X *trifida* have demonstrated, however, that the 12 chromosomes of giant ragweed are homologous with the 18 chromosomes of short ragweed, and the chromosome complement of *A. trifida* is interpreted to be the result of aneuploid reduction (Payne, Raven and Kyhos, 1964). Furthermore, no similar compliment is known elsewhere in the Ambrosieae, although aneuploid reduction to $n = 16$ or 17 is common in the genus *Iva*, and in *A. bidentata* $n = 17$. Polyploidy in *A. trifida* was suggested by Rousseau (1944), but was refuted by the studies of Payne and Jones (1962). To my knowledge, no *bona fide* report of polyploidy exists for the species.

Ecological Relationships and Specialization of Wisconsin Ambrosia

The ragweed species described above appear to be specialized within the genus, and are probably more or less recently evolved. The majority of specific character expressions are interpreted as derived expressions within character gradients established by comparison of ragweeds with general conditions in the family Compositae. These specialized characteristics, common to the three species treated, include: shallowly lobed staminate involucres, eccentrically borne on relatively short stalks; vestigial pales; single flowered pistillate heads, with few, vestigial spines, localized near the beaks; prominently lobed or dissected leaves, opposite at the lower nodes or throughout; herbaceous perennial or annual habits; and distribution in non-arid eastern and northern North America. Although they share these specializations, the three species do not appear to comprise a natural, evolutionary group. *Ambrosia psilostachya* and *A. artemisiifolia* are very similar and probably are the more specialized members of a subgeneric group that includes the Mexican *A. cumanensis,* the West Indian and South American *A. peruviana,* the Caribbean *A. hispida,* and the South American *A. tenuifolia* and

A. microcephala. The entire group bears considerable resemblance to the *A. confertiflora* assemblage (including also *A. canescens* and *A. pumila*) and is probably derived from shrubby progenitors characterized by regularly lobed and dissected leaves, hooked involucral spines, and usually non-striated stems, involucres and leaves. *Ambrosia trifida,* however, bears greatest resemblance to species of a distinct, derivative line, characterized by irregularly lobed leaves, straight, flattened involucral spines, and prominent vegetative striations. It can be traced to shrubby progenitors of the least specialized sort in the genus (such as *A. deltoidea*) along an evolutionary line represented by *A. chamissonis, A. nivea, A. cheiranthifolia, A. grayi, A. tomentosa,* and *A. acanthicarpa.*

Ambrosia Hybrids

The three species are capable of hybridization, although hybrid individuals are usually uncommon and highly sterile. Hybrid plants are most easily recognized by their intermediate leaf characteristics (Fig. 4). Wagner and Beals (1958) have found that the perennial hybrid *A. artemisiifolia* X *psilostachya* (*A.* X *intergradiens* Wagner & Beals) (Fig. 4ap) is persistent and fairly "common" in northern and eastern Michigan, where it often forms clonal populations that persist for many years. It is probable that similar populations are frequent in adjoining Wisconsin in areas of sympatry.

Palynological evidence (Bassett and Terasmae, 1962) indicates that ragweeds occupied sites in the northeastern United States and adjacent Canada during and since the Pleistocene, and it is probable that all of the species found today in Wisconsin were here long before the invasion of North America by European cultures. On the other hand, European man, by providing variable primary sites in much greater abundance than were ever before available for ragweed occupation, has greatly influenced the natures of the species and their population dynamics.

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