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TRANSACTIONS OF THE WISCONSIN ACADEMY

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HARRY HAYDEN CLARK

45th President of the

WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

INFLUENTIAL TEACHERS OF LITERATURE AT THE UNIVERSITY OF WISCONSIN

Harry Hayden Clark

May I invite you at this evening's banquet of the Academy to share memories of some of the influential teachers of literature of the generation before ours at the University of Wisconsin? Perhaps such memories will help to supplement what you have already heard during the last two days about the great advantages our state has in the way of environment, technology, recreational facilities, technology, and other physical things. After all, an outsider in moving to this state does not have to divorce himself or his children from opportunities to benefit from the non-physical *cultural* resources of mankind in general, from a cultural heritage which is both international and which stretches across the ages from classical antiquity. Our forefathers were far-sighted and generous in providing Wisconsin people with a state university which in its literary departments was designed to act as a kind of "transformer" to bring down to the level of individuals who live here the great over-arching currents of whatever the ages have proved to be conducive to ethical guidance, to human happiness, social justice, and emotional enjoyment.

Since our Academy is distinctive in combining a concern with the sciences *and* with the arts and literature (only two or three other academies of the fifty states combine these), it may not be amiss to mention a few of the common denominators of these approaches. Both the sciences and the literary arts at their best are fertilized by the imagination—the scientist such as Newton usually proceeds by formulating an hypothesis, an imaginary supposition to be tested inductively by the extent to which it explains the action of particulars; and the great writer such as Shakespeare relates his particular characters to types arrived at by imagination. Both the scientist and the literary man assume that the universe is orderly, that given causes will produce predictable consequences. Mixing certain chemical elements will insure producing repeatedly certain compounds. Jefferson, the father of democracy, remarked that one can learn more about the psychological ramifications of filial ingratitude from *King Lear* than from mountains of abstract sermons. And *Macbeth* clarifies the predictable outcome of murderous ambition. The psychiatrist and novelists such as Hawthorne, the historian of the guilty conscience, centering on exploring the individual's inner life, have much in common. Both the scientist and the literary man reason from particulars to universals, to immutable scientific laws abstractly stated and to principles about how man's mind and heart react. It was no accident that most of the founders of the Royal Society of Science in 1662 had been trained in the literature of the ancient classics which taught one to look for universals. Incidentally, Willard Gibbs first presented his epoch-making "rule of phase" in the transactions of one of our state Academies, and many theorists claim that investigations hardly transcend pedestrianism or vocationalism unless they "follow through" and rise to the plane of universal laws true for all times and places. In other words, both the scientist and the literary man seek to penetrate beneath the surface appearances guided by methods which try to be objective and austere. Individuals in both disciplines may adopt sectarian religions, but in their distinctive professional concerns both tend to generalize not so much from the supernatural or the miraculous as from verifiable human or mundane experience. In short, the scientist and the literary man in their higher reaches have much in common, and the founders of our Wisconsin Academy were wise in uniting them in the same organization, which has now endured for nearly a century.

I come now to our immediate topic, teachers of literature at the University of Wisconsin from about 1915 to 1935. They may be roughly divided into three categories according to what they chose to emphasize. (In actual practice, in catering to classes of different ages, most teachers have used many approaches and methods; but emphases may be illuminating in terms of individual temperaments and student interests.) First, reflecting the current vogue of historiography and of concern with change sanctioned by the vogue of evolutionism, teachers such as Karl Young, Alfred Holfeld, and Arthur Beatty tended to emphasize a turn from Coleridgean abstractions and judicial absolutes, and toward a concern in the study of literature with historical continuity and sequence, with historical influences, with explaining *why* a given book came to take the shape it did as it grew out of specific backgrounds. Second, continental theorists such as Brunetière, having emphasized the evolution of literary forms, University of Wisconsin scholars such as Neil Dodge, Warner Taylor, J. F. A. "Sunny" Pyre and Ruth Wallerstein tended to emphasize the place of literary techniques and formal patterns in the resources of creative genius and in enhancing the beauty of a given poem or novel. These people stressed not so much background as foreground, a close and appreciative study of the actual text so as to illuminate literary devices which help to explain different nuances of aesthetic quality. Third, continuing the classical concern with an appraisal of literary values, University of Wisconsin teacher–scholars such as Grant Showerman, William Giese, Philo Buck, and F. W. Roe emphasized bringing a given drama or poem into relation with the norms provided by the long tradition of values which had endured through the centuries, trying to winnow and sift literary masterpieces which in their wisdom and beauty might be of use to modern readers in quest of self-realization and serenity, if not happiness. Such judicial critics thought of literature—often in Matthew Arnold's sense—as roughly allied with religion as a potential guide to fruitful living in their own day. They tended to try to avoid antiquarianism and subjective appreciation, yet they approached literature in terms of the authority of examples of past excellence and they exalted beauty (as did Emerson) as the mark or by-product of virtuous living.

Granting some overlapping of these broad classifications among the teachers mentioned, I shall now proceed to more personalized sketches. Karl Young, born in Iowa in 1879, had taken his B.A. at the University of Michigan and his doctorate under G. L. Kittredge at Harvard. His teaching apprenticeship at Annapolis before coming to Wisconsin (where he taught for fifteen years, 1908–1923) accentuated his tendency toward a military manner. (His eminence is illustrated by the fact that Yale called him to head its English Department, and he was elected national president of the Modern Language Association.) Mr. Young was tall and slender and handsome, with prematurely gray hair, the epitome of poise, energy, refinement, and dynamic personal drive. He was the scourge, especially during his chairmanship at the University of Wisconsin, of anything fuzzy or nebulous or subjective or based on guesswork. He began publishing in the *Transactions* of our own Academy in 1910 on liturgical drama, an impressive early article which was a link in a long chain of historical investigations which led to his monumental two-volume book on *The Drama of the Mediæval Church* (Oxford, 1933). The current perverted slogan, "Publish or Perish," would have seemed to him a basic contradiction in terms. Himself a masterful teacher whose work benefited from the student discussions he inspired, Mr. Young held that by publishing one's best insights he not only helped other overworked teachers but kept his own teaching from perishing in the short memory of one generation. He was a realist if not a pragmatist, working inductively in rigorous relation to historical facts and often newly unearthed texts which he used to explain *why* such a master as Shakespeare should have been able to create his masterpieces.

Alfred Holfeld, also national president of the Modern Language Association, led his well-organized German Department not only in teaching the language but in producing a host of historical monographs illustrating in massive detail such matters as the actual vogue of German literary ideas in our early American magazines and the influence in America of writers such as Goethe. His orotund speeches in the Faculty of Letters and Science were masterpieces of persuasiveness and academic wisdom, and were very influential.

Arthur Beatty, a native of Canada with a doctorate from Columbia, early illustrated the historical approach in studies (published by our Academy) in the early drama in the roots that he found in non-classical folk-festivals and the early mummers' plays and other works associated with the rebirth of the seasons. Later, Mr. Beatty's epoch-making book on *Wordsworth* (1922) stressed the poet's use of the Hartleyan psychology of associations to emphasize retrospect and the continuity of his own personal experience as the subject-matter of *The Prelude,* a poem on the "growth of a poet's mind." (This approach eventually merged into Wordsworth's later concern with the continuous tradition of his people and their national religion in his later sonnet sequences and in his anti-revolutionary admiration for Edmund Burke, spokesman for the values of the continuity of tradition.) Mr. Beatty was a short, stout, roly-poly kind of man, beloved by his students for his geniality. In later years he and his motherly wife enjoyed escorting groups of American students through the places in England (such as the Lake Country) which have historic associations with great writers. He and his wife were active in various literary clubs and he did much to interest students in literature through his gusto and his ability to dramatize the man behind the book, to humanize literature as growing out of actual three-dimensional individuals who grew out of specific historical places and eras.

Since Merritt Hughes, a past president of this Academy is still happily with is, he must be left to a future memorialist. Mention will be made here of his long chairmanship of the English Department and of his editing of the works of Milton with voluminous notes illustrating matchless erudition. His devotion culminated in the publication of his many essays *(Perspectives on Milton)* by the Yale University Press, with a eulogistic introduction by Harvard's Douglas Bush.

Turning now to the second of our categories of scholars, Neil Dodge, born in the far west (Washington) in 1867, took his B.A. and M.A. at Harvard, and in lieu of a doctorate studied intenssively for three years in the great libraries of Italy, France and England. Beginning in 1898 he taught the rest of his long life at the University of Wisconsin, serving as an austere chairman during his last years. His rearing in the family of an army colonel was reflected in his ostensible sternness, which seldom hid his kindly warmth of heart from those who knew him well. His rich knowledge of Italian writers such as Tasso and Ariosto led him to serve as chairman of a committee on Comparative Literature which eventually brought Philo Buck to the University of Wisconsin to found a department in that field. Mr. Dodge's concern was literary in the strictest sense, emphasizing (especially in his teaching) matters of versification and formal techniques. I recall his once having his students, over a period of several weeks, demonstrate that the first part of Milton's "Lycidas" could be read in some twenty ways in terms of prosodic emphasis involving matters such as the substitution of an occasional anapest or dactyl for an iamb. He was chosen as a major authority on Edmund Spenser to edit his work for the renowned Cambridge Edition of the great poets. Beyond mastering the texts themselves, Mr. Dodge was especially concerned with getting his students to ferret out the distinctive secrets of a poet's verbal harmony and of how he used technical devices to create beauty. Mr. Dodge was also famous for a course in Advanced Creative Writing in which he coached mature students in a highly personal way much as did Dean Briggs at Harvard; he did much to get his students to avoid all affectations such as what he called "a highly rouged style" and any kind of extremism. Literary art to Mr. Dodge was the organic by-product of the concept of the gentleman, a concept which he incarnated with impressive distinction and ethical elevation.

"Sunny" Pyre advanced the appreciation of literature for thousands of students in his large survey course. His concern for form and technique are illustrated in his book on versification, *The Formation of Tennyson's Style,* 1921, which Mr. Dodge helped to inspire.

Warner Taylor took his B.A. and M.A. at Columbia University, where he also taught for six years before beginning in 1911 his 36-year teaching career at the University of Wisconsin. Here, as Director of Freshman English, Mr. Taylor had a tremendously wide influence in molding the writing habits of tens of thousands of students. His manner was quiet and gentle and persuasive. In the early days his great sympathy and understanding and warm hospitality helped to induct large numbers of young staff members into the art of teaching. Mr. Taylor had a rare combination of responsiveness to beauty along with an almost scientific interest in trying to ferret out the mechanistic secrets of how and why a given style produced its distinctive effect. (He was also a distinguished ornithologist and won national prizes for his remarkably beautiful photographs of birds.) Beside doing national surveys on the teaching of Freshman composition, Mr. Taylor published highly technical work such as his "Prose Style of Dr. Johnson" (1918), which illustrates his inductive concern with such matters as variations of sentence length, the use of parallelisms and antithesis or balance, imagery and metaphors, rhythm and cadence. Those of us who were privileged to listen to Mr. Taylor's annual talks to the Department on the English Qualifying Exam for Freshmen, an exam which included analyses of different kinds of style and literary structure, will always remember his lucidity and orderly procedure in elucidating the underlying design of the poems or passages studied. Many middle-aged faculty members today who owe part of their success to their power of expression have remarked to me that they feel they got their start in a composition class given by Warner Taylor, the man who stressed the importance of *how* one says a thing.

Ruth Wallerstein came to the University of Wisconsin in 1920 after studying the ancient classics at Bryn Mawr and at the University of Pennsylvania, where her doctoral dissertation was on one of Shakespeare's plays. She is aligned to those who emphasized literary form by virtue of her posthumous *Metrical Principles of English Poetry* (1961) and her *Seventeenth Century Poetic* (1950), which had the rare distinction of winning a national prize from Phi Beta Kappa. According to the Faculty Memorial of 1958, "She knew how to communicate her enthusiasms to her students, and she had a positive genius for discovering and awakening the gifted student. . . . All who came into contact with Miss Wallerstein as teacher and colleague and friend felt the charm and magnetism of a very rare spirit." (Incidentally, these faculty memorials of individual teachers provide a most interesting supplement to the history of the University.)

Since William Ellery Leonard, besides being a poet, taught linguistics rather than literature, his work is not quite relevant to this talk on teaching literature. However, his foible of unceremoniously holding up younger colleagues to ask them precisely where obscure passages appeared in the great writers, and his flamboyant excoriation of anyone ignorant of such things, did much to get young teachers to read with more precision. Trained by Kittredge, in his younger days Mr. Leonard was a dynamic and inspiring teacher and scholar.

Let us turn now to teachers who represent, broadly speaking, judicial criticism roughly in the tradition of Matthew Arnold. Grant Showerman and his *Eternal Rome,* along with his increasingly ethical familiar essays, paved the way for the blithe Ray Agard, who in the Hellenistic spirit enjoyed illustrating in a very broad and humane way the cross-fertilizations of ancient history, literature, architecture, and jurisprudence as these drew upon the vitality of the Great Tradition. Philo Buck, a native of New Jersey but reared in India by Missionary parents until he was sixteen, came to the University of Wisconsin in 1925 to found the Department of Comparative Literature, having been educated at Ohio Wesleyan and Harvard. With a famous course in the Great Books and another entitled "History and Myth on the Stage," Mr. Buck reached thousands of Wisconsin listeners in his radio program. His vitality, warmth, and genial individuality, along with his cultivated manner of lecturing, somewhat in the British tradition, tended to mellow the austerity which sometimes accompanies the judicial approach. But the latter, involving classical standards, was readily apparent in his critical guide entitled *The Golden Thread,* which regarded as a norm what Plato (and Emerson) meant by the One, the unity of mankind or the *consensus gentium,* which has had a continuous endurance through the ages. Books, according to this view, tend to live and to be applicable to the problems of each new age in proportion as they focus particulars upon timeless universals or the unity of human experience amid varying ephemeral distractions. As Philo Buck's memorial concludes, "He developed the new department along his own specific lines as a medium for correlating literature, art, philosophy and history and revealing man's efforts through the centuries to find meaning and value in life. If one might find the 'golden thread' of his thought, it was his optimistic faith in man as evidenced by the best he has thought and felt." Mr. Buck, who made gracious living a fine art in itself, was able to lift the spirit of his listeners to a glimpse of beauty and to awaken us to a sense of kinship in mankind's finest cultural heritage from all the ages.

William Giese of the French Department, trained at Harvard along with his friend Irving Babbitt, carried on something of the latter's tradition in his judicial criticism of such writers as Victor Hugo and Sainte-Beuve, whose short-comings he did not minimize. Contemplative and polished as a stylist, and not without asperity, Mr. Giese has been likened to a light-house of good sense amidst the more perilous shoals of nineteenth-century romanticism. Since Helen White is happily still with us, and last year's Academy's tribute (eloquently phrased by Mr. Welty) sums up her renowned personality and achievements, I need not speak of her at length here. Her main concern with devotional literature and the religious writers of the seventeenth century tends to locate her among the judicial ethical critics. Her unique sense of imaginative amplitude has inspired a very large number of nationally known scholars such as Mark Schorer. And her uncanny ability to appraise the potentialities of young candidates for University of Wisconsin positions has done much to insure the recruitment of those who will carry on her rich heritage.

Frederick W. Roe, who served as Junior Dean of Men, took his doctorate at Columbia and came to the University of Wisconsin in 1905, serving as chairman of the English Department during his later years. Of patrician tastes, living graciously in University Heights near Dean Sellery and Mr. Buck, Mr. Roe taught and published on the Romantic and Victorian writers as well as his beloved Emerson. (In a nation-wide speech reminiscing about his student days, the actor Frederick March once mentioned Mr. Roe's course in Emerson as one of his most memorable experiences.) He had a special talent for getting students to visualize the sharp individuality of authors such as Carlyle (to whose criticism he devoted an early book), but he was mainly concerned with the social criticism of authors such as Ruskin and Arnold. (Mr. Roe was distinctive in his Ruskin-like love of painting, and like Emerson he regarded beauty as a kind of symbol of the virtuous harmony and paternalism of the good society.) He had a talent for friendship, and did much in a personal way through correspondence to assure his best students that someone at the University of Wisconsin was interested in their continuing to do their best. Arnold's sweetness and light derived partly from the Hellenistic spirit represented his norm as a judicial critic in quest of values which we might use today to insure not only individual serenity but social justice.

As disciples of Arnold and Emerson, literary men such as Mr. Roe approached our cultural heritage with certain assumptions. Men do not live by bread alone, and all the material prosperity and mechanical gadgets in the world will not alone insure the inward emotional harmony essential to humane self-fulfillment. To this end, one of our reliable aids is a cultural education which includes a sense of the individual's initiation into the great tradition of the best that men have thought and that has already proved its power to endure and to sustain successive generations. The great writers such as Hawthorne have held that we need to balance the head against the heart, rationalism against humane feeling and compassion or the kind of empathy which underlies true brotherhood. In an era celebrating the anti-hero, Mr. Roe liked to remind us that Tennyson said that "we needs must love the highest when we see it," that Carlyle's "Hero-Worship" and the desire to emulate greatness and magnanimity are distinctively human traits still potentially among our resources. Amid all the bewildering changes in modern life, there are still constants in human motivation and reaction. As Joseph Campbell reminds us, the hero has a thousand different faces, but most of the heroes in the great books which have endured go upon somewhat the same journey through life, which involves an alienation, initiation into life's troubles, and then our return as humbler but wiser men to the universal certitudes. One of the resources of literature as an ally of religion in guiding us toward the good life or the good society is that it teaches inductively and indirectly by example touched by beauty. As Emerson remarks, "The beautiful is the highest, because it escapes the dowdiness of the good [which sometimes appears merely negative] and the heartlessness of the true," [when rationalism or science are reduced to syllogisms or formulas]. He concludes, "Beauty is the mark God sets upon virtue." In other words, ethics as suggested in the great books tends to benefit by the appeal of graciousness, by making goodness seem desirable and attractive. As for the tripartite concern of our Academy, it should be remembered that, after Darwin especially, not to mention problems created by technology, one of the great themes of literature has been ways and means by which the individual can incorporate the findings of science into his total thinking, religious and ethical, in such a way as to maintain some degree of emotional balance and serenity. In an era of fragmentation and specialization, as Emerson's "American Scholar" reminded us, literature's primary concern is to help the individual pick and choose so as to develop his personality into an integrated and well-proportioned whole, rounding his complete life to the circle fair of orbed fulfillment.

Theodore Roosevelt once defined Americanism as practical idealism. Our Academy can be justly proud of Wisconsin's substantial resources in land and factories and climate and city-planning and the conservation of our physical resources. Let us not forget, however, our non-physical resources in idealism as this has been made available to our younger citizens by the "transformers" at our state university who have enabled them to claim among their resources their birthright to a kinship in the great cultural traditions which have sustained and guided other generations toward greatness, toward self-fulfillment and emotional enrichment.

And literature, in books such as those by Dr. O. W. Holmes and Sinclair Lewis *(Arrowsmith),* being concerned with suggesting preferences, value-judgments, and envisaging goals for the good life, has done much to motivate the better kind of scientists not only in their quest of universal laws but in the practical relief of suffering and in implementing humane compassion.

ANATOMY OF A DECIPHERMENT

Alan D. Corré
University of Wisconsin–Milwaukee

Outstanding research in the humanities too often goes unrecognized. For this reason in 1965 the Wisconsin Academy of Sciences, Arts and Letters established a program of annual cash awards for authors of meritorious papers in the humanities.

Since its founding in 1870, the Wisconsin Academy has sought to encourage the diverse research interests of its members. Philology, the broad field we now label language and literature, was singled out from the start as worthy of support. Consequently the Academy Committee for Recognition of Research in the Humanities is pleased to make its first award in the field of linguistic scholarship.

The First Place Academy Award in the Humanities goes to Dr. Alan D. Corré for his fine essay "The Anatomy of a Decipherment." Dr. Corré is Associate Professor and Chairman of the Department of Hebrew Studies, University of Wisconsin–Milwaukee. As experts and lay readers alike will discover, the following essay contains much of interest and value.

Should readers of the *Transactions* wish to learn more about the humanities prizes, they may write to the Chairman of the Academy Awards Committee: Professor Goodwin F. Berquist, University of Wisconsin–Milwaukee, Department of Speech, Milwaukee, Wisconsin 53201.

INTRODUCTION

"Lecturer Learns Ugaritic"
From our Correspondent
Johannesburg

> Mrs. Leah Bronner, of Johannesburg, a lecturer in Hebrew at Witwatersrand University, has learned to speak Ugaritic, the language of the Canaanites in 1400 B.C.
>
> She learnt the language and Aramaic in order to write a thesis for a doctorate. Mrs. Bronner, a mother of three children, will be the first woman to receive a doctorate in Semitic literature at Pretoria University.

With all due respects to the distinguished newspaper[1] which published this item, one might differ with it on two counts. First, it is doubtful if anyone can learn to speak Ugaritic. The Ugari-

[1] *Jewish Chronicle* (London), March 28, 1964.

tians, like certain other peoples in the Near East, unfortunately did not indicate their vowels unequivocally, so that we cannot be sure what the vowels were. Scholars reconstruct these vowels with apparent certainty, but could we invent a time machine and chat with the Ugaritians, we should doubtless be in for some shocks.[2] Many factors of which we can have no knowledge may have been in operation to make the vocalic structure of the language very different from what we think it was. Second, it is rather surprising that learning Ugaritic is any longer considered newsworthy. Admittedly, Ugaritic shows no signs of becoming what political jargon terms a "critical" language; yet Ugaritic is now well established as a member of the Semitic group of languages, having been readmitted some 35 years ago when its sleep of 3,000 years was first disturbed by a peasant on the Syrian coast right across from the island of Cyprus, who found some small pieces of pottery at Minet-el-Beida. The Archeological service in Beirut heard about it and sent a man to investigate. He decided that the peasant had run across a Mycenean tomb similar to ones found in Cyprus dating from the thirteenth or twelfth pre-Christian centuries. Just half a mile from this spot lies the mound of Ras Shamra, one of the many heaps of earth in this part of the world that signal the existence of a long dead city. Ras Shamra turned out to be the site of the ancient city of Ugarit, already known from references in ancient sources, whose location had previously been entirely lost. The decipherment of the tablets discovered there in a previously unknown cuneiform script presents a case history in decipherment of lasting interest.

WHO DECIPHERED UGARITIC?

It is generally agreed that the decipherment of Ugaritic was "one of the shortest cases of decipherment on record."[3] The tablets bearing the hitherto unknown cuneiform script were unearthed by C. F-A. Schaeffer and G. Chenet about May 14, 1929. The first announcement of their partial decipherment was published just a year later, on June 4, 1930, by which time the tablets had been exhibited locally, shipped to Paris, cleaned, transcribed and published. By 1931 the decipherment was virtually complete. This stands in contrast to the decipherment of such languages as Egyptian and Akkadian which took long years of patient toil before they yielded their secrets; but of course the difficulty of their scripts

[2] One could not guess from written records that the vowels of merry/marry/Mary have fallen together in mid-western American English. We are in no better shape for Ugaritic, which in general does not indicate vowels. While Ugaritic has archaic features, it may have been highly innovating in others. The difficulties of bringing the distribution of the "three alefs" into any order is an indication of how little we really know about the vowel phonemes of this language.

[3] I. J. Gelb. *A Study of Writing* (Chicago, 1963), p. 129.

was far greater than that of Ugaritic, with its small number of signs. No bi- or tri-lingual text was available for Ugaritic, unlike Egyptian, which was deciphered only after the discovery of the Rosetta stone with its parallel Greek and Egyptian inscriptions. Akkadian too had to depend on multi-lingual texts for its decipherment (the Achaemenid inscriptions), although the other scripts in the inscriptions were also previously undeciphered.

Some have reported that the decipherment of Ugaritic was achieved independently and almost simultaneously by Hans Bauer, E. Dhorme and Ch. Virolleaud.[4] Others attribute priority to Bauer. Thus the discoverer of the tablets writes:

> It is to the credit of a German scholar, the late Professor Bauer of the University of Halle, that he was the first to recognize that this language was of Semitic origin, and that he tracked down certain words . . . working on the same lines, two French scholars in their turn unravelled the secret of the Ras Shamra alphabet . . .[5]

More recently Johannes Friedrich has also given first place to Bauer.[6] W. F. Albright, however, credits Bauer and Dhorme jointly,[7] while A. M. Honeyman ascribes the decipherment to H. Bauer, E. Dhorme "and other Semitists."[8]

Who was really the first to decipher Ugaritic? As we shall see, this question has no ready answer.

Preliminary Studies

On August 9, 1929, C. Schaeffer and G. Chenet brought before the French Académie des Inscriptions et Belles Lettres, meeting under President René Dussaud, the discoveries they had made three months previously at Ras Shamra.[9] On September 20, 1929, the French scholar Charles Virolleaud,[10] to whom Schaeffer had entrusted the tablets for study, presented to the Academy an assessment of the finds.

In his lecture he dealt briefly with the Akkadian tablets which had been discovered, and went on to the tablets in the hitherto

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[4] *Ibid.* Cf. C. H. Gordon, *Ugaritic Manual* (Rome, 1955), p. 1. This seems to be Gordon's considered judgment. In his earlier Ugaritic Grammar (1940) he ascribes priority to Bauer.

[5] C. F–A. Schaeffer. *The Cuneiform Texts of Ras–Shamra Ugarit* (London, 1939), p. 37.

[6] Johannes Friedrich. *Extinct Languages* (New York, 1957), p. 83. (German edition: *Entzifferung Verschollener Schriften und Sprachen.* Berlin, 1964, p. 70).

[7] H. H. Rowley (ed.). *The Old Testament and Modern Study* (Oxford, 1951), p. 30: ". . . its decipherment by Hans Bauer and Dhorme in 1931 *(sic)* . . . and its definitive interpretation by Virolleaud. . ." Cf. also his statement in "The Old Testament and Canaanite Language and Literature," *Catholic Biblical Quarterly* VII (1945), pp. 9–10.

[8] Rowley, *The Old Testament and Modern Study,* p. 272: "Decipherment of this system is due to the efforts of H. Bauer, E. Dhorme, and other Semitists."

[9] C. F–A. Schaeffer "Les Fouilles de Minet el Beida", *Syria* X (1929), pp. 285–303.

[10] Charles Jean Gabriel Virolleaud was born July 2, 1879, at Barbézieux. He studied at the Ecole des Langues Orientales in Paris.

unknown script.[11] Already he had taken some important steps toward decipherment. He recognized only 26 or 27 signs,[12] which meant without any possible doubt that the script was alphabetic.[13] He recognized too that the words were for the most part separated by vertical word-dividers; that the vowels were not represented, since the words were so short, rarely of more than five symbols; that although some signs were formally identical with some Akkadian signs, they would not have the same value, and in fact that the Akkadian script would have no value for the decipherment; and that there were different classes of texts. Virolleaud further observed that a number of adzes were inscribed with six signs, and that these same six signs were preceded at the beginning of one tablet by a seventh sign. He concluded that the six signs formed a name of two parts (since they were elsewhere divided into two) and that the seventh corresponded to the Akkadian *ana* denoting possession, on the assumption that the tablet was addressed to the owner of the adze. Another adze bore the same assumed name preceded by four signs, two of them already occurring in the name. He assumed that this was the word for adze. As it turned out, Virolleaud was correct in all of these assumptions, with only minor correction. However, his guess that the language of the tablets might be identical with the autochthonous language of Cyprus written in the Cypriot syllabary was incorrect.

The news of the Ras Shamra excavations reached a far wider public on October 12, 1929, when the French magazine *L'Illustration* published an article by Schaeffer and Chenet entitled "Des Tombeaux Royaux et un Palais du 2e Millénaire avant J-C."[14] The article refers to the finding of tablets written in alphabetic cuneiform, but as yet undecipherable.

In the *Révue Biblique* for January 1930 Edouard Dhorme[15] drew attention in a brief note to the "sensational discoveries" in Syria, and looked forward to the publication of the texts. Publication came in April 1930 as a supplement to Virolleaud's address to the

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[11] C. Virolleaud. "Les Inscriptions Cunéiformes de Ras Shamra" in *Syria* X (1929), pp. 304–340.

[12] Thirty are recognized currently. Actually there are more, but the additional signs are variants of other signs, made by the addition of an extra wedge. Cf. C. H. Gordon, *Ugaritic Manual* (Rome, 1955), pp. 11–12.

[13] If one regards the West Semitic scripts as syllabaries (i.e. a consonant plus any vowel), one might rephrase this in the sense that the script belonged to the West Semitic rather than to the East Semitic syllabaries, despite appearances. Cf. Gelb, *op. cit.*, chapter 4.

[14] Pp. 401 ff. Another popular article by Schaeffer, with excellent photographs, appeared in the *National Geographic Magazine,* October 1930 (vol. 58), pp. 476–516, under the title: "A New Alphabet of the Ancients is Unearthed." Here Schaeffer again refers to the "undeciphered" script, although by this time the script had in fact already been deciphered.

[15] Edouard Paul Dhorme was born at Armentières on January 15, 1881. He studied at the Ecole Biblique in Jerusalem and the Sorbonne.

Academy on September 20, 1929, published in *Syria.*[16] The texts were now available to the scholarly world in a clear and careful transcription.

BAUER'S DECIPHERMENT

On April 22, 1930, Virolleaud's transcription reached Hans Bauer[17] in Halle. Bauer immediately began decipherment and completed his tentative list five days later.[18] The next day he communicated with René Dussaud of the French Academy, who passed on the word to the Academy on May 23 and published an announcement in *Syria,*[19] according to which Bauer had identified some 20 letters. In the meantime (on May 15) Bauer had notified the Berlin newspaper *Die Vossische Zeitung* of his discovery, and the news was published in the supplement *(das Unterhaltungsblatt)* to the issue of June 4, 1930. Here Bauer claims to have identified 20 characters with certainty and four tentatively *(27 Buchstaben, wovon 20 sicher, 4 mit Wahrscheinlichkeit bestimmt sind).* He refers specifically only to *t* and *'*. He also claims to have read several words, among them those for *god, three, priests,* and *ax* (which he renders *garzen).*[20] Thereby he demonstrated the Semitic nature of the language and refuted Virolleaud's Cypriot hypothesis.

Further details were given in *Forschungen und Fortschritte* for August 20, 1930. He had used as his starting point the assumption that the language was Semitic, then the fact that west Semitic has a limited number of consonants which are used as prefixes and suffixes. He recognized that Virolleaud had already given the clue to the prefix *l* denoting possession. Bauer then sought common words such as *mlk* ("king")[21] and *b'l* ("Baal"). He also interpreted a number of phrases, and promised to publish shortly a full scale work on the texts, which appeared in due course under the title *Die Entzifferung der Keilinschrifttafeln von Ras Schamra* (Halle, 1930), incorporating his erroneous interpretation of half a dozen characters. He even became the first in three millennia to write something in the Ugaritic script, concluding this book with an

[16] See note 11.

[17] Hans Bauer was born at Grassmansdorf, Bavaria, January 15, 1878. He died at Halle in 1937, where he had been professor ordinarius.

[18] Cf. Hans Bauer. *Entzifferung der Keilinschrifttaféln von Ras Schamra* (Halle/Saale 1930), p. 3.

[19] *Syria* XI (1930), p. 200.

[20] In point of fact, Bauer had not read the word for priests. The word at issue is in 2.10 (Gordon, *Ugaritic Manual,* p. 129) and is to be transliterated *mhnš.* By pure coincidence Bauer's errors made this read *khnm* (cf. *Die Entzifferung,* p. 13). The rendering *garzen* was also incorrect, the true form being closer to the Akkadian cognate. It is doubtless a loanword, and it is entirely possible that the Hebrew *qrdm,* which also means a tool, is a doublet of this word which came via a different route and acquired a different meaning.

[21] Bauer erroneously read *šlm* (tablet 1, line 8) as *mlk* and *šlmm* (tablet 3, line 52) as *mlkk,* thereby introducing a confusion from which he never recovered until he was helped by Dhorme.

attempt to write in Ugaritic—or, more accurately, in Hebrew with Ugaritic characters—"Blessed art Thou, O Lord our God. Amen and Amen." It would probably be true to say that a Ugaritian scribe would have had more difficulty in understanding what Bauer wrote than vice versa.

Let us now examine Bauer's decipherment. In the *Vossische Zeitung* he claimed to have interpreted 20 signs with certainty and four tentatively. Two months later in *Forschungen und Fortschritte,* he published the values of eighteen signs, although he again affirmed that 20 could be read with certainty. Of these, ten have withstood the test of time fully (b, d, h, ḥ, w, l, n, ', r, t). In the two alefs (now transcribed *a* and *i*) Bauer did not reach the whole truth,[22] although he came very close. Hence Friedrich's statement[23] that Bauer had interpreted 17 characters correctly by April 1930 needs this much emendation. Six signs were incorrectly interpreted—g (which should be h), another w (for k), k (for m), z (for s), m (for š) and š (for ṯ). In the *Entziffering* he adds two further correct interpretations—g, which he writes ḡ because he already had another incorrect g and y—and five further incorrect interpretations—ġ (for q), q (for p), ẖ (for u), p (for s) and p̄ (for s̀). In view of the fact that Bauer, between publication of *Forschungen und Fortschritte* and the *Entzifferung,* had added five new incorrect interpretations, compared with two new correct ones, one may be permitted to wonder whether he would ever have achieved a full decipherment, i.e. one permitting the reading of connected texts, without the help he was to receive from Dhorme, because several of his errors were in letters of high frequency, and he had transcribed the entire corpus of texts then available without sensing the basic errors in his proposed decipherment. However, this help from Dhorme was forthcoming even before the *Entzifferung* left the press.

DHORME'S DECIPHERMENT

Dhorme began his research about the same time as Bauer. When Bauer's article appeared in the *Vossische Zeitung,* he had already independently identified *b'l,* but had confused n and t, an error which Bauer's article corrected for him. Since, however, Bauer only hinted at his full decipherment, Dhorme continued his researches, fortunately, since he was not so advanced as Bauer by June, and might possibly have accepted Bauer's erroneous decipher-

[22] Not surprisingly, since the whole truth still eludes us. Cf. J. Reif, "The Loss of consonantal aleph in Ugaritic," *Journal of Semitic Studies* 4.1 (January 1959), pp. 16–20. There is no doubt that this problem must be solved by observing the actual distribution of these alefs in Ugaritic, and not trying to fit them in to preconceived notions as to the nature of proto-Semitic.

[23] Johannes Friedrich. *Extinct Languages* (New York, 1957), p. 84.

ment if it had been published at that time.[24] As it turned out, he achieved a much better result than Bauer. In the *Révue Biblique* for October 1930 he published an article in which he deciphered correctly 18 characters (b, d, h, w, ḥ [which he transcribes ḫ], ṭ,[25] y, k, l, m, n, s, ', p, q, r, š, t) and six incorrectly (ṣ [for the correct u], ' [for g], g [for ḫ], z [for ṣ], ś [for ḏ] and š [for ṯ]). Additionally, like Bauer, he had come close to the truth in two of the alefs. This decipherment enabled Dhorme to read the inscription on the adzes as meaning "the chief of the priests" (which Virolleaud had suggested must be a name) and much more besides.

This study was completed on August 15, 1930. A month later, Dhorme, alerted by René Dussaud, read Bauer's article in *Forschungen und Fortschritte,* which he found to his surprise differed basically from his decipherment. He thereupon added a postscript to his article in which he commented that "it will be interesting to see which of us is right," and sent the proofs to Bauer. At this time Bauer had just completed his *Entzifferung;* Dhorme's communication obliged him to add a *Wichtiger Nachtrag* in which he accepted Dhorme's interpretation as more fruitful in explaining enigmatic passages. On October 3 he wrote to Dhorme accepting his findings, and on October 5 he communicated to Dhorme a revised decipherment representing the combined efforts of both scholars which was published by Dhorme the next year.[26] This list was quite good enough for all practical purposes. Of the 27 letters they recognized at the time, 23 were correct— b, g, d, h, w, z,[27] ḥ, ḫ, ṭ, y, k, l, m, n, s, ś, (which they wrote s_2), ', p, ṣ, q, r, š, t. The interpretation of the two alefs remained the same; the third alef was transcribed ẖ, and ḏ was transcribed ś. Thus, about a year after the publication of the texts, a decipherment was available which was substantially correct.

Virolleaud's Decipherment

Virolleaud had also been working on the decipherment. About the same time as Bauer was publishing his results in *Forschungen und Fortschritte,* Virolleaud had received a new set of tablets found by Schaeffer in 1930. These took about a month to clean, and

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[24] Cf. E. Dhorme. "Un nouvel alphabet sémitique." *Révue Biblique* XXXIX (October 1930), p. 573; and "Le dechiffrement des tablettes de Ras Shamra," *Journal of the Palestine Oriental Society, 1931,* reprinted in E. Dhorme. *Recueil Edouard Dhorme* (Paris, 1951), pp. 531–536.

[25] There is a nondescript sign for this in his list, which is probably a transcriber's error, since Bauer had not succeeded in identifying this sign, but it appears later in the joint Bauer–Dhorme list.

[26] E. Dhorme. "Première traduction des textes phéniciens de Ras Shamra," *Révue Biblique* XL (January 1931), p. 33.

[27] In Dhorme's transcription the sign for z is omitted, doubtless an error.

a few days later Virolleaud had confirmed his previous suppositions with regard to the decipherment, which seemingly he was unwilling to publish until confirmation was forthcoming. On October 3, 1930 (the very day on which Bauer wrote to Dhorme accepting his corrections), Virolleaud's communication was read to the French Academy, and three weeks later he himself presented his results.[28] Like the others, Virolleaud used the l as his point of departure. He then searched for the frequent words containing the l, *mlk, b'l.* A set of signs in which the first and last were identical and the middle was l furnished a word cognate with Hebrew šlš (three). These findings were confirmed by a text containing several of the numerals.[29] Virolleaud also recognized that Ugaritic possessed three signs for the alef (only two had been recognized previously) and that one of them contained the vowel a. Virolleaud does not point out specifically the value of some common signs (such as d, h, y [which he transliterates i̭], n, r) although he certainly had them, because he correctly translates words containing them.[30] In addition to these five he had 17 other signs correctly deciphered (a, i [written as e, which this sign may often represent], b, g, z, ḥ, ẖ, ṭ, k, l, m, s [which he transliterates š], ', p, ṣ, q, t). His incorrect decipherments are u (which he transliterates é), z (which he transliterates f), ǵ (of which he is uncertain, but suggests may be another h), š (which he transliterates s), and ṯ (which he transliterates š). For some reason he fails to mention w altogether, although he probably knew its value. Virolleaud's treatment of the subject indicates that his purpose was first to get to the meaning of the texts and not secure a decipherment only.

This presentation was treated by the French newspapers[31] as the first decipherment of this "mysterious alphabet", whose enthusiastic reports received a tart rebuttal from Dhorme. "Our readers will know," he declared, "what reliance can be placed on these statements."[32]

[28] Cf. C. Virolleaud. "Le Déchiffrement des Tablettes Alphabetiques de Ras-Shamra," *Syria* XII (1931), pp. 15–23.

[29] This text (which was not available to Bauer and Dhorme) was published in *Syria* XV (1934), p. 249.

[30] Virolleaud admits (*La Légende Phénicienne de Danel,* Paris, 1936, p. 71) that he obtained the value of the d from Bauer, presumably from the article in *Forschungen und Fortschritte.*

[31] For example, *Le Figaro* for October 25, 1930, reported (p. 3):

> M. Virolleaud est parvenu a déchiffrer, par une methode qu'il a exposé, a cette Compagnie, les tablettes cunéiformes trouvées par MM. Schaeffer et Chenet, à Ras-Shamra . . . La découverte de M. Ch. Virolleaud . . . ne souffre d'ailleurs . . . aucune incertitude, et le déchiffrement admirable fait par M. Virolleaud en est definitif.

[32] "Nos lecteurs savent a quoi s'en tenir sur la portée de ces affirmations." E. Dhorme, "Première traduction des textes phéniciens de Ras Shamra," *Révue Biblique* XL (January 1931), p. 33.

Nor was this remark by Dhorme an end to the dispute. In 1936 Virolleaud indicated that the information which was read to the French Academy on October 3, 1930, had also been communicated to Bauer, who used it to correct his work, and it was later published under Dhorme's name, as we have seen.[33] This produced an indignant rebuttal from Bauer,[34] who called Virolleaud's assertion "eine glatte Unwahrheit." He indicated that Virolleaud had indeed written to him, but did not communicate any usable information. Whatever may in fact have passed between the two men, it seems fairly clear that Bauer and Dhorme's combined efforts were sufficient to produce the "alphabet of 5 October" without Virolleaud's help.

Conclusions

What then was the contribution of each of these scholars to the decipherment? Unquestionably Bauer was the first to publish, on June 4, 1930, the correct decipherment of *some* signs. Although no cuneiform signs appear in the article in the *Vossische Zeitung*, Bauer's comment

> so bedeutet z.B. der einfache liegende Keil, der im Babylonischen *asch* zu lesen ist, in unserer Schrift t . . .

leaves no doubt that he had deciphered the t. Bauer's incredibly rapid progress in the decipherment calls forth admiration, and one cannot doubt the brilliance of his initial efforts. But this admiration must be tempered by the fact that his later work was unsound, and one cannot avoid the impression that his urge to publish in haste entirely set aside the need to sift his findings.

Dhorme was the first to publish (in the *Révue Biblique* for October 1930) an alphabet sufficiently accurate to permit the reading of texts. Thus Dhorme was able to read the inscription of the adze, which according to the decipherment of Bauer's *third* publication on the subject (die Entzifferung) was to be read *rb whnk*—which is meaningless. However, Dhorme had received some early help from Bauer, as we have seen.

It would seem therefore that Bauer and Dhorme should share the honors, as Albright suggests. What of Virolleaud? It is entirely possible that Virolleaud had achieved a partial, or perhaps almost complete, decipherment before the others ever started.[35] Virolleaud's exposition of October 24, 1930, shows such detailed understanding of

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[33] C. Virolleaud. *La Légende Phénicienne de Danel* (Paris, 1936), p. 71. ". . . en même temps que j'informais l'Académie des inscriptions, j'avais cru bon de communiquer a M. Bauer les résultats complets de mes récherches personelles. M. Bauer a immediatement adopté ces résultats . . ."

[34] H. Bauer. "Zur Entzifferung der Keilschrift von Ras Schamra," *Orientalistische Literaturzeitung,* XL (1937), col. 81–83.

[35] As of February 14, Virolleaud was still orienting his research to Cyprus, since he communicated thus to the Société Asiatique. Cf. H. Bauer, *Das Alphabet von Ras Schamra* (Halle, 1934), p. 41.

the *contents* of the tablets that it is clear that the decipherment was far behind him. Particularly his discovery of the statement "He pleads the case of the widow, he judges the suit of the orphan" was a strong, almost prophetic, hint of the importance that Ugaritic was to assume in the elucidation of the Hebrew Bible, and points to his grasp of the texts. He himself testifies that he was just about ready to publish his decipherment when Bauer communicated his finding to Dussaud. Should we therefore perhaps grant priority in the discovery to Virolleaud in spite of Bauer's publications?

The answer may safely be left to the historian of the decipherment of Akkadian, Robert W. Rogers, who, in granting "an unassailable superiority in translating" to Sir Henry Rawlinson over Edward Hincks, remarks that in Hincks' *notes* he shows great skill as a translator, but for some reason he did not publish. Rogers goes on:

> The judgment must remain as it is, for the historian of the science must base his decision on the published work of the pioneers and not upon that which they left hidden in their notes.[36]

Similarly, Bauer, joined perhaps by Dhorme, must remain the first decipherer, whatever may have lain on Virolleaud's desk the day before the issue of *Syria* reached Halle.

But one must admire Virolleaud's part in this whole story, for he displayed a remarkable scholarly altruism. He could easily have delayed publication of the tablets until he was sure of a decipherment, or despaired of achieving one. As it was, he published them immediately, knowing full well that another might thereby carry off the prize of elucidating them first, as in fact happened. It was no doubt the fact that Bauer had rushed into print—"un peu prématurement, peut-être" to quote Virolleaud—while Virolleaud was still working on a really sound decipherment that brought about the note to which Bauer objected so violently.

But if Bauer was the first decipherer, and Dhorme the first accurate decipherer, Virolleaud, by virtue of his great contributions then and later, is the true father of Ugaritic studies. As Rogers says: "To each man his own gifts and his own reward."

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[36] Robert W. Rogers. *History of Babylonia and Assyria* (New York, 1915), I, pp. 239–240.

DEUSTER AS A DEMOCRATIC DISSENTER DURING THE CIVIL WAR: A CASE STUDY OF A COPPERHEAD*

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Wisconsin made a notable contribution to the winning of the Civil War. No Northern State, in proportion to population, had a better record in furnishing soldiers. No state's soldiery received more acclaim for courage and heroism. Three Wisconsin regiments helped to give the famous Iron Brigade its enviable reputation, and General William T. Sherman one time said that he always considered a Wisconsin regiment "equal to an ordinary brigade." Wisconsin's five Civil War governors, all Republicans, gave full support to the war effort. Such newspapers as the *Milwaukee Sentinel,* the *Racine Advocate,* and the (Madison) *Wisconsin State Journal* consistently endorsed all the war measures of the Lincoln administration. Most of the state's citizens were patriots. Yet, on the other hand, Wisconsin also furnished some well-known critics of Abraham Lincoln and Civil War policy. Marcus Mills ("Brick") Pomeroy of the *La Crosse Democrat* brazenly opposed most measures of the Lincoln administration and had the gall to label Lincoln "a flat-boat tyrant"—even hoping for the president's assassination. Edward G. Ryan, destined to become Wisconsin's most famous jurist, wrote a scholarly critique of Civil War policy and instructed the Democracy to oppose the changes which the conflict was imposing upon the country. Moses M. Strong of Mineral Point frequently spoke against some of President Lincoln's war measures and worked hard to put a Democratic president in the White House in 1864. George H. Paul of the *Milwaukee News,* Flavius J. Mills of the *Sheboygan Journal,* and Stephen D. ("Pump") Carpenter of the (Madison) *Wisconsin Patriot* wrote editorials critical of Lincoln and the war. No Wisconsin Democrat, however, developed as solid an anti-war bloc as Peter V. Deuster, the prominent politi-

* Several years ago the author did a very brief and semi-popular article entitled "Peter V. Deuster, the *See-Bote,* and the Civil War" for the *Historical Messenger* (of the Milwaukee County Historical Society), XVI (December, 1960), pp. 2–6. That cursory study has served as a springboard for this article.

cian who used the (Milwaukee) *See-Bote* as an outlet for his anti-Lincoln and anti-war views.[1]

By 1860 Peter Victor Deuster served as chief spokesman for the thousands of German Catholics who lived in southeastern Wisconsin. His rise to leadership was no accident—rather it was the result of his ability, experience, and audacity. He had much in common with the thousands of German Catholics who found their way to Wisconsin in the 1840's and 1850's. He was born near Aix-la-Chapelle (Aachen) in Westphalia on February 13, 1831. As a lad of sixteen he accompanied his parents from the Rhineland to Milwaukee, just as Wisconsin Territory was preparing for statehood. After spending a year with his parents on a farm near Milwaukee, young Deuster went to work for Moritz Schoeffler, publisher of a German-language newspaper named the *Wiskonsin-Banner*. Four years later he undertook the publication of his own newspaper, a German-language family weekly named *The Hausfreund*. Six months later he sold that paper and became business manager of the (Milwaukee) *See-Bote*, a newspaper with great influence among German Catholics of the area. In 1854, tired of administrative chores, he moved to Port Washington to edit the *Zeitung*, the fourth German-language newspaper with which he was associated. Deuster became a community leader in Port Washington, serving as notary public, clerk of the circuit court, and postmaster as well as editor of the Democratic-oriented *Zeitung*. In 1856 he had a chance to return to Milwaukee to team up with August Greulich in publishing the *See-Bote*, and that paper flourished. Less than four years later, in January of 1860, the twenty-eight year old immigrant American became sole proprietor of the

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[1] Wisconsin's contribution to the war effort is reviewed and summarized in two different paperbacks, Frank L. Klement, *Wisconsin and the Civil War* (Madison, 1963), and Robert Wells, *Wisconsin in the Civil War* (Milwaukee, 1963). The role of the Iron Brigade is superbly related in Alan T. Nolan, *The Iron Brigade* (New York, 1961) and the role of the governors is judiciously portrayed in Robert H. Jacobi, "Wisconsin Civil War Governors" (M.S. thesis, typewritten, University of Wisconsin, 1948). The general subject of Democratic opposition to the Civil War is treated in Frank L. Klement, *Lincoln's Critics in Wisconsin* (Bulletin No. 14, Lincoln Fellowship of Wisconsin, Madison, 1956) and in Frank L. Klement, "Copperheads and Copperheadism in Wisconsin: Democratic Opposition to the Lincoln Administration," *Wisconsin Magazine of History*, XLII (Spring, 1959), pp. 182–188. The author has discussed "Brick" Pomeroy as an anti-war man in three different articles—see Frank L. Klement, "'Brick' Pomeroy, Copperhead and Curmudgeon," *Wisconsin Magazine of History*, XXXV (Winter, 1951), pp. 106–113; "A Small-Town Editor Criticizes Lincoln: A Study in Editorial Abuse," *Lincoln Herald*, LV (Summer, 1952), pp. 27–32, 60; and "'Brick' Pomeroy and the Democratic Processes: A Study of Civil War Politics," in *Transactions of the Wisconsin Academy of Science, Arts and Letters, 1963* (Madison, 1963), pp. 159–169. The role of Edward G. Ryan as a critic of Lincoln and the war is treated in scholarly fashion in A. J. Beitzinger, "The Father of Copperheadism in Wisconsin," *Wisconsin Magazine of History*, XLIX (Autumn, 1955), pp. 17–25. Both Ryan and Moses M. Strong have found competent biographers—see A. J. Beitzinger, *Edward G. Ryan: Lion of the Law* (Madison, 1960) and Kenneth W. Duckett, *Frontiersman of Fortune: Moses M. Strong of Mineral Point* (Madison, 1955).

See-Bote, and he rose rapidly in importance as a force in the community.[2]

The *See-Bote* dated back to the early 1850's, when it was founded by Bishop John Martin Henni to counteract the radicalism and anti-Catholicism preached by several newspapers published in Milwaukee. The *Volksfreund,* the *Flugblaetter,* and the *Humanist* were anti-clerical, and their editors believed Catholicism the antithesis of freedom and individualism. Alarmed at the anti-Catholic tone of the press, Bishop Henni authorized the Reverend Dr. Joseph Salzman to establish a German-language weekly to present the Catholic point of view upon the issues of the day. Father Salzman founded the *See-Bote* and boldly entered the conflict. "Radicalism," he wrote, "has egotism as its basic principle, which will turn to destruction, if necessary, in order to fulfill the attainment of its desires."[3] Although the *See-Bote* was never the "official" newspaper of the diocese, it published a good deal of church news, and it neutralized the radicalism expressed by the other German-language journals.

When Peter V. Deuster took over direction of the *See-Bote* early in 1860, sectionalism and abolitionism were national issues, emotionalizing the country. Several months earlier, John Brown had stoked the controversy at Harpers Ferry and Southern radicals talked of secession and separation. Furthermore, 1860 was an election year and Republicans and Democrats argued party politics heatedly and accused each other of bigotry. William H. Seward and Salmon P. Chase seemed to be favored by most Wisconsin Republicans, while Democratic chieftains argued the merits of James Buchanan and Stephen A. Douglas.

Editor Deuster worked hard to keep his readers from joining the Republican party. Since prominent 'Forty-eighters like Carl Schurz and Bernhard Domschcke were free-thinkers and abolitionists as well as Republicans, it was easy for the editor of the *See-Bote* to make a case against the radicalism of the Republican party. Deuster could also point out that most of the Know-Nothings (members of a nativist, anti-Catholic movement of the 1850's) and most temperance advocates were also Republicans. It was possible for Deuster, therefore, to convince German Catholics that their interests were tied to the Democratic party.[4]

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[2] Fairly lengthy obituaries of Peter V. Deuster appear in the *Milwaukee News,* December 31, 1904, and the *Milwaukee Journal,* December 31, 1904. The *Dictionary of Wisconsin Biography* (Madison, 1960), p. 100, contains a recital of his achievements.

[3] (Milwaukee) *See-Bote,* March 1, 1854, quoted in Peter Leo Johnson, *Crosier on the Frontier: A Life of John Martin Henni* (Madison, 1959).

[4] The rise of the Republican party in Wisconsin is treated in Andrew W. Crandall, *The Early History of the Republican Party* (Boston, 1930). Bernhard Domschcke's contribution to Wisconsin politics is well discussed in J. J. Schlicher, "Bernhard Domschcke," *Wisconsin Magazine of History,* XXIX (March–June, 1946), pp. 319–332, 435–456, and Carl Schurz's link to Badger State history is superbly summarized in Chester V. Easum, *The Americanization of Carl Schurz* (Chicago, 1929).

After the northern wing of the Democracy nominated Stephen A. Douglas for the presidency and the Republicans nominated Abraham Lincoln, election fever swept the state. Although two other contenders, John Bell and John C. Breckinridge, entered the presidential race in 1860, most Milwaukeeans knew that the race was between Lincoln and Douglas. Deuster criticized Lincoln less than he did the party which "the Rail-Splitter" represented. He defined the Republican party as "a conglomeration of isms"—radicalism, abolitionism, prohibitionism, and Know-Nothingism. He labeled Carl Schurz, who campaigned for Lincoln, "a political mountebank" who would do anything for money, incite passions and encourage fanaticism. He warned his readers not to be deceived by Schurz's excursions in oratory nor his claim that Lincoln would get a large percentage of the German–American vote.[5]

Although Deuster successfully convinced German Catholics to repudiate Carl Schurz and vote for Stephen A. Douglas, he could not prevent Lincoln from carrying Wisconsin by 20,000 votes. Wisconsin counties most heavily populated by German–Americans gave Douglas a majority over Lincoln. The Democratic party schism, the Lincoln image, President Buchanan's bungling, and the homestead plank—not the officious oratory of Carl Schurz—put Lincoln in the White House in 1860.[6]

Dramatic events followed each other rapidly. Southern states seceded. Peace and compromise efforts failed. The Fort Sumter affair inaugurated a civil war between the North and the South. President Lincoln called for volunteers to suppress the "insurrection" and issued a number of emergency or extraordinary proclamations. A wave of patriotism swept over the countryside, and flags flew on every hand, "till the whole Northern heavens seemed a perfect aurora borealis of stars and stripes."[7]

Deuster's failure to bow to the surge of patriotic passion brought attacks from several quarters. "Raise the Palmetto Flag at once," advised the editor of the *Milwaukee Journal,* "and openly declare that the Government, under which you live, is not to be supported." The Republican editor of the *Sentinel* added, "Those who are not for their country are against it, and in times of war it is best that all men should be known." The next day the *Sentinel* again criticized Editor Deuster: "The *See-Bote* of yesterday, in reply to an item in the *Sentinel,* endeavors to squirm out of the unenviable position in which its secession predilections have placed it. We again ask our German contemporary a plain question—on which

[5] *See-Bote,* October 31, November 7, 28, 1860.

[6] The Lincoln–Douglas contest of 1860 in Wisconsin is well summarized in Lloyd Spohnholtz, "Wisconsin and the National Election of 1860" (M.A. thesis, typewritten, Marquette University, 1962).

[7] (Chicago) *Prairie Farmer,* June 6, 1861.

side are you? There can be no incivility in this. How many words are wasted by men when they get in a corner, trying to convince themselves and the public that facts are optical illusions. We affirm that unless the *See-Bote* is in favor of supporting the government, he [it] is an enemy of the government, and we shall wait with no little anxiety to see how long an article its editor will write to-day to mystify and abuse us, when the thing could be settled in half a dozen words."[8]

The *Sentinel's* comments stirred up some misguided patriots, who threatened to burn down or destroy the *See-Bote* establishment. When fire destroyed Deuster's home in the Fifth Ward several months later, there was a tendency to suppose "patriots" had gained revenge because Deuster and the *See-Bote* had not given unequivocal support to the war. The fire, however, was unrelated to the patriotic passions of the hour, for it had started in a bakery and spread to nearby houses.[9]

The *See-Bote's* anti-war editorials were mild enough in the early months of the war. Deuster blamed Republicans for defeating compromise efforts, he blamed abolitionists for bringing on the war, and he expressed the fear that the war might evolve into an abolitionist crusade. He questioned the constitutionality of some of President Lincoln's emergency measures, and he predicted that burdensome taxation and compulsory conscription would be imposed upon the citizenry. Some Democrats, nevertheless, talked of establishing a pro-war Democratic paper to counteract the *See-Bote's* influence and "to neutralize its mischievous effects." Self-styled patriots again talked of using the torch. The *Sentinel* lashed out at Deuster and the *See-Bote* for undermining support of the war "among the German element." "We will not call the *See-Bote* a pestiferous sheet," concluded one editorial writer; "its influence is that of a deleterious miasum [miasma] that mingles with the purer air of our city, entering the shades of those who have no safeguards, nor antidotes . . . ."[10]

Actually, the *See-Bote* gave the Lincoln administration qualified support in the first year of the war. Deuster, strongly opposed to abolition, deplored the pressure exerted upon the president to add emancipation as a second objective of the war. When Lincoln revoked General John C. Frémont's proclamation freeing the slaves of rebels within his jurisdiction, Deuster gave the president a pat on the back. For a time he envisioned Lincoln to be "a faithful, conscientious, constitutional ruler" holding back the flood tide of abolition. He did, however, continue to hope for peace and com-

[8] *Milwaukee Sentinel,* April 18, 19, 1861.
[9] *Ibid.,* April 19, 20, June 19, 1861; *See-Bote,* April 25, 1861.
[10] *Milwaukee Sentinel,* August 9, 21–23, 28, 1861; *See-Bote,* August 21, 1861.

promise, wanting "spontaneous action by the people" to effect "the calling of a national convention." He also pointed out that taxes were "ruinous" and arbitrary arrests "unnecessary." Always he criticized Yankees and the mailed fist of Puritanism. Always he defended General George B. McClellan, a Democrat, against the attack of radical Republicans. Yet he asked for popular support of the "war policies" of the Lincoln Administration, arguing that since the people had not adequately supported compromise before the war, they were obligated to complete "the work which they had endorsed." A military draft, Deuster re-asserted, would be a necessity.[11]

Deuster's aversion to abolition turned him against Lincoln as the president retreated before abolition pressure and as the number of arbitrary arrests multiplied. Lincoln's message of March 6, 1862, endorsing compensated emancipation, made Deuster realize that his fears had a solid basis. He referred to abolitionists as "disunion demagogues" or "disunion devils," and he warned that emancipation would release "a flood of free Negroes and cheap labor" to rob the immigrant Americans of the crumbs on their tables. German–Americans, the *See-Bote* asserted, would lose their jobs to the "contrabands" (the newly freed slaves). One issue of the *See-Bote* carried a long and well-written article entitled "Abolition the Worst Enemy of Free White Labor." Another carried the story of an employer offering eight contrabands a mere twenty-five cents a day. Free Negroes, Deuster argued, would be shipped to northern cities to replace white laborers—he even said that some abolition-minded employers preferred Negro labor to the immigrant Americans. Using words quite like those earlier enunciated by Karl Marx, Deuster wrote, "Workmen! Be Careful! Organize yourself against this element which threatens your impoverishment and annihilation." He added, "Let us resist this evil from the beginning! The North belongs to the free white man, not the Negro. To him, Nature has provided other regions."[12]

Spouting pessimism, Deuster saw the war as destroying the ideals which had brought immigrants by the hundreds of thousands. "It is strange," wrote the editor of the *See-Bote,* "that so many men emigrate to this country. Either the people in the old country do not know that we have worse times before us, or they are having worse times themselves. But the latter is not so. The motives which induce immigration are hope of freedom and lighted taxation. But neither freedom nor light taxation is to be found here. The taxes in the future will be heavier and more oppressive than they were

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[11] *See-Bote,* January 3, 15, 21, February 19, 26, March 12, April 19, May 14, 28, July 16, 1862.

[12] *Ibid.,* April 9, 16, 23, 30, June 4, 1862.

in Germany, and as for freedom, we confess that we are living in the century of the Bastile and a muzzled press. The freedom which we receive from Washington is gone forever, and under the name of political necessity, the government takes away *peu à peu* the constitutional rights of the people."[13]

As Deuster became more critical of the Lincoln administration, the editor of the *Sentinel* cracked the whip again. He accused the *See-Bote* of substituting partyism for patriotism. He charged that Deuster was guilty of "false statements" regarding the state of affairs in the country. He contended that the *See-Bote* neutralized the efforts of the recruiting officers, "spawning its treacherous stuff for the special delectation of this class [the German Americans]."[14] One letter-writer who signed himself "Union" suggested extra-legal measures to silence the *See-Bote.* "Such papers," he wrote, "should be suppressed. . . . If they will continue in their work of *treason,* the people should take the matter into their own hands. I do not wish to encourage violence, but there is a time when forbearance ceases, etc. Traitors at home should be dealt with as the common enemy. Let them beware. 'A word to the wise' etc."[15] Other Milwaukee newspapers added censure. The *Daily Wisconsin* reprimanded Deuster for preaching "a pro-Southern gospel" and for trying to lead German Americans down the road of treason.[16] William W. Coleman of the German-language *Herold* offered "to discontinue publication" of his paper and join the army if Deuster would do the same.[17]

Deuster, of course, ignored the criticisms which Republican editors tossed in his direction. The Lincoln administration lost popularity during 1862, after time tempered the patriotic passions which swept the North at the start of the war. The agricultural and financial depression which engulfed the upper Mississippi area in 1861 continued to affect pocketbooks throughout 1862. The frequency of arbitrary arrests gave critics of Lincoln a chance to chant that a despotism seemed to be enveloping the country. The ascendancy of New England industry and eastern capital gave western sectionalists a chance to say that their region was becoming "slave and servant" of New England. Furthermore, the specious spirit of Negrophobia was abroad in the land—it was widespread among German- and Irish-American laborers. Deuster excelled in appealing to the latent spirit of Negrophobia to keep German Catholics in Democratic party ranks. He had referred to Negroes

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[13] *Ibid.,* June 11, 1862.

[14] *Milwaukee Sentinel,* June 16, July 22, 29, August 5, 1862.

[15] Letter, "Union" to "Editors, *Sentinel,*" August 7, 1862, published in *Milwaukee Sentinel,* August 8, 1862.

[16] (Milwaukee) *Daily Wisconsin,* August 13, 1862.

[17] *Milwaukee Herold,* August 13, 1862; *Milwaukee Sentinel,* August 14, 1862.

as "black cattle" and warned his readers that abolitionists intended to establish a "Negrocracy" in America. He gloated when he heard that Wendell Phillips, "the orator of freedom," had been stoned and mobbed in Cincinnati, and he hoped that Milwaukeeans would give him like treatment if he appeared in their city. When anti-Negro riots erupted in Cincinnati and Toledo, Deuster blamed abolitionists for "those realistic results." And he referred to the (Milwaukee) *Herold,* which endorsed emancipation, as belonging to "the German Nigger Press."[18]

When President Lincoln finally bowed to abolition pressure and issued the preliminary proclamation of September 23, 1862, Deuster acted as if the world had come to an end. He labeled the proclamation "ridiculous," calling it "an unsavory piece of paper." He claimed it was "unconstitutional" and deplored its "consequences." It would incite Negroes in the South to insurrection, repeating the scenes of horror which had been enacted by the Sioux in Minnesota. He again recited his time-worn statement that free Negroes would flood northern cities and take jobs and security away from the German Americans. When the editor of the Milwaukee *Sentinel* supposed that Negro labor was apt to be "non-competitive," Deuster disagreed vigorously, and added, ". . . if free Negro laborers came to take the place of white workers sent off to war to be killed, the problem would be less acute." When the editor of the *Cincinnati Gazette* suggested that those who feared the competition of the free Negroes could secure "employment" by presenting themselves "at any of the army recruiting offices," Deuster's indignation knew no bounds. It was plainly evident that Peter V. Deuster knew how to develop Negrophobia and weld readers of the *See-Bote* into a solid Democratic bloc.[19]

The election returns of November 4, 1862, heartened Deuster and other Democrats. Deuster, a candidate for the State Assembly in the Fifth District. carried his ward by an impressive margin—726 votes to 364 for his Republican opponent.[20] The anti-administration tide of the fall of 1862 gave the Wisconsin Democrats three of the six congressional seats—they were deprived of another seat in Congress by the Republican-devised political stratagem called

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[18] *See-Bote,* January 28, April 2, June 18, 23, 1862. The sectional and economic aspects of Democratic and midwestern opposition to the Lincoln administration are analyzed in Frank L. Klement, "Economic Aspects of Midwestern Copperheadism," *The Historian,* XIV (Autumn, 1951), pp. 27–44, and "Middle Western Copperheadism and the Genesis of the Granger Movement," *Mississippi Valley Historical Review,* XXXVIII (March, 1952), pp. 679–694. Midwestern Negrophobia is discussed and dissected in Jacque Voegli, "The Northwest and the Race Issue, 1861–1862," *Mississippi Valley Historical Review,* L (September, 1963), pp. 235–251, and Frank L. Klement, "Midwestern Opposition to Lincoln's Emancipation Policy," *Journal of Negro History,* XLIX (July, 1964), pp. 169–183. Deuster is quoted in the latter article.

[19] *See-Bote,* August 13, October 1, 8, 15, 22, November 3, 1862.

[20] *Milwaukee Sentinel,* November 14, 1862.

"soldier-voting-in-the-field"—and nearly captured control of the state legislature. Democratic victories in northern states like Illinois, Indiana, Ohio, Pennsylvania, and New York gave Deuster's colleagues a chance to crow and a chance to sponsor "party jollifications." One of Deuster's colleagues, pleased that Democracy was again in style, composed the headline: "Fall Fashions—Democratic Victories."[21]

After Wisconsin Democrats finished celebrating their election victories, they fixed a jaundiced eye upon the pending state draft, which Governor Edward Salomon, at the request of Republican politicos, had postponed from August until after the November election. Early in the war Deuster had supposed that a draft would be necessary and he restated that contention in mid-July, 1862. Fully aware of anti-draft sentiment among most Milwaukee Germans, Deuster did not hesitate to make political capital out of the issue. He built up apprehension about the "coming draft" and he gave publicity to Governor Salomon's proclamation of August 13, 1862, that all foreign-born citizens who had exercised the franchise would be enrolled and subject to conscription, even if they had not applied for their final naturalization papers. The *See-Bote* also reported on the "draft disorders" in Pennsylvania, and Deuster built up a draft consciousness among his readers. He exposed the postponement of the draft until after the November election as "a political trick." He also questioned the constitutionality of conscription, pointing out that the Pennsylvania State Supreme Court had declared the federal "limping" Draft Act of July 17, 1862 (a federal act providing for states to conscript and recommending procedures for a state-conducted draft), as unconstitutional. Deuster added his own concern about military power becoming superior to civil authority. Furthermore, he complained that excessive and unfair quotas had been assigned to Democratic wards and he implied that the draft would be administered dishonestly because abolitionists, Republicans, and Know-Nothings had been appointed county draft commissioners. And he added that the draft of November, 1862, would be but the first of many. "God Almighty only knows," concluded the doughty Democrat, "when the drafting will stop."[22]

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[21] *Sheboygan Journal,* November 21, 1862. Historians generally interpret the fall elections of 1862 as "a repudiation" of Lincolnian policy; see Winfred H. Harbison, "The Elections of 1862 as a Vote of Want of Confidence in President Lincoln," in *Michigan Academy of Science, Arts, and Letters Papers,* XIV (1930), pp. 499–513, and Harry E. Pratt, "The Repudiation of Lincoln's War Policy in 1862—the Swett–Stuart Congressional Campaign," *Journal of the Illinois Historical Society,* XXIV (April, 1931), pp. 129–140. The thesis that soldier-voting was little more than a political stratagem is advanced in Frank L. Klement, "The Soldier Vote in Wisconsin during the Civil War," *Wisconsin Magazine of History,* XXVIII (September, 1944), pp. 37–47. In the *See-Bote* of November 12, 1862, Deuster called the election returns "a popular revolution."

[22] *See-Bote,* July 16, August 6, 20, November 5, 12, 1862.

Governor Salomon and draft officials had every reason to be apprehensive about the approaching lottery. During the enrolling process, officers had received a hostile reception at many homes—several German housewives had used broomsticks to chase out "the intruders" and one Milwaukee woman had thrown scalding water upon an inquisitor. Enrolling officers expressed amazement at the embarrassing number who claimed physical disability, set out for Canada or "the woods," or filed exemptions as "aliens." Most men with families and mortgages worried about the draft. Who would pay the mortgage when it fell due if the breadwinner marched on far-away battlefields or was killed fighting the Confederates? Opposition to the draft seemed to occur in those counties which held a predominance of German–Americans. As immigrants arriving in New York City, many had been met by state agents who described Wisconsin as a land of milk and honey—a region of freedom and opportunity. Compulsory conscription seemed to violate promises made by the state agents. Furthermore, most German–Americans did not understand what the war was all about, nor did they have a chance to develop much loyalty to their newly adopted land. Then too, newspapers like the *See-Bote* and the (Port Washington) *Ozaukee County Advertiser* had dealt rather harshly with the Lincoln administration, even challenging the propriety and constitutionality of the draft. The readers of the *See-Bote* and the *Ozaukee County Advertiser* were apt to adopt the editorial views of those newspapers as their own.

As "D-day" approached, uneasiness and apprehension increased. Some Milwaukeeans—many from Deuster's own ward—marched up and down the streets shouting "No! No!" ("Nein! Nein!") and carrying "No Draft" ("Nein Militardienst") signs. When the cup of forbearance overflowed in nearby Ozaukee County and brought forth the Port Washington draft riot of November 10, 1862, the draft commissioner of Milwaukee County wisely postponed the draft for a week, until troops from nearby camps could be brought in to overawe the crowds and supervise the lottery.[23]

Deuster received more than a fair share of the blame for the unrest in Milwaukee and for the Port Washington draft riot. After

[23] *Milwaukee Banner & Volksfreund,* November 11, 1862; *Milwaukee Sentinel,* November 10, 1862; *See–Bote,* November 19, 26, 1862. The story of the Port Washington Draft Riot is summarized in Lawrence H. Larsen, "Draft Riots in Wisconsin, 1862," *Civil War History,* VII (December, 1961), pp. 421–427, although Larsen fails to deal adequately with causation. Peter Leo Johnson, "Port Washington Draft Riot of 1862," *Mid-America,* I (January, 1930), pp. 212–220, develops the thesis that anti-Catholic policy in the naming of an army chaplain brought on the draft disorder in Ozaukee County. John W. Oliver, "Draft Riots in Wisconsin during the Civil War," *Wisconsin Magazine of History,* II (March, 1919), pp. 334–337, is most superficial. Lynn I. Schoonover, "A History of the Civil War Draft in Wisconsin" (M.A. thesis, typewritten, University of Wisconsin, 1915) is a third-rate study and badly outdated. The best narrative account of the Port Washington riot can be found in *History of Washington and Ozaukee Counties* (Chicago, 1881), pp. 360–366, 493–496.

all, the *See-Bote* enjoyed a widespread circulation among German Catholics in Milwaukee and Ozaukee counties and most of the rioters were German Catholics. The *Milwaukee Sentinel,* of course, blamed Deuster and the *See-Bote* for creating a climate of apprehension and hostility which transformed citizens into rioters and mobsters. The (Madison) *Wisconsin State Journal* derided the editors of the *See-Bote* and the Democratic-oriented *Milwaukee News* for teaching the German–Americans *(this poor, deluded and ignorant class of men")* that the war had been "provoked" by abolitionists and that it had evolved into a crusade to free the slaves. According to the *State Journal,* Deuster's hands were bloodstained and he was clearly guilty of causing the riots. The Republican-minded editor of the (Hartford) *Home League* also put the blame for the riot at Deuster's door. The *See-Bote* was "a baneful influence" among "a large portion of our citizens"—Deuster's words were "the law and gospel" to many German–Americans and he could have soothed apprehension instead of agitating it. Frederick W. Orban of the (Milwaukee) *Banner & Volksfreund* tried to blame Deuster and the *See-Bote* for the discontent, yet at the same time he felt sorry for his fellow Germans.

> The poor misguided ones—because we don't believe they are anything else—will now realize that their resistance against the law has reacted adversely. But since their resistance was caused by love for their mostly poor families—delivered to need without their supporting hands—the authorities should use mildness as far as compatible with the law. It is easier to pronounce a harsh judgment on poor, hard-working people when sitting in a soft, upholstered easy-chair than to bear the miseries of life without questioned reservation.[24]

Questions as to who deserved the blame for the Port Washington draft riot were also raised in the state legislature. In the state senate, Herman L. Humphrey pointed his finger in Deuster's direction and asserted that the *See-Bote* deserved most of the blame.[25] Certainly the editor-publisher of the *See-Bote* was attacked from many directions.

Emboldened by the election returns, Deuster refuted Republican-made contentions that the rioters were poor, deluded, and ignorant. He ridiculed Republicans for seeming to claim that they had a monopoly upon virtue, literacy, and learning. He offered no apologies for being a critic of conscription or emancipation. He refused to bow before his critics. Instead he seemed to become bolder and more aggressive, more critical of the Lincoln administration with

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[24] *Banner & Volksfreund,* November 18, 1862; (Hartford) *Home League,* September 7, 1862, March 14, 1863; (Madison) *Wisconsin State Journal,* November 11, 1862; (Madison) *Wisconsin Patriot,* November 17, 19, 1862; *Milwaukee Sentinel,* November 11–17, 1862.

[25] State of Wisconsin, *Journal of the Senate . . . 1863* (Madison, 1863), pp. 458–459; (Madison) *Wisconsin Patriot,* March 13–14, 1863.

each passing week. He interpreted the election returns of November, 1862, as a mandate to cease his qualified support of the war and become an all-out critic. He bluntly blamed Republicans for the deplorable state of affairs.[26]

Republicans countered with editorial and oratorical blasts at Deuster and the *See-Bote*. The federal marshal in Milwaukee called Deuster and Christian Ott, who wrote most of the editorials for the *See-Bote*, into his office, trying to intimidate them and threatening arrest.[27] The Union general commanding the Army of South-east Missouri, through his provost marshal (Major Gustavus Heinrichs) forbade the circulation of the *See-Bote* in his sector and among his soldiers. He claimed that Deuster's newspaper rendered "aid and comfort to the enemy" and issued a boycott. "Public journals using as mean and disgraceful language as this paper," concluded the military edict, "is [*sic*] injurious to military discipline, and is not the literature to be tolerated in the army."[28]

The edict suppressing the *See-Bote* in one military sector stirred up a controversy, and the issues of treasonable conduct and free press received a public airing. Republicans generally endorsed the army edict and Democrats claimed that a constitutional guarantee had been violated. The issue received a hearing in the State Assembly, where Deuster sat as a member. Andrew J. Turner, of Portage, introduced a resolution which gave "hearty approval" to Major Heinrichs' action in expelling the *See-Bote* from his department. The resolution was referred to the Committee on Federal Relations. The majority report, dated March 31, 1863, endorsed Major Heinrichs' edict. "We are of the opinion," the report read, "that all such newspapers should be suppressed in and out of the army lines." The report concluded:

> In times like these there is no neutral ground. We are either for the government or against it—either patriots or traitors. We cannot be loyal to the government and disloyal to the administration. . . . We, therefore, regard the sentiments promulgated by the *See-Bote* . . . as of the most dangerous character; and that Major Heinrichs was fully warranted in prohibiting its circulation in the army under his command.[29]

Democratic members of the Committee on Federal Relations, quite naturally, disagreed with the majority report. Alden S. Sanborn, of Madison, presented a dissenting report which defended Deuster and freedom of the press. Sanborn's minority report de-

[26] *See-Bote,* November 19, December 10, 17, 31, 1862, January 7, 14, 21, 1863.
[27] *Ibid.*, January 21, 1863.
[28] The edict, dated January 12, 1863, and signed by Major Gustavus Heinrichs as "Provost Marshal General, Army of Southeast Missouri," was published in the *Milwaukee Sentinel,* January 27, 1863. For some unknown reason, the document does not appear in *Official Records of the Union and Confederate Armies* (128 vols., 1880–1901).
[29] State of Wisconsin, *Journal of the Assembly . . . 1863* (Madison, 1863), pp. 106, 123–124, 895, 956–957.

scribed the *See-Bote* as "the uncompromising friend of the people, firmly attached to the principles of liberty, an unwavering advocate of the restoration of the United States into the same fraternal relations that existed before sectional parties menaced their disruption."[30] Democratic and Republican legislators, wearing partisan spectacles, saw the same act assuming different shapes.

Neither the *Sentinel's* fulminations, the threats of a federal marshal, nor a general's edict checked the *See-Bote's* criticism of the Lincoln administration. When Congress discussed the need for federal conscription during February, 1863, Deuster printed his anti-draft views. He claimed that federal conscription would destroy civil liberties of individuals as well as the sovereignty of the states. It would keep the Republican party "permanently in power," wiping out the opposition party. The presidency would evolve into a dictatorship and the republic turn into a despotism. Negro troops, Deuster warned his wary readers, might even be employed to enforce the draft and drag white men off to war, insulting them in the process. Yes, "compulsory conscription" and "the excesses of the Administration" might even force the liberty-loving people of the North "to the edge of the chasm," bringing civil war to them.[31]

After the Conscription Act of March 3, 1863, became law, Deuster continued to play critic. He compared the federal measure to "the Polish forcing act," reminiscent of the drafting of the Poles by the Russian government. German Americans, Deuster asserted, would be sacrificed at the whim of New England Yankees. Deuster also criticized "the $300. commutation clause," a provision which absolved a man of military service upon the payment of $300. Rich Republicans, the *See-Bote* supposed, had incorporated that "iniquitous section" into the Conscription Act so that they might stay at home while the poor immigrant Americans would then die upon the battlefields.[32]

Other issues besides federal conscription drew the wrath of Peter V. Deuster and the *See-Bote.* When the Lincoln administration carved West Virginia from the northwestern section of "the Old Dominion," in violation of a constitutional clause guaranteeing the integrity of each state, Deuster printed his protest, labeling such action unwarranted and unconstitutional. When successive issues of greenbacks or legal tender notes were authorized by a Republican-dominated Congress, Deuster cried "Foul!" and claimed that property rights were sacrificed and inflation sanctified. When Congress raised the tax on distilled spirits and considered doubling

[30] *Ibid.,* pp. 958–959.
[31] *See-Bote,* February 11, 1863.
[32] *Ibid.,* March 25, April 20, July 29, 1863.

the levy on fermented liquors, the *See-Bote* again raised its voice. Deuster believed beer "the healthiest and most innocent alcoholic drink." The proposed beer tax would fall heaviest upon the laboring classes and those immigrant Americans whose cultural patterns made them beer-drinkers. Deuster also criticized the removal of General George B. McClellan from command of the Army of the Potomac and decried the arrest of Clement L. Vallandigham, prominent Copperhead and critic of the Lincoln administration, early in May of 1863. He called the trial of Vallandigham of Ohio by a military commission in an area where the civil courts were open "an outrage," arguing that force and arbitrary measures had been substituted for wisdom and justice. He applauded when Ohio Democrats retaliated by nominating Vallandigham as their party's gubernatorial nominee. Such bold action, Deuster argued, was a proper protest against "usurpation and tyranny." As far as Deuster was concerned, the wheel of revolution turned too fast and too far. The "more radical measures of the Lincoln Administration" could be compared with "the excessive measures of the French Revolution." Carl Schurz, a onetime Milwaukeean, seemed to be one of Deuster's favorite targets. The *See-Bote* seldom missed a chance to throw mud at Schurz, who vainly sought military glory upon Civil War battlefields. Deuster considered General Schurz "incompetent" and "egotistical," qualified only to carry a gun in "Wide-Awake parades."[33]

A peace movement gathered momentum during the first six months of 1863 and Deuster jumped with alacrity upon that bandwagon. Continued war might crush out the last vestiges of civil rights, for it continued to centralize the government. The weary boatman at the river Styx ferried heavy loads, and the people on the home front tired of the bloodshed and shuddered at the long, long casualty lists. Defeatism became more and more widespread as some became convinced that the South could not be conquered. Then, too, ruinous taxes sapped the nation's economy and robbed men of their hard-earned dollars. Many Democrats were convinced that the original objective of the war had been perverted. New England capital seemed to have moved into the driver's seat, using Lincoln as a pawn in its game to make western interests servile to eastern interests. Conciliation and compromise could stop the bloodshed and the centralization of the government, giving midwesterners a chance to regain the balance of power they had held politically before the war. "When will the hideous moloch who holds the press and sword of this nation," asked one of Deuster's

[33] *Ibid.*, December 24, 1862, May 7, 13, June 10, 17, July 2, October 14, 1863.

friends, "call off his dogs of war, and suffer peace once more to bless our bleeding country?"[34]

Just when war weariness and defeatism seemed to be taking over the northern heart, the fortunes of war changed. The tide turned at Gettysburg and Vicksburg early in July, 1863. The peace movement then retreated, for it vacillated with the vicissitudes of war, advancing with Union defeats and ebbing with Union victories. Deuster, evidently convinced that a draft was necessary, quit criticizing the Conscription Act and turned, instead, to promoting "a social plan" to help needy draftees. Deuster's devastating criticism of the administration also seemed to soften, giving way to mildness. Early in November, 1863, the *See-Bote* even printed an advertisement from the general government. The editor of the *Milwaukee Sentinel,* somewhat chagrined, protested, asserting that the *Herold* was more deserving than the *See-Bote*. "Such being the case," concluded the editor of the *Sentinel,* "We hope no further official patronage will be bestowed upon a paper which is doing all it can to embarrass the government. Let the proper authorities look to the matter."[35]

Early in 1864, Republicans and Democrats began to talk of presidential candidates and to weigh the possibility of Lincoln's re-election. Union military victories, like those at Gettysburg and Vicksburg, combined with Republican political victories at the polls in October and November, 1863, gave Lincoln a claim to renomination and re-election. Although some dissident Republicans favored John C. Frémont as a candidate, the party's national convention put Lincoln's name at the head of the ticket. From the first, it was almost a foregone conclusion that Deuster's party would name George B. McClellan as its choice in the presidential contest of 1864. The presidential race stirred partyism and Deuster joined other Democrats in denouncing Lincoln and praising McClellan. The *See-Bote* seemed to delight in reporting critical comments made by Deuster's fellow Democrats. Edward G. Ryan, prominent party mogul, had described Lincoln as "a weak, vain, amiable man" characterized by "his utter imbecility and . . . moral incapacity" —"a mere doll, worked by strings."[36] Mayor Abner Kirby, another Milwaukee Democrat, labeled Lincoln "a weak and vacillating president" and "a tool of fanatics"—"the weakest man on the whole list of presidents."[37] Deuster, who had earlier judged President Lincoln "the most incapable of statesmen and the most irresponsible of butchers of men," predicted that history would deal harshly with the president. He claimed that Lincoln's nomination was made at

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[34] *Sheboygan Journal,* April 9, 1863.
[35] *See-Bote,* November 5, 1863; *Milwaukee Sentinel,* November 6, 1862.
[36] Quoted in the *Milwaukee News,* July 2, 1863; *See-Bote,* October 14, 1863.
[37] *See-Bote,* April 24, 1864.

a convention dominated by rascals—"griffins, hypocrites, pharisees, shoddy contractors, and 'two-legged cattle'." There was not "an honest man in the whole convention." These "hell-on-earth men" nominated Lincoln, Deuster wrote, despite "the sighing of the widows, the complaining of the children, and the moaning of the wounded upon the battlefield." Lincoln had no "conscience;" he was guilty of telling smutty stories while soldiers were dying. The *See-Bote* associated "Godlessness," "perjury," "irresponsibility" and "dirty ditties" with Lincoln and radicalism. Evidently God was punishing the nation for the sins of the Lincoln administration, imposing suffering, taxes, and hardship upon the people because radicals and fanatics directed affairs in Washington.[38]

The *See-Bote,* of course, endorsed McClellan's candidacy and placed his picture on the front page. It reviewed McClellan's qualifications most favorably, praising the man and the soldier. McClellan could lead the nation out of "the desert of troubles" and into the promised land. Lincoln's policy was failure; it was time for a change. Lincoln's re-election would mean more "troublous times", more drafts and more bloodshed.[39]

Party loyalties and the heat of political campaigns sometimes prompts men to make irrational statements. Such was the case when "Brick" Pomeroy of the *LaCrosse Democrat* hoped that "some bold hand" would pierce Lincoln's heart "with dagger point for the public good." Such was the case when the editor of the *Beaver Dam Argus* wrote, "History shows several instances where the people have only been saved by assassination of their rulers, and history may repeat itself in this country. The time may come when it is absolutely necessary that the people do away with their rulers in the quickest way possible." And such was the case when Deuster wished Lincoln were dead. Upon hearing the story that a soldier standing next to Lincoln (while the President was visiting the front lines) was wounded by a bullet. Deuster wrote, "Oh, if a fortunate coincident had caused that bullet to pierce the black, inhuman heart of this great butcher of men, rather than lodge in the leg of the poor soldier."[40]

Despite the heat generated by newspaper editors and excited orators, the election passed off with few incidents in Milwaukee and Wisconsin. Although Deuster's ward and the city of Milwaukee gave McClellan a two-to-one margin (4,908 votes for McClellan,

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[38] *Ibid.*, December 18, 1862, June 15, July 27, 1864.

[39] *Ibid.*, September 14, October 25, 1864.

[40] *La Crosse Democrat,* August 23, 1864; *Beaver Dam Argus,* September 14, 1864; *See-Bote,* August 3, 1864. An account of the election of 1864 in Wisconsin can be found in Frank L. Klement, "Wisconsin and the Re-election of Lincoln in 1864: A Chapter of Civil War History," in *Wisconsin in Three Wars* [*Historical Messenger,* XXII (March, 1966)] pp. 20–42.

2,535 for Lincoln), Lincoln carried Wisconsin by 17,000 votes and won re-election by a comfortable margin.[41]

Deuster was not surprised by the election returns, but he expressed his disappointment nevertheless. His editorials seemed to say, "The Republicans started this war; let them finish it." "Everyone," he wrote, "views the future with apprehension and anxiety." He seemed depressed and disgusted, and he tossed another taunt in Lincoln's direction: "His watchword is war—that's what the vote meant. Disintegration of the country, with the end of civil order and collapse of the government, will come. Then the people, deceived by Lincoln, will wake up and realize their plight."[42]

In the closing months of the war Deuster remained a caustic critic and an unredeemed Democrat. He referred to the country's president as "a usurper," and he moaned each time the president called for more troops.[43] Yet Deuster and most Democrats sympathized with President Lincoln when he feuded with the radicals in his own party over Reconstruction policy. Lincoln favored a rather mild Reconstruction policy, whereas the radicals wanted vindictive measures and civil rights for the newly freed Negroes. Democrats like Deuster and Edward G. Ryan openly supported the president against most leaders of his party.

Lincoln's death at the hands of an assassin shocked Peter V. Deuster. He feared that the president's death might give the radical Republicans control of Reconstruction and that "retribution and revenge" might become official policy. Deuster even claimed that Democrats could mourn with a "pure conscience." He rationalized for his readers: "We have voted against Lincoln's election; written against it; spoken against it. What we have said and written was done with a clear conscience. We may say with an equally clear conscience that there are no more sincere mourners today—none who deplore the death of President Lincoln more than the Democracy of the Northern States."[44]

Deuster's role as a Copperhead and critic of Lincolnian policy did not adversely affect his business or political success. The *See-Bote* became a prosperous business enterprise in the postwar years. For two years, until the "Great Chicago Fire" of 1871, he also published the *Chicago Daily Union,* another German-language newspaper. During the postwar years he again sought public office, serving one term in the state senate and three in Congress. In the

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[41] The soldier vote padded the rather scant majority Lincoln received of the home vote in Wisconsin. The canvassers counted 68,906 Lincoln votes and 62,494 McClellan votes cast in Wisconsin—they set aside the Kewanee County votes (157 for Lincoln, 753 for McClellan) because "no seal was attached." Lincoln received 13,805 of the 16,789 votes cast by soldiers in the field.

[42] *See-Bote,* November 23, December 14, 1864.

[43] *Ibid.,* February 11, 25, 1865; *Milwaukee Sentinel,* February 27, 1865.

[44] *Milwaukee Sentinel,* April 26, 1865.

postwar era he gained recognition as the most forthright and respected champion of the wants and rights of the German Catholics of the Milwaukee area.

Peter V. Deuster can be classified as a conservative. He opposed the changes which the Civil War imposed upon his adopted country. He opposed the centralization of the government, for the war helped to transform a federal union into a truly national state. He opposed the triumph of industrialization and its ascendancy over agriculture, objecting to the trend which caused the upper Midwest to bow to the economic domination of the Northeast. He opposed the extension of democratic rights to the former slaves; he opposed emancipation and the granting of civil rights to the newly free. Yet he was a leader and spokesman for many German Americans because he could put into words the hopes and the fears of his countrymen, immigrant Americans adjusting to their American environment.

GEORGE MADISON HINKLEY
SAWMILL ENGINEER FOR E. P. ALLIS

Walter F. Peterson
Lawrence University

In 1905 the *American Lumberman* at the death of George M. Hinkley, honored him with a special article. He was "among the men who had done much to elaborate and perfect saw mill machinery." His contribution to sawmilling was widened when "fortune cast his lot with one of the largest machinery manufacturing houses in the country or the world," Edward P. Allis and Company. The career of G. M. Hinkley, master sawmill designer and builder, cannot be separated from that of E. P. Allis, whose Reliance Works in Milwaukee, Wisconsin, manufactured the machinery that made Hinkley famous among lumbermen.[1]

Edward Phelps Allis (1824–1889) was a New Yorker who turned from the study of law to go West to seek his fortune as a businessman. By 1873 Allis had established himself as a leader in the Wisconsin business community, had purchased and expanded the Reliance Works founded in Milwaukee in 1847 by Decker and Seville, and employed more than 300 men and apprentices. Millstones and mill supplies, along with castings and engines, were the principal products. Although sawmill equipment had been listed in the catalog for some years, it was no more than a minor line.[2]

Allis developed a technique of management that made him the largest manufacturer in Wisconsin in the late nineteenth century. "It has been Mr. Allis' policy to secure the assistance of the best specialists in the different lines of machinery manufacture, and thus turn out the best machinery made, to which is due in a large measure his great success," reported an observer.[3] Allis brought together the engineering talent for the production of goods and the financial support to secure the constant expansion of his works. It was up to his engineers to provide the excellence of product and efficiency in production that would yield profits.

In 1873 Allis invited George Madison Hinkley to become head of the Reliance Works' sawmill department. Hinkley was one of the men who made up an engineering triumvirate which would lead

[1] *American Lumberman,* December 23, 1905, p. 1.
[2] *Dictionary of American Biography* (New York, 1928), pp. 219–220. Milwaukee *Sentinel,* April 2, 1889.
[3] *Sentinel,* January 2, 1889.

Allis and the Reliance Works to international fame and financial success. The second major appointment was that of William Dixon Gray to head the flour milling department. E. P. Allis rounded out his staff of brilliant engineers by securing in 1877 the services of Edwin Reynolds, who became the great steam engine builder of the late nineteenth century. The American Society of Civil Engineers, which had invited Allis to become a Fellow in 1883, published this appraisal of his successful business technique: "Mr. Allis was not an engineer, not an inventor, not a mechanic, but he had in full measure that rare talent for bringing together the work of the engineer, the inventor, the mechanic, that it might come to full fruition, and the world at large be the gainer thereby."[4] The achievement of Edward P. Allis was based on the success of Hinkley's sawmill equipment, Gray's flour milling inventions, and Reynolds' steam engines, which powered the sawmills and flour mills. As it turned out, E. P. Allis could not have picked better men than Hinkley, Gray and Reynolds.[5]

Allis and his engineers could hardly have lived at a better time. After the wreckage of the depression of 1873 had been cleared away, the United States very rapidly developed to maturity as an industrial nation. From an economic point of view the period 1873 to 1893 was in some respects a golden age of American history. During this period the public debt was rapidly reduced, even though taxes were low. The federal government was usually more concerned with a surplus than a deficit. Gradually, after the violent shock of civil war, the spiritual unity of the nation was restored. Manpower resources were unlimited as young and ambitious Europeans settled in cities and on farms. Inventions of all kinds added greater comfort and convenience to daily life. But most of all, there was a consciousness of progress, development and growth which made possible an optimism in American life that has perhaps never been so great.

E. P. Allis was always alert to business possibilities. The lumber industry, found in his own back yard, presented a remarkable opportunity. Given the enormous stands of accessible timber, Allis might almost have anticipated that between the Civil War and 1890 the principal center of the lumber industry would be the Great Lakes region. In fact during that period Michigan and Wisconsin accounted for nearly 30 per cent of the national production. During the decade following Hinkley's appointment as manager of the sawmill department, the quantity of white pine sawed annually in the Great Lakes area was to double, increasing from roughly four

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[4] *Proceedings of American Society of Civil Engineers,* 1889. Louis Allis Scrapbook, Vol. 1. Courtesy of Mrs. Louis Allis, Milwaukee, Wisconsin.

[5] Walter F. Peterson. "E. P. Allis: A Study in Nineteenth Century Business Technique," *Marquette Business Review,* Fall, 1962. pp. 44–48.

billion to eight billion feet. Moreover, the industry was soon to develop in the West and in the South. During the decade of the eighties the total value of the product was to increase from $210 million to $404 million. Supplying the rapidly expanding lumber industry with equipment represented an enormous opportunity.[6]

The change that Allis must have noted was that sawmill methods during the previous decade had been undergoing a rapid development. Introduction of the circular saw increased cutting capacity more than ten times, although early circular saws were exceedingly wasteful, sawing out at each cut a half inch of kerf. The movements of the log carriage had been accelerated and the double edger and later the gang edger had been introduced. At the close of the sixties steam replaced manual labor in handling logs. These and many other lesser improvements were accompanied by the increasing efficiency and power of the driving engines. In short, the better sawmill of 1870 bore little resemblance to the mill of 1860, and was still improving.[7]

Hinkley, born in Seneca, New York, May 24, 1830, was appointed head of Allis' sawmill department in October, 1873. As a young man he had recognized the great future in the lumber industry and increasingly aware of his growing taste for mechanical work, decided to learn the millwright trade. His first effort in this new occupation was in 1851 on a mill at Zilwaukee, Michigan. He then worked on mills at East Saginaw and Thetford, Michigan, and one on the Flint River.[8]

The Civil War broke out while Hinkley was operating a shingle mill in Tuscola county. On September 11, 1862, he enlisted as a corporal in Company 1, Sixth Michigan Calvary, and was mustered into service on October 11, 1862. On May 6, 1864, Hinkley, now a sergeant, crossed the Rapidan with General Grant and on June 11 he was captured by the Confederate forces during the battle of Trevellian Station, when his horse was shot from under him. As a prisoner he was confined in Confederate prison camps, including Andersonville, until he was paroled in late November, 1864.[9]

After the war Hinkley was kept busy building mills; first the Farr mill at Muskegon; then a mill at Manistee; and in 1866 a shingle mill in Milwaukee. After its completion, John Eldred, the owner, engaged Hinkley as the operator. In 1870 Hinkley decided

[6] Victor S. Clark. *History of Manufactures in the United States* (New York, 1929), 11, pp. 482–3.

[7] Frederick Merk. *Economic History of Wisconsin During the Civil War Decade* (Madison, 1916), pp. 69–71.

[8] *Dictionary of Wisconsin Biography* (Madison, 1960), p. 171. *American Lumberman*, December 23, 1905, p. 1.

[9] *History of Milwaukee, Wisconsin* (Chicago, 1881), p. 1288. *Allis–Chalmers Sales Bulletin*, December, 1905, p. 1. Hinkley kept a diary during the Civil War. Although the original has been lost by the family, portions of the diary in typescript are in the files of the Allis–Chalmers Manufacturing Company, Milwaukee, Wisconsin.

to develop his ideas for improving sawmill machinery and to establish his own business. He invented and sold a saw swage, a mill lathe and other devices which Filer and Stowell, sawmill manufacturers in Milwaukee, produced for him. His worth and his potential as inventor and engineer moved E. P. Allis to hire him for the Reliance Works.[10]

Upon joining the Allis company, Hinkley contributed his sense of organization, his drive, his inventiveness and his engineering abilities. Actually his productivity in new sawmill devices had just begun, for during the 32 years that he was head of the sawmill department he patented 35 inventions.[11] So that Allis might secure not only the services of such inventive minds as Hinkley, and later Gray and Reynolds, but also keep them in his organization, he allowed departmental managers to hold all or part of their patents, as well as those of their departmental co-workers. The company then paid the managers for the use of their patented devices. Moreover, the name plates on machines and company catalogs frequently featured the name of the department head, thus giving him international recognition.[12]

When George Madison Hinkley came to the Reliance Works, the annual sales of sawmilling equipment had not reached $1,000. Hinkley poured all of his talent and energy into his job. At the outset he did all the drafting, traveled, and carried on the correspondence. Most of the machinery turned out was under Hinkley's patents and his genius was such that some of the mill appliances invented by him were manufactured and used in mills without marked change for two to three decades afterward. As the reputation of the Reliance Works and of Hinkley's inventions grew, so did the sales of sawmill equipment.[13]

Logging was a rough, tough business in the late nineteenth century and the sawmill owners were a hard-bitten lot. It took a particular type of person, besides the quality of the product, to sell effectively to them. Hinkley was known for his commanding bearing, his forceful manner and pungent speech. A fine beard added to his impressive appearance. His outbursts were considered classic. One sawmill man vividly remembered his "highly scientific and gifted knowledge of picturesque language." Once when something

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[10] *American Lumberman,* December 23, 1905, p. 1.

[11] W. H. Whiteside, President of Allis–Chalmers Company, *Circular Letter No. 62*, December 20, 1905.

[12] The *Sentinel,* February 29, 1888, notes that a patent was granted on a sawmill carriage, one-half to George M. Hinkley and one-half to E. P. Allis and Company. The contract, in Allis–Chalmers files, between William W. Allis, President of Edward P. Allis Company, and Edwin Reynolds, April 9, 1890, reaffirmed his previous contract, which gave him full right to his patents. Ernest C. Shaw, who knew G. M. Hinkley well, understood that Hinkley held the same rights to his patents as did Reynolds and also some patents of departmental co-workers. Edward P. Allis and Company *Catalog,* 1885.

[16] *American Lumberman,* December 23, 1905, pp. 1, 37.

had gone wrong, Charles Allis, the third oldest of the Allis boys, rushed out of his office to suggest less profanity, only to give up when G. M. Hinkley furiously expanded on his original statement with even greater force and added that he would "kow-tow to nobody!"[14] But he understood the loggers and sawmill owners and could speak their language. Here was a man who knew what he wanted and had the courage and ability to go after it. Hinkley employed no tricks of salesmanship but sold the products of the Reliance Works solely on their merits, "recommending them for the value that was in them, and of that value and its most minute details no man ever had more intimate and thorough knowledge."[15]

When George M. Hinkley assumed management of the sawmill department, the company produced only a circular saw which was described as a fast-running disc "with teeth on its periphery." Only two years after Hinkley joined the Reliance Works, the catalog of the sawmill department was increased to a fat 70 pages. Hinkley's patents, together with his ingenuity and energy, had made the difference.[16]

In 1876, three years after joining the Allis Company, Hinkley sent his first complete sawmill to Japan, and filled many larger domestic orders as the reputation of the department continued to grow. In the spring of 1878 ten carloads of sawmilling equipment were sent to Texas, including two large double sawmills, setworks, engines, boilers, and everything necessary for a complete outfit. Later the same year the *Sentinel* reported that "in the matter of sawmills the reputation of Messrs. Allis & Co. stands alone."[17]

In the hard-fisted and free-wheeling sawmilling business a less energetic man than Hinkley and a smaller concern than the Edward P. Allis Company would have had difficulty maintaining the identity and integrity of its patents. The mechanical "dog," the device to hold the log in place on the log carriage, was of critical importance. In 1880 the Allis Company brought suit against Filer, Stowell and Company for infringement of a patent dog used in sawmills. Allis and Hinkley sought to recover royalties from all firms that had manufactured or were using their patented device to the extent of $600 to $800 for the use of the dog during past years and recognition of rights in the future. When the Allis position was sustained by the courts, the lumbermen of Oshkosh, Wisconsin, formed the Northwestern Sawmill Protective Association to defend themselves against an additional Allis claim of 25¢ per

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[14] Ernest C. Shaw to Alberta J. Price, August 23, 1954. Axel Soderling to Alberta J. Price, August 3, 1954. Interviews in Allis–Chalmers historical files.

[15] *American Lumberman,* December 23, 1905, p. 37.

[16] Edward P. Allis and Company *Catalogs,* 1871, 1875.

[17] *Sentinel,* October 9, 1876; March 19, 1878; May 15, 1878.

1000 feet of lumber cut by mills using its devices if not manufactured by the Reliance Works. The decision on this claim was in favor of the Allis company and a referee was appointed to determine the extent of the damages. Allis and Hinkley continued to press their claims against a growing list of firms and lumbermen. The first case, against Filer, Stowell and Company of Milwaukee, was settled in 1883 when that company agreed to pay for past infringement and take out a license from E. P. Allis and Company covering future use of the patent. This action provided the principle for settlement of the remaining cases.[18]

At the fairs and exhibitions popular after the Civil War manufacturers of all types entered their products in competition for prizes and to widen their markets through the education of the public. Hinkley supervised elaborate displays of Allis sawmill equipment all over the country during the seventies and eighties. The progress made by Hinkley in developing a first class sawmill department can be seen in the impressive collection of prizes awarded his sawmill equipment at the New Orleans World's Fair of 1885. For a circular sawmill in practical operation he was awarded a medal of second class; headblocks in operation with circular sawmill, medal of second class; collective display of sawmill machinery, medal of second class; gang edger, medal of first class; automatic lumber trimmer, medal of first class; two-saw lumber trimmer, honorable mention; flooring machine, medal of first class; for the Reliance mill dogs, operated with circular saw mills, medal of first class. This record becomes more impressive when it is compared with those of two other Milwaukee manufacturers who also entered their equipment at the New Orleans fair. Filer, Stowell and Company received honorable mention for its display of mill machinery, and the T. H. Wilkin Company a medal of first class for its saw stretcher. G. M. Hinkley's sawmill department was obviously helping to establish the national and international reputation of the Allis company.[19]

Although Hinkley did not invent the band saw, he is given credit for perfecting it.[20] This was a machine carrying a saw made from an endless steel band with teeth on one edge running over two flat-faced wheels, one above and one below the level at which the log was sawed. The great advantage was that the steel band was one-half the thickness of the old circular saw and reduced the waste from sawdust proportionately at every cut. When Hinkley

[18] *Sentinel*, August 16, September 27, 1880; January 29, 1881; October 4, 1882; March 22, September 2 1883.

[19] *Sentinel*, May 23, 1885.

[20] *American Lumberman*, December 23, 1905, p. 1.

was convinced that the band saw could work a great advantage, he proceeded to perfect it.[21]

With his characteristic skill and energy Hinkley pushed the development of the band mill. His first band mill was announced on December 6, 1885, in a notice entitled "TO THE ATTENTION OF LUMBERMEN."

> We have just completed our new band saw mill, which is without question, the best machine of its kind ever offered to the market. One of these mills is now set up at our works, corner of Florida and Clinton Streets where it will remain on exhibition until December 15. It will then be removed to Dorchester, Wisconsin, and placed in active operation about January 1 in the mill of the Jump River Lumber Company. We make this announcement in order that parties interested in band saw mills may have an opportunity to inspect our machines.[22]

This was a nine-foot mill designed for saws ten inches wide. The lower wheel had a cast-iron rim on the outside of which was bolted a hardwood rim. The weight of this lower wheel was about 3,000 pounds. The top wheel was constructed almost entirely of the best seasoned hardwood to make it as light as possible and at the same time perfectly rigid.[23] Soon after the new band mill was placed in operation at the Jump River Lumber Company, Prentice, Wisconsin, the E. P. Allis Company received the following letter:

> Your combined Band and Rotary Mill put in for us was started up about the first of February last. It started off perfectly and our satisfaction has been constantly increasing. We are cutting from mixed logs, knotty, frozen, shaky and sound, at the rate of 3,000 feet per hour, of measured lumber, requiring no more care than a circular mill. We expect with a little more familiarity with operating the mill, to saw 35,000 feet per day. We have examined other mills in operation and unhesitatingly say we have seen none that compare favorably with this one. We cordially recommend anyone desiring a mill to examine this one in operation.
>
> Jump River Lumber Company[24]

Although the later development of the Hinkley Automatic Power Swage and the Hinkley Power Guide, along with his other numerous inventions, rounded out his contributions to the sawmill industry, it was the perfected band saw that the *American Lumberman* regarded as "the monument of his rare genius and mechanical ability."[25]

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[21] Ernest C. Shaw to Alberta J. Price, August 23, 1954. Allis–Chalmers historical files. It was characteristic of all the sawmill developments of the sixties and seventies that they were calculated to secure increased output or a saving of labor. Little effort was made toward achieving a saving of timber which was both cheap and abundant.

[22] *Sentinel*, December 6, 1885.

[23] In the *Southern Lumberman*, December 15, 1931, p. 82, E. A. Hall, then manager of the milling machinery department of Allis–Chalmers, provided details on construction of the mill.

[24] Jump River Lumber Company, undated letter in Allis–Chalmers historical files.

[25] *American Lumberman*, December 23, 1905, p. 1.

It is significant that Hinkley lived and produced his equipment during the period of greatest lumber expansion, when every manufacturer of sawmilling equipment was pushed to the utmost to meet both the great demand and the intense competition. At his death in 1905 the *American Lumberman* paid him tribute:

> Mr. Hinkley was as great a man in his line of business as Carnegie in his. He has been as useful in his day and generation, in view of the circumstances which surround him, as any great inventor whose name could be mentioned. His relation to the improvement of saw mill machinery was almost akin to that of Edison to electrical development or of Ericson to the evolution of naval construction. Had he so elected his name would have been as eligible to enrollment in a national hall of fame as any of those cited. But he chose—if he gave that matter a thought—that his works should be his monument.[26]

Hinkley distinguished himself within the company well beyond his ingenuity as an inventor and machinist. It was the business ability of George Madison Hinkley that E. P. Allis prized equally highly. With the management and the sales of the department wholly in his charge, he raised the status of his department to the first rank in the field and annual sales to nearly $400,000 by 1889 when Allis died. Hinkley had vindicated the business technique by which E. P. Allis operated and whose fortunes, in part, were created by him.[27]

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[26] *Ibid.*, p. 37.

[27] After more than 32 years of service to the company as manager of the sawmill department, G. M. Hinkley died on December 14, 1905.

WISCONSIN TERRITORIAL AND STATE CENSUSES

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State census work can be best understood against the background of the important and excellent United States censuses. Although the national census organization in the U.S. has become perhaps the world's best, the development from a simple beginning in 1790 to the present was slow, at least in the early decades. Art. A, sec. 2 of the U.S. *Constitution* provided for the U.S. census:

> Representatives and direct taxes shall be apportioned among the several states which may be included within this Union according to their respective numbers, which shall be determined by adding to the whole number of free persons, including those bound to service and excluding Indians not taxed, three-fifths of all other persons. The actual enumeration shall be made within three years after the first meeting of the Congress of the United States and within every subsequent term of ten years in such manner as they shall by law direct.

Although this was a landmark in census development, it limited the work to an enumeration of the inhabitants of the country. Very early there were demands for other information, such as data on agriculture and industry. In the rapidly developing states and territories the ten-year interval was sometimes longer than convenient for state and local government, especially in frontier areas.

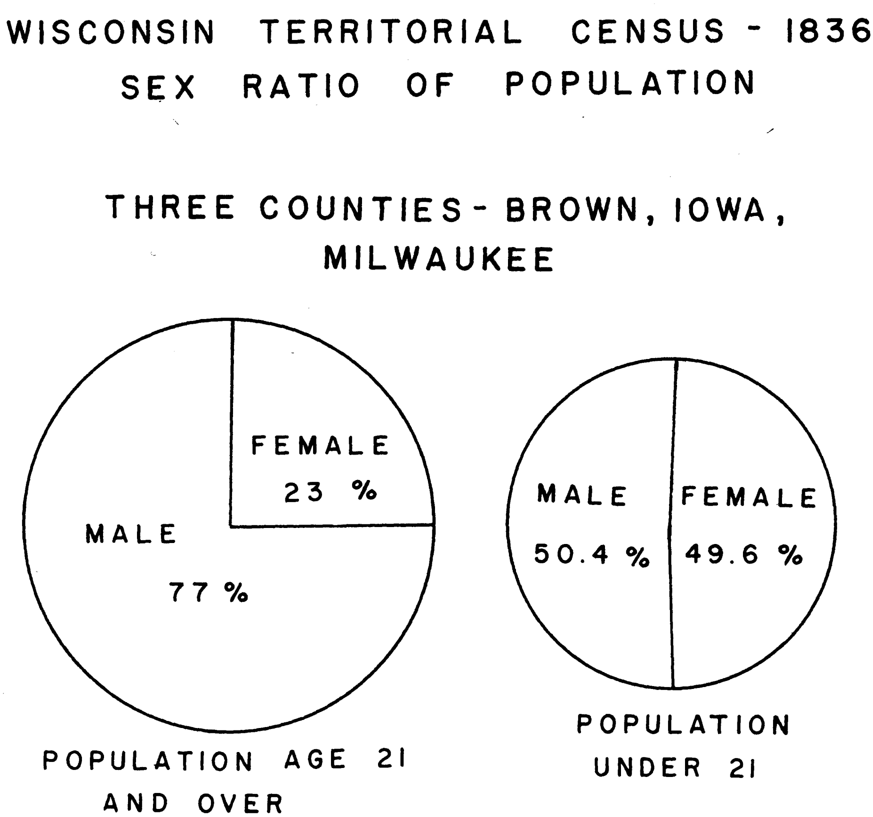
As demands came for more frequent or more detailed data on population, manufacturing, industry or agriculture, the national census organization was lacking in both experience and skills. For nearly fifty years the question of the constitutionality of such additional census work was a deterrent to progress. When people needed more data on population or in new fields, they turned to the states for them.

Actually State census work goes back into colonial times, census enumerations being reported in Massachusetts as early as 1643; Rhode Island, 1708; and New Hampshire, 1767.[1] In 1854 the Superintendent of the United States Census reported that 20 of the 31 states then in the Union had some kind of state census.[2] Although the earliest work was concerned largely with population, some later state enumerations included agriculture, manufacturing and mining. These state censuses have now disappeared, except for the mid-decade one in Massachusetts[3] and a somewhat different one which provides population data annually in Kansas.[4]

Territorial Census Work by Wisconsin

Like other states, Wisconsin engaged in census-taking during territorial days. Eleven state censuses were taken between 1836 and 1905. The first five came between 1836 and 1847. These territorial censuses were concerned only with population, first for the organization of the territorial government and then for statehood. A provision for state censuses at ten-year intervals was also written into the Wisconsin State Constitution in 1848.

The first territorial census of 1836 was described in a report of the State Historical Society of Wisconsin in 1892.[5] The editor pointed out that the Act of Congress, April 20, 1836, establishing the territorial government of Wisconsin provided that previous to



In the census of 1836 the population was shown by age groups. The inhabitants age 21 years and over were 77 per cent men and 23 per cent women for Brown, Iowa, and Milwaukee Counties. Crawford County is not included in this chart because the data were influenced by the military personnel stationed at Fort Crawford.

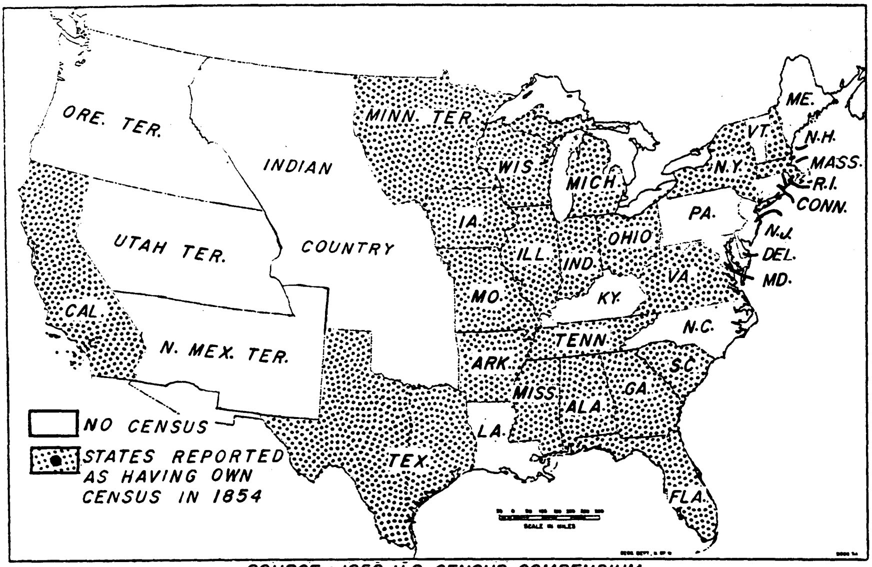
the first election the governor should order a census or enumeration of inhabitants of the several counties to be made by the sheriffs and reported to him.[6] Upon the basis of this census the governor was to apportion in the ratio of population the council members and representatives, Indians excepted.

The first territorial census for Wisconsin was taken in July of 1836. No printed blanks were furnished for the enumeration. Sheriffs were instructed simply to report in writing the names of white families, with the number of persons in each family, divided into four groups:

I. Males under 21 years
II. Females under 21 years
III. Males 21 years and over
IV. Females 21 years and over

In 1836 Wisconsin Territory was much larger than present Wisconsin because it included most of Iowa, Minnesota, and other land west of the Mississippi River to about the present site of Bismark, N. D. The enumeration, however, covered only the populated parts of Wisconsin and some of the counties of Iowa west of the Mississippi River, an area temporarily attached to Wisconsin Territory

IN MID 19th CENTURY MOST STATES HAD THEIR OWN CENSUS •



SOURCE : 1850 U.S. CENSUS COMPENDIUM

In 1854 of the thirty states in the U.S., twenty-one had their own census. Wisconsin took censuses from 1836 to 1905.

pending further organization. Governor Dodge provided for representation in the Territorial Council (13 members) and House of Representatives (26 members) on the basis of population, which for the four counties—Brown, Crawford, Iowa, and Milwaukee—amounted to 11,683 persons.

In 1838 the Territory took another census of population, again by the county sheriffs, with the data recorded by towns and cities.[7] No age divisions were required. The sheriffs recorded the names of the master, mistress, steward, or overseer of each household, and the township in which the family lived. They recorded the number of white males, white females, free males of color, and free females of color, with a column for totals and one for remarks. Each sheriff was required to summarize the reports and submit them to the Secretary of the Territory.

In 1842 another territorial census was authorized and taken. The headings were the same as those in 1838, with the addition of a column for errata.

As statehood approached, a further census enumeration was necessary. An Act in Relation to the Formation of the State Government, January 31, 1846, provided in sec. 1 that every white male inhabitant above the age of 21 who resided in the territory six months previous to the census and who was a citizen of the U. S. or had filed his declaration of intention, according to U. S. naturalization laws, was authorized to vote for or against the formation of a state government in Wisconsin.[8] Sec. 3 provided for the governor to appoint in each of the counties some suitable person to enumerate the number of inhabitants, omitting non-citizen Indians and officers and soldiers of the U. S. Army. The census-takers were empowered to choose as many assistants as necessary, assigning to each one a portion of his county accurately defined either by Congressional Township lines, the boundaries of towns organized for town government, or distinctly bounded by water courses or public roads.

The appointment of special persons to take the 1846 census was a major departure from previous census work by the sheriffs or their deputies in each county. The appointed persons were required to take an oath that they would obtain an exact enumeration of all residents within their county or division and make duplicate reports for the Secretary of the Territory and the Register of Deeds. A penalty was provided in sec. 6 of the Act for failure to perform assignments properly. The enumeration was to begin on June 1, 1846, and be completed within 30 days.

Upon the basis of the population determined in this census the governor was to issue a proclamation and appoint delegates apportioned to each county and territory according to population for the first state constitutional convention. Thus this census differed from previous ones, the details being carefully prescribed for the purpose of Statehood.

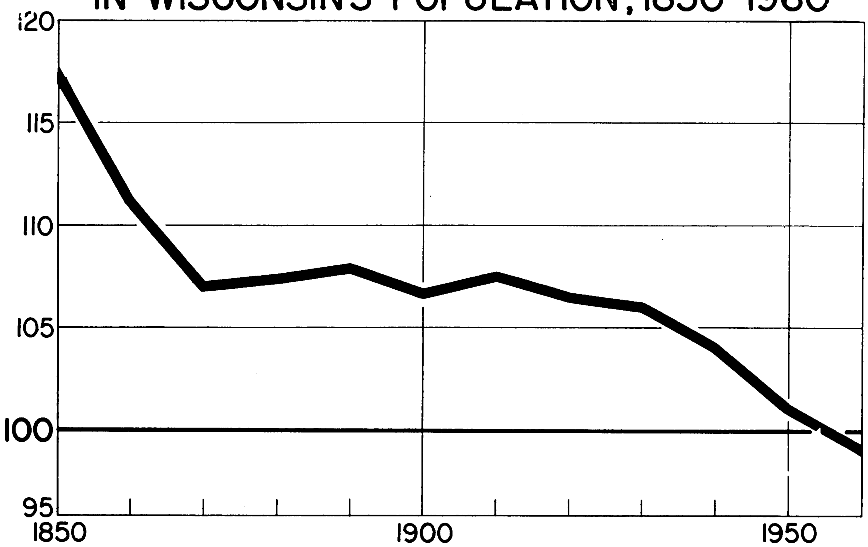
The first Constitution for Wisconsin, produced by a constitutional convention in 1846, was rejected by the voters in a referendum in April, 1847. To provide a basis in the territory for the apportionment of members for a second constitutional convention, a special legislative session in October 1847, passed a new act for the formation of a state government. Secs. 13–19 provided for another census in December 1847, only 18 months after the previous one. This census recorded 210,546 people, an almost unbelievable increase of 35 per cent in a year and a half.

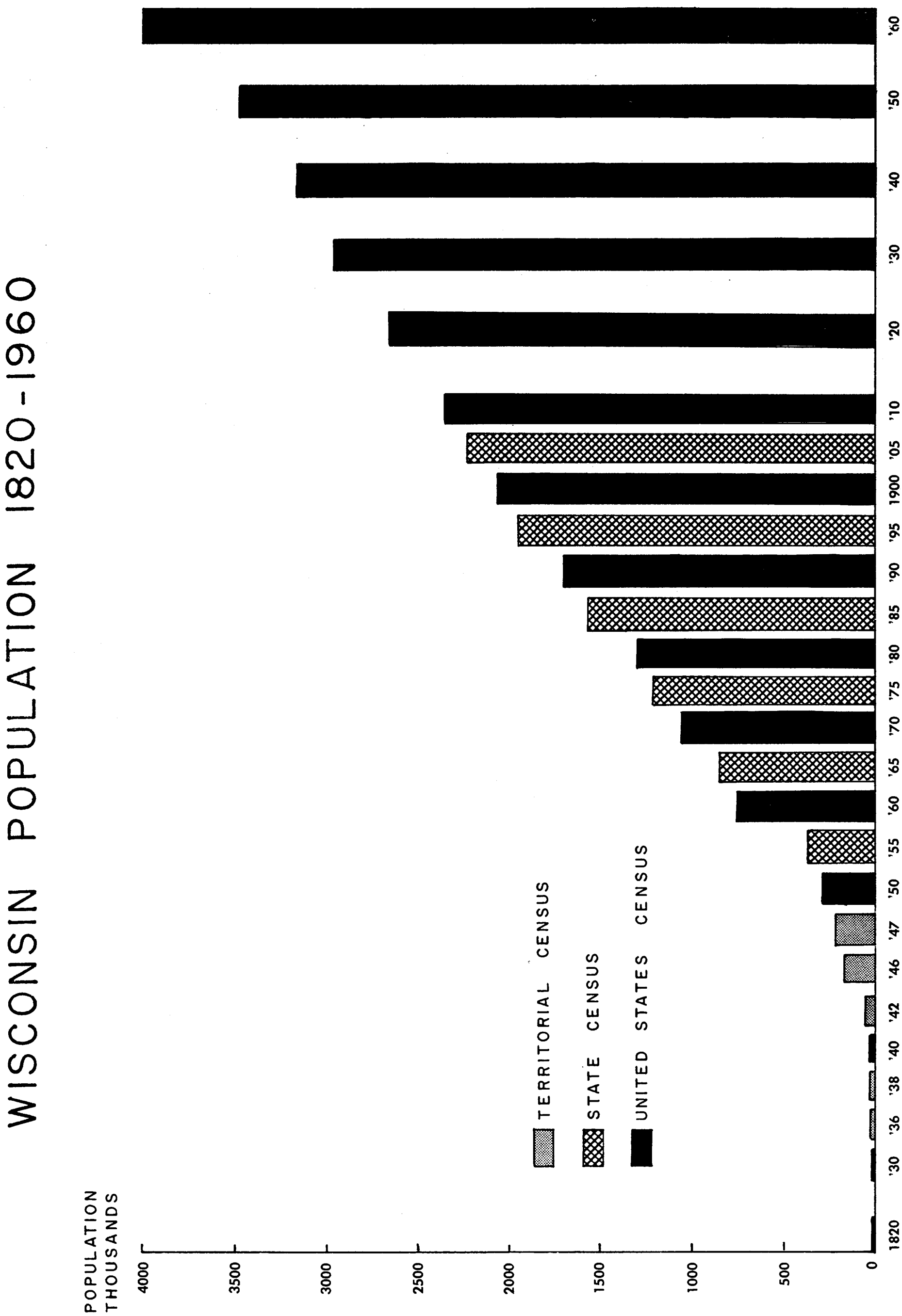
State Census Continued Under the Wisconsin Constitution

The five censuses of population during territorial days in Wisconsin were largely for the apportionment of representatives to the territorial legislature and the constitutional conventions, but of course they also showed the rapid growth in population and the advancement of the frontier.

After Wisconsin became a state, the Constitution provided for the continuing of the state census enumerations at ten-year intervals for the mid-decade years ending in five.[9] Six such censuses were conducted for the mid-decade years from 1855 to 1905.

RATIO OF MALES PER 100 FEMALES IN WISCONSIN'S POPULATION, 1850-1960




WISCONSIN POPULATION 1820-1960
POPULATION THOUSANDS
4000
3500
3000
2500
2000
1500
1000
500
0
1820
'30
'36
'38
'40
'42
'46
'47
'50
'55
'60
'65
'70
'75
'80
'85
'90
'95
1900
'05
'10
'20
'30
'40
'50
'60
TERRITORIAL CENSUS
STATE CENSUS
UNITED STATES CENSUS

Obviously during a period of rapid settlement, population change, and the frequent addition of new counties, apportionment of the members of the legislature according to population needed to be made frequently. The state Constitution provided that the membership of the legislature be reapportioned after each census enumeration, both federal and state, every five years. As the state became more mature and population more stable, however, the need for such frequent reapportionment was less pressing than during the days of most rapid growth and geographic advance of the population.

In November, 1910, a constitutional amendment relating to reapportionment was adopted. It provided that apportionment of members of the legislature according to population should be done only at ten-year intervals in accordance with the U.S. census, thus eliminating the need for a state census of population. The 1905 census, therefore, the sixth one under statehood, was the last of the Wisconsin state censuses as provided under the Constitution.

Agricultural, Manufacturing and Mineral Data in the Wisconsin State Census

The territorial and state census as in Wisconsin was developed originally for the enumeration of the inhabitants. An explosive increase in the work began with the 1885 census. The Revised Statutes of 1878 had made substantial additions to state census work. These included a long list of questions on agriculture (animals, crop acreage, land tenure, equipment, product values), manufactured products and minerals produced in the state. The new material was so extensive that much larger reports for the censuses for 1885, 1895 and 1905 were required, with major portions devoted to the new subjects.

The responsibility for carrying out this enlarged work was assigned to the Secretary of State, who prepared the schedules and sent them to county clerks for enumeration by town, city, and village clerks. The county clerks filed the original reports with the Registers of Deeds and sent copies to the Secretary of State, who was responsible for tabulation and publication.

Filing original reports in the counties and making hand-written copies for the Secretary of State had serious faults. There is no evidence that counties had much use for the original documents, many of which were lost, and the making of copies by cheap labor in the counties resulted in errors and omissions which reduced the accuracy of the tabulations.

Although the reasons that triggered the spectacular enlargement of the Wisconsin state censuses beginning with 1885 are not entirely clear, several are apparent. To begin with, the state economy was largely agricultural and with the post-Civil War depression of the 1870's and 80's, data on agricultural trends and changes were of great interest. Another and perhaps major reason was that the U.S. Congress in the census legislation for 1880 authorized the Secretary of the Interior to pay states and territories half the cost of a mid-decade census in 1885 if they met certain requirements. Apparently Congress hoped that if all states could perform a mid-decade census patterned after the U.S. census, mid-decade data for the nation might be produced. As a result more elaborate state censuses, including many of the U.S. census inquiries of 1880, were taken in various states and territories, but the U.S. census of 1880 had been so enlarged that states could not duplicate it entirely. A few received federal payments but most of them, like Wisconsin, did not. Although this federal legislation applied only to 1885 and was not re-enacted,[10] Wisconsin continued the enlarged program through the 1905 census.

Another subject included in the state census of Wisconsin beginning in 1885 and continuing for the following two censuses—1895 and 1905—was the "enrollment of militia." Wisconsin furnished 91,327 men in the Civil War. The 1885 state census recorded

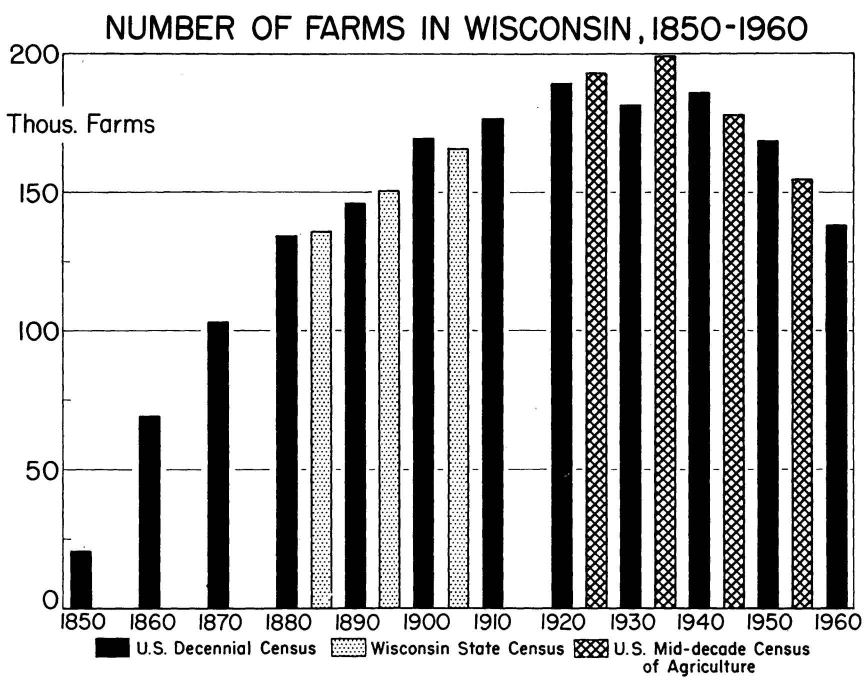


TABLE 1. SOME CHARACTERISTICS OF WISCONSIN STATE CENSUSES.

Date	Number Counties	Enumerated by	Administering State Agency	Subjects	Number of Inhabitants	Approximate % Annual Increase from Previous Census
July 1836	4	County Sheriffs	Territorial Governor	Population	11,683	
May 1838	12	County Sheriffs	Secretary of Territory	Population	18,139	7.8
June 1842	21	County Sheriffs	Secretary of Territory	Population	44,478	6.1
June 1846	24	Persons appointed by Territorial Governor	Secretary of Territory	Population	155,277	10.0
Dec. 1847	27	Persons appointed by Territorial Governor	Secretary of Territory	Population	210,546	23.0
June–July 1855	50	County clerks and town and city clerks	Secretary of State	Population	552,451	20.0
June 1865	58	County clerks and town and city clerks	Secretary of State	Population	868,325	5.7
June 1875	60	County clerks and town and city clerks	Secretary of State	Population	1,236,729	4.0
June–July 1885	67	County clerks and town and city clerks	Secretary of State	Population, Agriculture, Manufacturers, Minerals, Ex-soldiers and sailors	1,563,413	1.7
June 1895	70	County clerks and town and city clerks	Secretary of State	Population, Agriculture, Manufacturers, Minerals, Ex-soldiers and sailors	1,937,915	2.4
June 1905	71	County clerks and town and city clerks	Secretary of State	Population, Agriculture, Manufacturers, Minerals, Ex-soldiers and sailors	2,228,949	1.5

the names and addresses of 29,686 veterans living in Wisconsin. By 1895 the number of Civil War veterans in the state declined to 26,367 and by 1905 to 9,521. Clearly by another decade few Civil War veterans would remain and the need for this information would disappear.

It is not surprising, therefore, that with the greater stability of the state's population, thus reducing the need for frequent legislative reapportionment, with agriculture more prosperous and becoming a smaller segment of the state's growing economy, and with the number of Civil War veterans greatly reduced, the move developed to amend the state constitution to eliminate the state census. The amendment was passed by referendum in 1910, thus closing seven decades of state census work.

These censuses, in addition to serving important purposes in their time, provide a rich mine of historic information. Because they were published by various divisions of the state, by counties, towns, cities, and villages, they provide useful detail for historic studies. Partly because a mid-decade census of population is useful and because some present problems require more frequent censuses than at ten-year intervals, administrators of new projects dealing with apportionment of federal funds are now demanding a federal mid-decade census. In recent years hearings have been held, with many agencies urging Congress to provide a mid-decade census of population. The latest of these hearings was in Washington on May 4 and 5, 1965; a fifty million dollar appropriation was being sought for this purpose.

Summary

State census taking developed in early American history when population and frontiers were changing rapidly. The U.S. Census at ten-year intervals was not frequent enough to provide information necessary under those conditions. State censuses, undertaking to fill a part of the need, for a time served an important purpose. However, they could not provide for the needs of an increasingly complex society over the longer period and they have largely disappeared. Continuing needs for data at shorter intervals caused the U.S. Census in 1925 to undertake a Census of Agriculture at five-year intervals. A Census of Manufacturing is also taken at shorter intervals. Because of other needs for population data at five-year intervals one may expect that the U.S. Census will take action within the next decade.

References

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2. U. S. Census Compendium 1850, by J. D. B. DeBow, Superintendent.
3. Statement by Raymond D. Lavalle, Census Director, State of Massachusetts, May 4, 1962, before congressional subcommittee on census and government statistics of the Committee on Post Office and Civil Service, Hon. Harley O. Staggers, Chairman, pp. 653–660. Part 4, Mid-decade census hearings.
4. Statement by Dr. Conrad Taeuber, Assistant Director, U. S. Census Bureau.
5. Wisconsin Historical Collections, Vol. XIII, 1892, pp. 247–270.
6. Organic Act establishing the Territorial Government of Wisconsin of April 20, 1836, Sec. 4.
7. The legal basis for the 1838 Census is found on pages 239–244 Territorial Laws of Wisconsin 1837, Act No. 53, providing for the taking of a second census or enumeration of the inhabitants of the Territory of Wisconsin, approved December 30, 1837.
8. Laws of Territory of Wisconsin, 1846, Act approved January 31, 1846.
9. Section 3 of Article 4 of the Wisconsin Constitution read as follows: "Section 3. The legislature shall provide by law for an enumeration of the inhabitants of the state in the year 1855 and at the end of every ten years thereafter: and at their first session after such an enumeration and also after enumerations made by the authority of the United States the legislature shall apportion and district anew the members of the Senate and Assembly according to the number of inhabitants excluding Indians not taxed and soldiers and officers of the U. S. Army and Navy.
10. WRIGHT and HUNT, History and Growth of the U. S. Census 1790–1890, U. S. Government Printing Office 1900, page 67 and footnote.

In addition to the above mentioned sources, the various laws and published reports relating to this work in Wisconsin have been examined. Credit must also be given to J. E. Boell, the state archivist, for encouraging a study of which this paper is a part and to the staff of the State Historical Society, especially Librarian Ruth Davis, who has been most helpful. The Secretary of State's office, especially Miss Kay Thompson, assisted in making records available.

DETOURING CALAMITY IN WATER RESOURCE DEVELOPMENT A CASE IN POINT: SOUTHEASTERN WISCONSIN

*Spenser W. Havlick**

Water pollution control, inadequate water-based recreation facilities, and flood control loom as a trio of critical issues which the American urban dweller must face with new urgency. The approach in this discussion is first to present difficulties in water-resource planning in general terms and second to analyze the southeastern Wisconsin situation, using the Milwaukee River basin as an example of a potential and relatively untapped water resource. Implicit in the discussion is the assumption that the Milwaukee River Valley could qualify as an experiment and model demonstration of water planning and development in an urbanizing basin—a matter of local as well as state and national concern.

The use of untreated surface and/or well water for metropolitan centers began to be questioned in Milwaukee and across the nation at the turn of the century, when surface water deteriorated. Sanitary engineers had followed the European practice of combining storm and sanitary wastes in a sewer network whose effluent was discharged into the available water course. In arid regions where stream flow was undependable and meagre, the population density was at first both scattered and transient. Rotation of privies resolved the waste problem until density became high. Technologies in transportation opened new opportunities to expanding populations and industries. In most areas, however, it appears that naturally available water resources for supply and waste assimilation became inadequate. By the 1920's, the need for better waste treatment and water purification was recognized in all of the large American cities. The shortage was particularly critical in western water supplies and in the eastern industrial centers with water pollution.

Curiously, metropolitan cities on sizable lakes or rivers were usually the last to be forced to take action in water development schemes. By the 1950's and early 1960's state and federal agencies were authorized to take stronger measures in guiding water re-

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sources, especially in flood control, pollution abatement, and in water supply. The Water Quality Act of 1965 is a preview of more comprehensive efforts by the Johnson administration to strengthen the federal role in water quality management in 1966 and 1967.

With new and more leisure hours, increased income, interstate highways, and the congestion of urban areas, water availability has taken on values previously assumed to be costless (see Fig. 1). Water-based recreation demand has increased sharply. Forty-four percent of the United States' population prefers water-based recreation activities over all others *(Outdoor Recreation for America, 1962)*. New premiums are attached to water resources because of increased demand from waste disposal operations, water supply, real estate developers, irrigation, power, and fish and game interests. According to the Kerr Committee Report of 1960 the rate of increase will be dependent upon the level of the population growth. The improvement and application of technology to keep pace with this increase, and the more intensive use of our land and water will require more research and acceleration of programs for conservation, development, and management of these resources *(Water Resources Activities in the United States, 1960)*.

Gilbert White, University of Chicago geographer, suggests that there is a tremendous gap between what exists and what is technically feasible. There seems little doubt that in every basin of more than 2000 square miles drainage area and in many smaller ones, there is the physical possibility of evening out flow by further storage, of decreasing the pollution of waters, and of readjusting upstream land use so as to reduce unnecessary soil loss and make wise use of water. Of course the *social* feasibility of such water and land management is a separate problem, according to White (1957).

Without a crisis in a river basin, rational long-term planning struggles along with the most modest budget. A severe drought or flood catalyzes activity—often misdirected because of the urgency of a recent catastrophe (Hart 1957). If protective legislation or policy is not soon established, however, the justification for the law fades with the memory of the crisis. With sustained public interest and support, ultimate decisions about present and future degrees of regulation and basin development are eventually cast into the political arena—as they should be. Through the political and institutional processes, objectives can be clarified and refined, countervailing forces can be organized and operated, public information can be dispersed and the goals of the public can be brought to fruition. As in so many other matters of rational land and water planning for metropolitan growth, there is a general apathy on the part of the uninformed and already overburdened taxpayer as well as a reluctance on the part of the politician to lead the way for fear of controversy that might cost him a vote (Higbee 1960).

The engineer is able to anticipate the quality conditions of any river passing through a basin. For example, assume that a stream receives domestic or industrial wastes from a community. After a period of recovery or "self-purification" under certain conditions, the stream is restored to specific levels of quality in terms of dissolved oxygen, bacteria, sludge deposition, biochemical oxygen demand (B.O.D.), or even temperature. As other communities load the stream with effluents regardless of the level of recovery, the conditions of the river at any point can be calculated with surprising accuracy. Yet the growing pool of knowledge is still incomplete, with several glaring examples such as the effect of algal photosynthetic activity on oxygen levels in flowing water or the effect of agricultural fertilizers accumulating by runoff in the river or lake.

Conceivably a better understanding of the human ecology in a river basin is an avenue which must be explored for better water-resource planning in the future. Once the human interdependencies, better deciphered, are superimposed upon the matrix of biophysical interactions, the calamity of irrational planning may well be avoided. The calamity, disaster, or sometimes merely the misfortune of the basin plan or design has been a national misallocation of resources and perhaps more important—an undermining of self-help by the region and population directly affected because of crisis decisions which force federal jurisdictions upon the disaster area. Hart (1957) emphasizes that a premium is placed on the unanimity engendered by crisis, and a hindrance placed on mobilization of a general interest of people in an interstate region in planning.

Numerous crises in basin development stem from an order of events which should be reversed. Many times projections for population growth and economic development have been used as a fundamental premise for water-resource development without the concept of a carrying capacity at present technology and prices. Would it not seem advisable first to establish clearly the carrying capacity of the basin in question and the array of alternatives available under various costs and intensities of development? With these data at hand, the political, economic, and administrative machinery at local (basin) and national levels would function with the realization that water resources are a major determining factor in economic activity, population growth, and the stabilization of a basin.

The benefit-cost analysis of public water resources projects assumes that prices in private markets generally register social values. But relief measures are not initiated by most polluters unless they are forced. Seldom can an inarticulate public (often uninformed) prevail against either the organized lobby of the heavily-endowed polluter or the small unknown polluter.

Too many departures from the narrow scope of ideal market conditions can occur for us to place great faith in benefit-cost analysis when it is subjected to the pragmatic test. Often dumping wastes into a river or a lake appears costless, on the assumption that natural processes will do the job. When the self-purification capacity is overloaded, however, the necessary job cannot be done. Thus a fuller cost should be assessed, although perhaps no cost whatever is calculated. The serious drawback is that distorted resource allocations and social costs are frequently applied because market or engineering plans create inefficient mixes of dilution, water supply treatment and waste treatment. The polluter wonders why he should incur a cost whose benefits are diffused downstream, often unclaimed but available to all.

My contention is that when the data are more comprehensive, a fee and bounty system could be arranged and subsidized through public–private cost-sharing. Costs have been assessed and accepted by users and nonusers of the national and state highways. The "truckers" of our streams should certainly be charged, once the data gap is closed. Once the computers can be fed the pertinent information, the terms and costs can be assessed with considerable certainty.

When computing the costs of alternative quality control devices, we should consider competitive and complementary relationships between water values and uses. For example, dilution through flow augmentation would have to be evaluated in light of the fact that this alternative is usually competitive to prime power production and complementary perhaps to flood control, navigation, and irrigation (depending on the season for the latter).

Visualize a private basin with many manufacturing activities of a single owner operating where the only allowable pollution would be that for which he would be willing to bear the full costs of sewage disposal and water treatment. Water treatment, to deal with higher pollution levels from effluent and flow augmentation, theoretically would substitute partially for sewage treatment.

Let us assume that the sales and purchases of goods and services in a model basin-wide firm provide an adequate yardstick. With this "market device", pollution abatement can be measured in economic terms as the ratio of inputs/outputs. Public decisions about pollution can be inferred from the actions of a firm which bears the total costs. Two problems confront public policy when it recognizes an area (our basin) as an interdependent system that would produce results varying in different beneficient ways from those yielded by the operation of free markets in a basin with independent pollution-producing and water-using units. One is the problem of devising an optimum system for waste control and treatment of water. The other is provision for an appropriate distribution of costs among economic units and activities.

One shortcoming of the hypothetical firm is an inability to show peoples' preferences in significant social values in the market of goods and services. Although not a new problem, it is one which demands a more thorough investigation. Another flaw is that the "economic efficiency" is much too narrow, coupled with a gross lack of information on pollution interrelationships. If this sort of welfare maximization (or cost minimization) were to become national policy, great care would have to be taken to prevent industries and municipalities or districts from passing on excess costs. Public regulation could experience difficulty keeping in step with these cost movements. No effort could be made until the necessary data is available, political valuations filling the vacancy for the time being. Overall, however, market criteria in a basin can establish guideposts and indicators of social value for the majority of goods and services.

Some of the unique organizational and engineering constraints which can be avoided only at very high cost are evident in the *inability to internalize* many pollution-created externalities. Sometimes a lake receiving 90% treated effluent over time shows an irreversible eutrophication. Indeed, no one can fix a cost on lake-aging in terms of littoral sludge buildup, a diminished hypolimnion (less depth and more toxicity), or increased turbidity. It is equally difficult to "charge" for high levels of electrolytes, alkyl-benzene-sulphonates, and assorted inorganics which resist breakdown because of infrequent detection and inadequate treatment. Inorganic concentrations may increase as water use increases and even as treatment continues. Political constraints have less rigorous conditions but add in with technical constraints to represent the extra cost limitation put upon achieving an ultimate goal.

Attention is called to southeastern Wisconsin, which will illustrate the merits and objections about the basin-wide firm. My case in point is the Milwaukee River, which begins 80 miles northwest of Milwaukee, Wisconsin, and meanders among morainal landscape into a heavily industrialized urban area of more than one million people. Dairy farms, heavy industry, tanneries, breweries and food processing represent key economic activities in the 845-square-mile drainage basin. As the stream approaches and parallels Lake Michigan, cities of progressively larger population pour untreated and treated wastes into the Milwaukee River. The river enters Lake Michigan at Milwaukee, spewing industrial and municipal wastes into the lake, which is after considerable dilution the source of drinking water for numerous cities, including Milwaukee, along the Wisconsin–Illinois shore. Before 1900 and the subsequent industrial and population growths, the river was used for swimming, boating, water supply, fishing, power, and navigation. Today pollution curtails the first four uses; the last two have been halted for other reasons.

Three abbreviated models tailored from Kneese (1962) suggest solutions for the pollution problem in southeastern Wisconsin. Since the vast industrial and manufacturing complex at Milwaukee represents the key economic growth and the greatest user of the basin, benefits should be based mainly on industrial expansion and increased waterfront use envisioned after pollution abatement. Please assume that the present economic growth will continue, and that factors of production (labor and capital) will be mobile. Also assume that governmental agencies and political structures will maintain present constraints in addition to the physical or technical constraints of today's pollution level, which has drawn the limit on industrial growth and municipal use of the river. Let us now consider models X, Y, and Z.

Model X proposes specialization of the river. Certain tributaries are zoned as clean-water streams, others and the main trunk as legal carriers of waste. Regrettably, time and information available do not permit a thorough presentation of pertinent data about benefits to industry and to recreation, value added, least alternative costs, and the benefit-cost ratio. For all alternatives, the data must be complete and specific if courses of actions are to be qualified, compared, and evaluated. The physical layout of Milwaukee suggests that specialization under Model X might be ideal: when the river becomes loaded with pollution beyond the point of marginal costs of treatment, industries and users turn to the clean streams left in the basin, to ground water, or to Lake Michigan. But ground waters are sinking out of economic sight and clean streams have found competitive uses in recreation as well as in the complementary use of diluting the main polluted stream. The lake is logically next. Biologically and chemically, however, something is happening to the quality of the lake water, making it progressively more expensive to treat and use. With the relaxation in Model X of waste treatment to substitute for greater water treatment, a problem has been created far beyond the basin model.

Lake Michigan, despite its size, has begun to show significant signs of eutrophication primarily from excessive siltation, agricultural runoff, and wastes from the eight million people along its shores. Hard to calculate in the workings of the model is the water quality level which Chicago would like to maintain for dilution purposes as it takes Lake Michigan water to augment flow in the Chicago Sanitary Canal—Illinois River flowing to the Mississippi.

Model Y presents an alternative of flow augmentation which strangely enough in one situation means recirculation. Again necessary volumes of data, benefits, and costs are needed. Three types of flow augmentation should be applicable. The first is a system of storage reservoirs which would flood a highly developed flood plain at very high social costs for translocation, etc.

A second possibility is flushing the river with Lake Michigan's water, an action which presupposes the need for river water quality maintained by cold, oxygen-abundant lake water. However, the intake for the flushing tunnels would include increasing amounts of water polluted by the river, whose mouth is nearby. A combination of the first two techniques could be a third type of augmentation. Would this water quality permit the reopening of city beaches now closed?

It might be of interest here to note that a proposal from the mayor's special water pollution committee suggested that the lake pollution be abated by chlorinating the harbor basin (where the river empties into Lake Michigan). Inadequate information is conspicuous when investigators with or without cost analyses come up with such a suggestion.

Model Z offers the possibility of widespread secondary treatment (activated sludge, trickling filters, etc.) by users—individuals, industries, and municipalities. Refined secondary treatment, stabilization ponds, tertiary treatment, separate storm and sanitary system, and better-than-nothing primary treatment could and should be evaluated singly or as a composite activity for the basin plan. In addition, as in the other methods and models, the downstream and downlake effects (in an interdependent system) must somehow be ascertained and the cost functions of alternatives including the pollution damages of models X and Y must be known. Only when these are available can the over-all comparable costs of alternative systems be explored.

These three models could serve as frameworks on which to hang various data. A present normal is provided in the assumptions. A budget analysis of opportunity costs, comparable values, and benefit-cost ratios is implied before and after a particular model is applied. A new allocation of resources should follow if suggested by economic efficiency. In short, the goal is the most efficient combination of factors to minimize cost and maximize social welfare in the basin. Sometimes, as on the Miami River, Ohio, a power plant is forced out of an area because of demands of economic efficiency. Loss of the tax base and the farther distance of power transmission pass along a higher cost to the consumer. Yet the total "economic ecosystem" must be taken into account before a final judgment.

By drawing up comparable budgets of anticipated returns and costs of certain alternatives, we can make significant strides toward water allocation in a water-dependent economy which may make the fullest use of available resources. Alternative choices need not, however, be judged totally on economic efficiency. Success is apparently forthcoming in Germany's Ruhr Valley. The Milwaukee situation illustrates, however, that a system has a constraint in the dependence on larger watersheds and basins. Time, distance, and natural processes make cost assessment difficult and highly complex. As well as quantity, water quality must be treated as a variable.

Pollution abatement facilities must be judged on more than just technical-engineering estimates. When alternate economic terms are combined with engineering solutions, the prospective beneficiaries are still confronted by institutional and administrative problems. Even an economically and technically sound proposal can be crushed in the institutional meshwork, whether it be in the valley of the Milwaukee or the Missouri or the Huron. The marginal approach is not perfect because marginal data are often unavailable and ideal market conditions do not exist in a river basin, even if the economic service area is identical with the basin boundaries. Nevertheless, these alternatives help to bring out the real problems, which is a step toward finding answers for their solution.

Upon close scrutiny, even "non-consumptive" uses can, in fact, be costly. Hirshleifer *et al.* (1960) lists the very significant values of water that can be lost when the "non-consumptive use" is for cooling, navigation (streamflow conflicts with values accruing to pollution dilution and/or irrigation and/or hydropower peaking pools), and water percolating underground, which is lost because of extraction costs or minerals added. To avoid a calamity in water-resource planning stemming from a crisis in the basin, economic analysis alone will not suffice. In sectors of the western states, water has become more scarce than the dollars needed to recapture it. Folz (1957) warns that if additional water supplies are not made available, water may become a *limiting factor* to economic expansion—and such situations are increasing. Certain parts of California are already facing an arrest of growth owing to water shortage; and the future growth of the populous industrial areas in the East will largely depend on their ability to restrict those uses of water the marginal utility of which is lower than that of urban development uses.

It would appear unwise, therefore, in spite of temptations that will be presented in the future, to base the expansion of the economy on temporary increases in the supply of investment capital and similar increases in the supply of water, since almost certainly the future will bring renewed periods of drought. The wiser course would seem to recognize the carrying capacity or minimum supplies available in the long run—permitting adjustments from innovations in technology—and development of the economy on those criteria.

The idea should not be conveyed that every basin crisis brings a calamity because of irrational planning or even that every basin is destined to experience a catastrophe. Commentators on the Delaware River Basin insist that "there is time to plan and build to provide for all the uses of as much water as engineering and economic techniques are capable of providing. There is no overpowering crisis (flood, famine, depression) today that is compelling precipitate action toward ill-considered, unbalanced, and unwise construction along the Delaware. Water development clearly is not *the* key to economic growth in this humid eastern area, hence other broad social and economic considerations will need to be taken into account if the maximum economic potential of the basin is to be realized. Serious shortages of good water may appear by around 1980, for the supply is becoming progressively less generous. Undoubtedly, development will be planned and construction begun before any crisis appears" (Martin *et al.*, 1960).

Aside from some work being done by the Wisconsin Southeastern Regional Planning Commission, other commendable efforts toward basin-resource planning in the absence of critical crises are those in the Huron River Basin in southeastern Michigan. After more than seven years of citizen participation in organizational planning, including a Huron River Watershed Intergovernmental Committee, the 1964 Michigan legislature provided the basin and the state with an enabling act (Act. No. 253, Approved May 28, 1964) which authorizes units of local government to cooperate in planning and carrying out a coordinated water management program in the watershed which they share. If the planning process enables the citizenry to foresee and prevent a crisis in the basin, the management and planning effort should serve the best public interests over the long run as well as the short run. The recently formed Huron River Watershed Council is a positive step.

For comparison of a less envious record of achievement in a river basin development for the public good, attention is directed to another small watershed in southeastern Wisconsin, the Milwaukee River Basin. During the early part of the twentieth century, exemplary efforts were made by the Milwaukee County Park Commission in river parkway recreational development (See Fig. 2). In recent decades, however, Milwaukee and its environs have grown in a typical urban sprawl without concern for the river or the basin

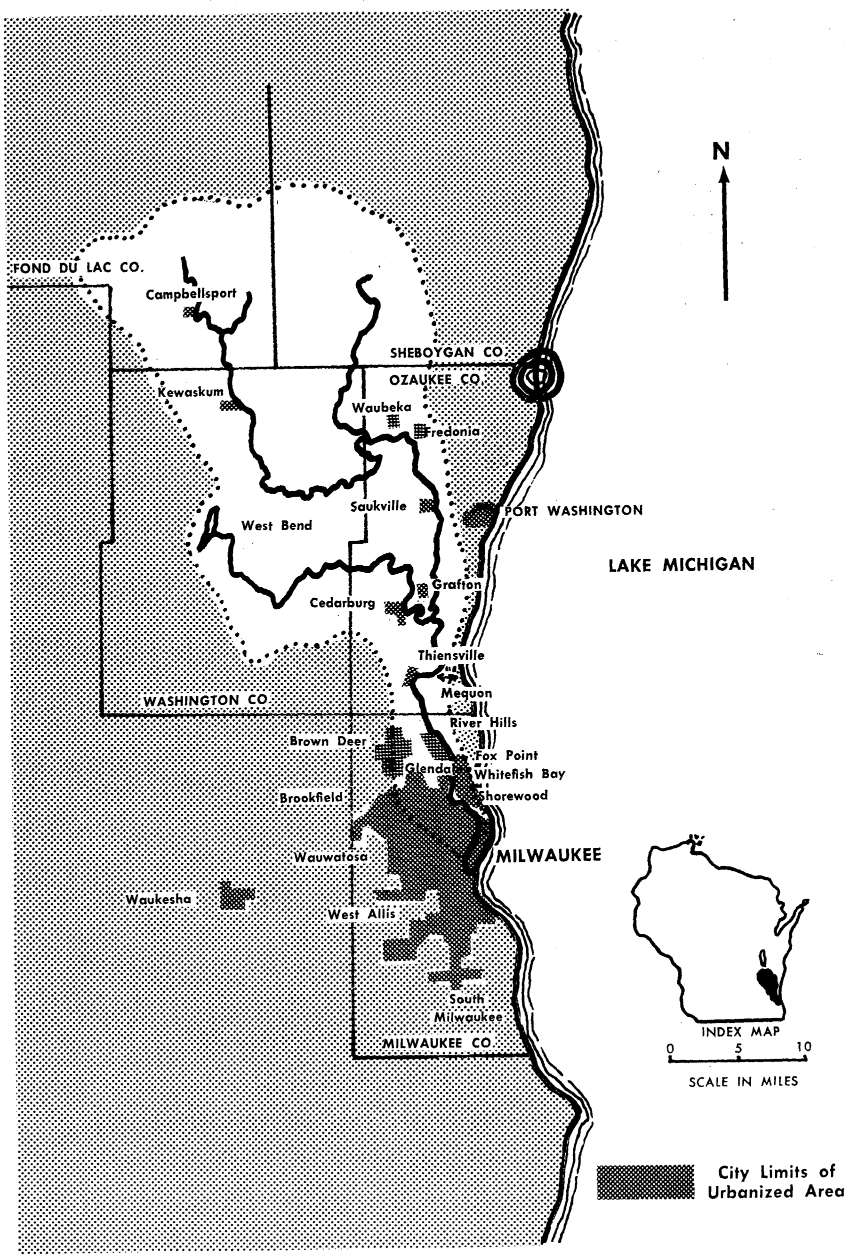

FIG. 1 MILWAUKEE RIVER BASIN

FIGURE 2. View from Gordon Park across Milwaukee River one block downstream from Locust Street bridge circa 1920. (Milwaukee Public Museum photo.)

beyond the political boundary of the county (Fig. 1). Perhaps the most calamitous assumption in the minds of local planners was that because the Milwaukee metropolis adjoined one of the largest and deepest fresh-water lakes in the world, the city would never face a water resource problem. Lake Michigan may not always be the water planner's Elysium. Nevertheless, this visual and mental association with "limitless" Lake Michigan has prevented the intensification of public interest even in light of minor crises. Only recently has some effort been made to call upon the Southeastern Wisconsin Regional Planning Commission to suggest a plan for the Milwaukee Valley, as was done in another smaller basin whose representatives expressed concern. In summary, it is felt that certain modest proposals should be offered in the form of hypothetical recommendations which if implemented through proper and as yet unestablished administrative and political channels might prevent a calamity in the event of a crisis in basin resource allocation and planning.

The five recommendations which follow offer the most feasible possibilities for basin water development from the author's observations of the predicted growth in the basin and his analysis of the physical features of the basin landscape. It is suggested that the proper authorities (still to be determined) propose a schedule of priorities for these or other suggested projects in the hope that one politically and economically practical may emerge. It is absurd to contend that all the developments must begin at once, and it is equally absurd that all must wait—especially in the light of present demand for recreational facilities and even the most modest population projections for the region.

(1) Fifteen existing reservoirs should be brought into greater use. A number of new small reservoirs in the upper regions of the Middle and North Branches of the Milwaukee River would provide excellent pools for swimming, boating and fishing. Some should be designed particularly as wildlife refuge. Long Lake, Kettle Moraine Lake, Mauthe Lake, Lake Ellen, Wallace Lake, Silver Lake, and Little Cedar Lake all typify the use and the congestion in Milwaukee River Basin lakes. The topography southeast of Eden in southern Fond du Lac County has abutments for artificial lake impoundment. Much of the land along the North Branch of the Milwaukee River is marginal pasture or sub-marginal cropland. Most of the land suggested for the small catch basins on both branches is presently marsh. With reforestation to improve the terrain bordering the artificial lakes, attractive recreation areas can be created now at low social costs. Proposed recreation sites are about 45 minutes by auto from Milwaukee.

(2) Four and one-half miles north of the interchange of U.S. Highway 141 and Wisconsin 100, the Milwaukee River loops within about 5,400 feet of Lake Michigan. A recommendation is made that a two-way channel or tube be constructed which would carry in times of flood almost 10,000 c.f.s. from a small auxiliary reservoir on the Milwaukee River to Lake Michigan. Perhaps a pump-siphon arrangement is feasible (the river channel downstream has been improved to carry 6,000 c.f.s. and the maximum flow on record is 15,100 c.f.s.). In dry weather, pumps reversed from flood conditions could lift Lake Michigan water to the "aqueduct" to augment flow according to the needs of industry and waste assimilation. Lake water would have to be lifted about 104 feet before gravity would carry it down to the river channel (See Fig. 1).

(3) It appears that at least four stretches of "blue-green corridors" are or will be urgently needed to prevent flood plain buildup as well as to provide critical recreation area along the Milwaukee Waterway. The Milwaukee County Park Commission has successfully used the parkway-river bank idea. Estabrook, Lincoln, and Kletzch Parks are excellently-designed examples of what needs to be done basin-wide.

Taking into consideration present residential and commercial development, the author urges the establishment of at least these four blue-green corridors, which offer scenic river beauty and recreation besides a safeguard against future severe property loss from flood inundation (all four corridors are shown shaded in Fig. 3).

(a) A four-mile river parkway just north of Kewaskum, Wisconsin, with easy access from U.S. Highway 45. It is assumed that land would be obtained 0.5 mile in both directions from the river bank, usually by easement, donation (as in most of Detroit's metropolitan parks), or outright purchase.

(b) Another four-mile scenic corridor from Kewaskum south along the river to almost the Barton–West Bend area. A small corner of the Kettle Moraine State Forest reserves an additional mile near the northern portion of this corridor (See Fig. 3).

(c) East of West Bend a scenic six-mile waterway meandering toward Newburg. Easy entry to the sparsely settled river bank would be possible from roads paralleling the corridor on the north and south. Before the heavy picnicking and camping season, high water canoeing should be popular in this and in the other corridors.

(d) Probably the first blue-green corridor which should be established, a five-mile stretch from the Waubeka–Fredonia vicinity south to Saukville. Fortunately the Ozaukee County Parks of Waubedonia and Ehler's begin and end this proposed blue-green corridor. Again highways parallel the corridor conveniently on the east and west. Parenthetically, the greatest expected flood plain residential and commercial development will be from Waubeka–Fredonia south along the river through Saukville, Grafton, and Mequon to Milwaukee.

(4) Several Lake Michigan bathing beaches in Milwaukee are closed 25–30% of the swimming season because of increased coliform counts after at least 0.1 of an inch of rain and excessive aquatic plant growth from eutrophication caused by nutrients from basin runoff and normal "efficient" sewage treatment. Even with cool lake water most of the summer and deteriorating water quality, excessive crowding on the beaches is a critical problem. In providing recreation facilities for the 1970's, the suggestion is made that a new Milwaukee Metro-Basin Lake Michigan Beach Park be created 36 miles north of Milwaukee, east of Lake Church. Approximately 640 acres with 6,000 feet of sandy beach frontage, in no danger of water pollution, appear to offer excellent potential as a recreation area. The high bluffs of the Lake Michigan shoreline near Milwaukee are absent here. Land back from the lake in the proposed park (held by private out-of-state owners) is wooded

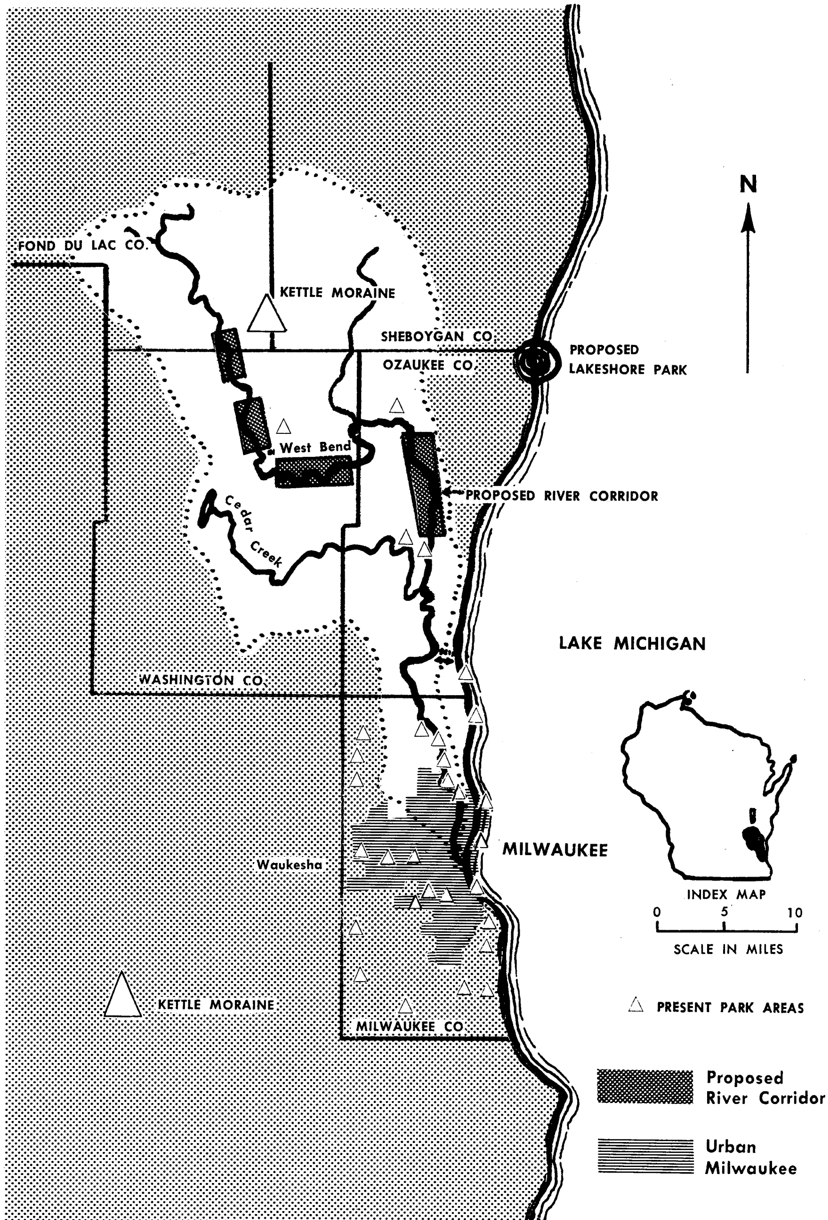

FIG. 3 MILWAUKEE RIVER BASIN WITH PRESENT AND PROPOSED RECREATIONAL AREAS

and contains a small bedrock lake. See the triple circle along Lake Michigan shore in Fig. 1 or Fig. 3.

(5) The final recommendation focuses on the revitalization of mid-metropolitan boating. An extensive small craft marina is under construction and a boat launch ramp is in operation in the outer harbor area. With this development it would seem economically rewarding to attract marine craft into the downtown area via the lower river. Riverside docks, shops and promenades would be possible if storm-sanitary sewer separation continues, along with increased waste treatment and reduced ground water infiltration into the sanitary system.

Above North Avenue dam abandoned property already owned by the Milwaukee County Park Commission and private firms should be converted to river bank-parkland similar to upstream Estabrook and Lincoln Parks. Kern, Riverside, Hubbard, and Gordon Parks are fine beginnings along the two-mile double bank potential. Forty years ago, when pollution was probably an equally or more severe problem (before separate sanitary sewers), great activity occurred along the mid-city waterway (See Figures 4 and 5). If boating facilities were provided, following this recommendation, and riverside landscape improved, recreation of the past could be restored, offering additional use and enhancement of the present green corridor. Augmentations of stream flow suggested in (2) would be provided and balanced in a volume beneficial to industry, civic amenities, and river recreation but not to jeopardize presently useful Lake Michigan beaches and water intakes.

Conclusions

(1) Lake Michigan offers unlimited water supply for industrial and population growth but at increasing cost of water treatment as pumping increases and as intakes are extended. Part of the added cost is caused by deteriorating lake water quality. No use of Milwaukee River water is for potable supplies.

(2) Lake Michigan offers limited recreational facilities in the Milwaukee vicinity. As an alternative, several possibilities are spelled out in the form of upriver recreation corridors and small artificial lakes zoned for specific uses. These reservoirs should not be justified primarily by flood-control benefits as has been attempted previously. The dual purpose diversion and flow augmentation facility east of Thiensville would provide both flood and low flow protection. Minimum monthly average flows could most probably be *maintained* in excess of 300 to 500 c.f.s., using the new facility in combination with present reservoirs.

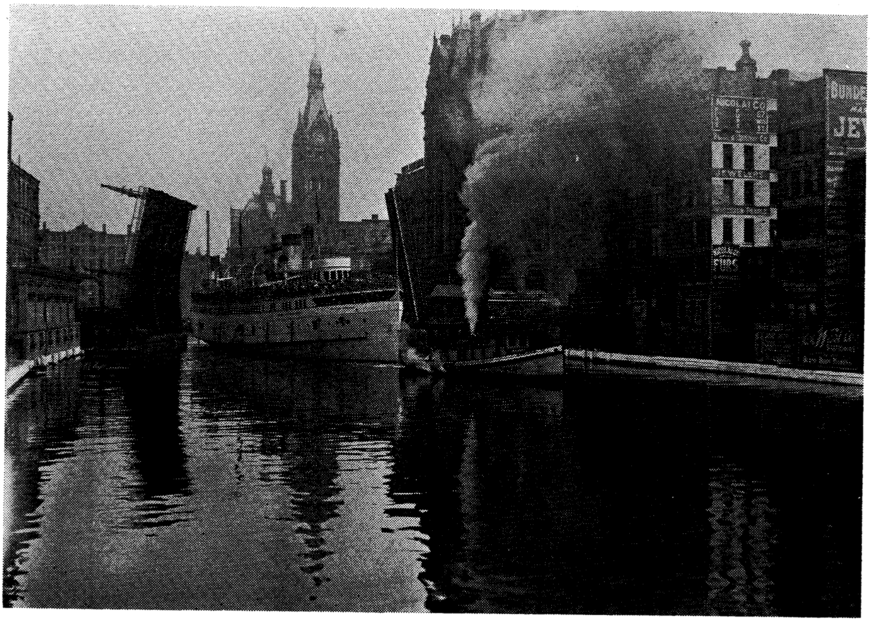

FIGURE 4. Excursion boat on Milwaukee River at Wisconsin Avenue bridge. Milwaukee City Hall in background. Marine National Exchange Bank has replaced buildings on the right. Circa 1920. (Milwaukee Public Museum photo.)

(3) Instead of major waste lagooning, flow augmentation, or both to furnish drastic pollution abatement, the proposal is made to provide increased and alternative recreation areas within easy driving distance of a growing metropolis, and hold the line on river and lake water quality deterioration through treatment, separation of sanitary and storm sewers, and elimination of ground water infiltration into the Metropolitan Sewerage Commission facilities.

(4) A basic assumption is that a dilatory program in recreational water development and enhancement of the basin environment can act as the greatest constraint on growth in the basin, which has ample water, transportation facilities, and other factors to expedite growth and social welfare.

We can be certain that the demand and need for recreation facilities along the Milwaukee River Waterway will continue. It is hoped that these wants can be met through appropriate water-resource development and management. Crisis should be avoided in planning to satisfy the multiplicity of wants of any basin. The water potentials which move states, cities, and the nation to act hastily are fleeting and capricious and incapable of being harnessed economically, save by measures which assume long-term human enterprise. One alternative before us, therefore, is to continue to try to

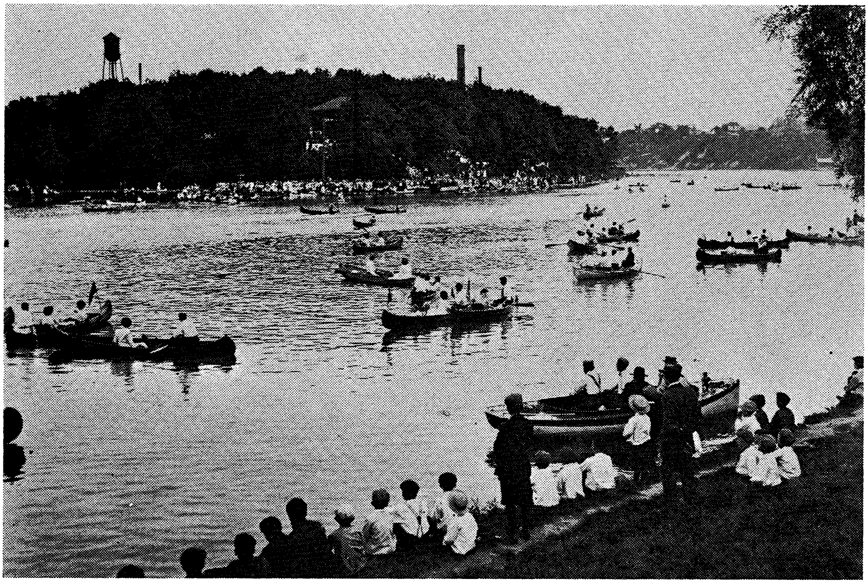

FIGURE 5. Mid-city Milwaukee River recreation activity at Riverside and Gordon Parks about 1918. Revived river use is proposed in conjunction with vigorous water pollution abatement. (Milwaukee Public Museum photo.)

rationalize our national government and to make uniform devolutions to the states—although consent born of crisis will continue to thwart and misdirect those efforts (Hart 1957). Organizational interrelationships of a basin are a fascinating phenomenon in human ecology. When considered together with the basin carrying capacity and with the physical and economic features which determine substantive policies and practices, they should help maximize present opportunities and permit prudent, rational future alternatives in basin planning.

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THE TRENTON METEORITES

W. F. Read and H. O. Stockwell

Although meteorites are commonly named for the town large enough to have a post office nearest to their discovery location, the Trenton meteorites are an exception. Trenton is not a town but a 36-square-mile township in Washington County, Wisconsin. The center of the township is about four miles east of West Bend, or roughly 30 miles north of Milwaukee.

First published notice concerning the discovery of iron meteorites in this township was a short article by J. Lawrence Smith[1] in the *American Journal of Science* for 1869. Smith reported that four specimens had been found, weighing 62, 16, 10, and 8 lbs., and that all had been acquired by the German Natural History Society of Wisconsin. F. Brenndecke reported to the Natural History Society in 1869[2] that the 62 lb. mass was found in 1858 and purchased by I. A. Lapham. The three smaller specimens turned up "in the years immediately following" and went into the Society's collection. A fifth piece was said to have been found but could not be located. The 62, 16, 10, and 8 lb. specimens will be referred to as Nos. 1, 2, 3, and 4.

In 1872, Lapham reported[3] the finding of two additional specimens: one of 16¼ lbs. in 1869 and another of 33 lbs. in 1871. He purchased the first for his own collection. The second was sent to M. Von Baumbach "to be taken to Europe." The 16¼ and 33 lb. specimens will be referred to as Nos. 5 and 6.

Mr. Carl Gauger has advised the authors that about 1880 a specimen weighing approximately 10 lbs. was found on his property and taken to the Milwaukee Public Museum. This specimen will be referred to as No. 7.

H. O. Stockwell of Hutchinson, Kansas, visited the area in September, 1952, and went over considerable ground with a metal detector. Results were spectacular. On the second day he found one mass of 413 lbs. a few feet away from another of 527 lbs. Later he found a small specimen weighing 1½ lbs., and purchased two more specimens from local residents. One was a 6½ lb. mass reportedly found before 1890. The other, weighing 3 lbs., was said to have been found about 1933. The 6½ lb. mass will be referred to as No. 8; the 3 lb. mass as No. 9; and the 413, 527, and 1½ lb. masses as Nos. 10, 11, and 12.

Some notes concerning the disposition of Stockwell's five specimens are in order. About 80 lbs. were removed from the 527 lb. mass and sold to Ward's Natural Science Establishment. The remainder of this and the entire 413 lb. mass have been purchased by the U. S. National Museum. The 6½ lb. mass and half of the 1½ lb. mass were sold to R. A. E. Morley of Salem, Oregon.

In August 1964, W. F. Read and his son discovered another specimen of 9½ lbs. while working with a metal detector similar to the one used by Stockwell.[4] This will be referred to as No. 13.

A summary of the finds to date is as follows:

		Found	Weight
No. 1		1858	62 lbs.
2		1858–68	16
3		”	10
4		”	8
5		1869	16¼
6		1871	33
7	c.	1880	10?
8	c.	1885	6½
9		1933	3
10		1952	413
11		”	527
12		”	1½
13		1964	9½

Location of Finds

The only finds whose locations have been recorded with any precision are those made by Stockwell and Read. Smith reported that the first four specimens were found "within a space of ten or twelve yards very near the north line of the 40 acre lot of Louis Korb". Lapham's manuscript notes[5] include a map which shows that the Korb property was the SW¼ of the NE¼, Sect. 33, T 11 N, R 20 E, and that the meteorites were found near the center of the north line. Lapham's 1872 report on the finding of Nos. 5 and 6 states only that they were found "in the same field". His manuscript notes, however, say that No. 5, at least, came from "very near" the place where Nos. 1–4 were found. The approximate discovery sites of Nos. 7 and 9 were pointed out to W. F. Read by Mr. Carl Gauger, who now owns the property. According to information obtained locally by H. O. Stockwell, No. 8 was discovered on an old stone pile formerly about 500 ft. northwest of the Gaedke barn.

Figure 1 shows with varying degrees of accuracy the discovery sites of all specimens except No. 8. Coordinates of the main site

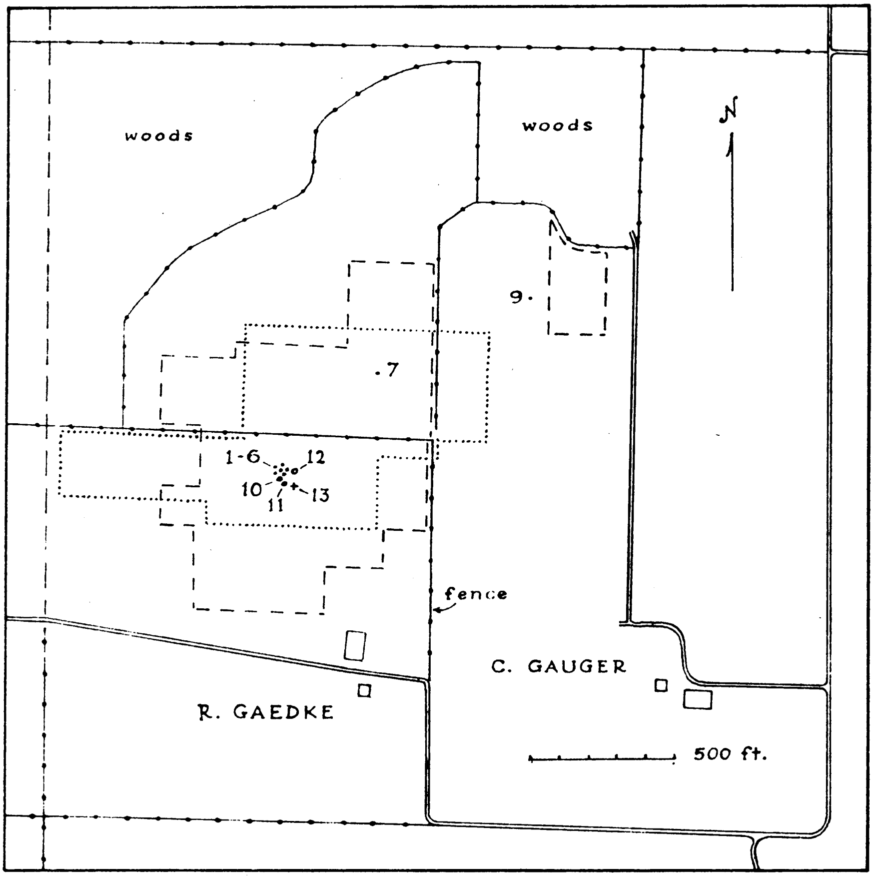

FIGURE 1. Northeast quarter of Sect. 33, T 11 N, R 20 E. Meteorite discovery sites: cross indicates precise location; circle, fairly precise location; dot, approximate location. Dashed line shows limits of detector coverage by W. F. Read; dotted line, approximate limits of detector coverage by H. O. Stockwell.

(Nos. 1–6, 10–13) are Lat. 43″ 22′ 44″; Long. 88° 6′ 30″. (Smith gives the latitude as 43° 22′, and the longitude as 88° 8′.) The nearest town is West Bend, about 4 miles to the northwest, for which according to modern usage the meteorites should have been named.

No. 5. External Form

The Greene collection at Milwaukee–Downer College included a 16¼ lb. uncut iron meteorite identified in the catalog as from Washington County, Wisconsin. Presumably this is specimen No.

5, found in 1869 and acquired originally by Lapham. When and how it came into the Greene collection is unknown. When Milwaukee–Downer merged with Lawrence College in 1964, the bulk of the Greene collection was purchased by the University of Wisconsin–Milwaukee. This specimen was loaned to W. F. Read for study. Its external form is shown in Fig. 2. The original shape has doubtless been somewhat modified by oxidation. The bottom side in the upper photograph (same as upper two thirds of lower photograph) shows low knobs separated by shallow depressions and may be an ablation surface from the exterior of the parent mass. The other three surfaces are evidently the result of rupture, with no apparent subsequent modification by ablation. The one to the left of the label in the upper photograph is jagged and suggests rupture by pulling apart. The bottom surface in the lower photograph is smoothly curved, as if by shearing. The (poorly shown) top surface in the upper photograph is about two thirds smooth and one third jagged, suggesting a combination of shearing and pulling apart. Whether rupture took place on or before impact (or both) is not clear.

No. 5. Structure and Composition

Fig. 3 shows the appearance of an etched section. Kamacite bands are about .7 mm. wide, making this a medium octahedrite, as noted in the Prior–Hey Catalogue.[6] Since the Widmanstätten pattern is continuous across the entire section, this is evidently a fragment from a single large Ni-Fe crystal.

An interesting feature of the kamacite bands is their tendency to show a certain amount of curvature. This can be seen by using a straight edge on Fig. 3. Presumably the bending is from stress encountered either (1) during the meteorite's pre-terrestrial history, (2) while passing through the earth's atmosphere, or (3) on impact. These alternatives are certainly not mutually exclusive. Along the upper right edge of the section as shown in Fig. 3, the Widmanstätten figure disappears in a jumble of irregular kamacite grains. These are transected by a small "fault", clearly traceable for a distance of about 6 mm. The fault is quite tight, certainly not an open fracture, and suggests shearing under high pressure, presumably pre-terrestrial. The reason for the granular structure and its genetic relation, if any, to the fault, remains a question. The oxide-filled fracture visible along the lower edge of the section in Fig. 3 clearly differs in origin from the fault. It appears to be the result of incipient rupture under low confining pressure. Another indication of stress (Uhlig's interpretation[7]) is seen in the occurrence of Neumann lines in many of the kamacite bands.

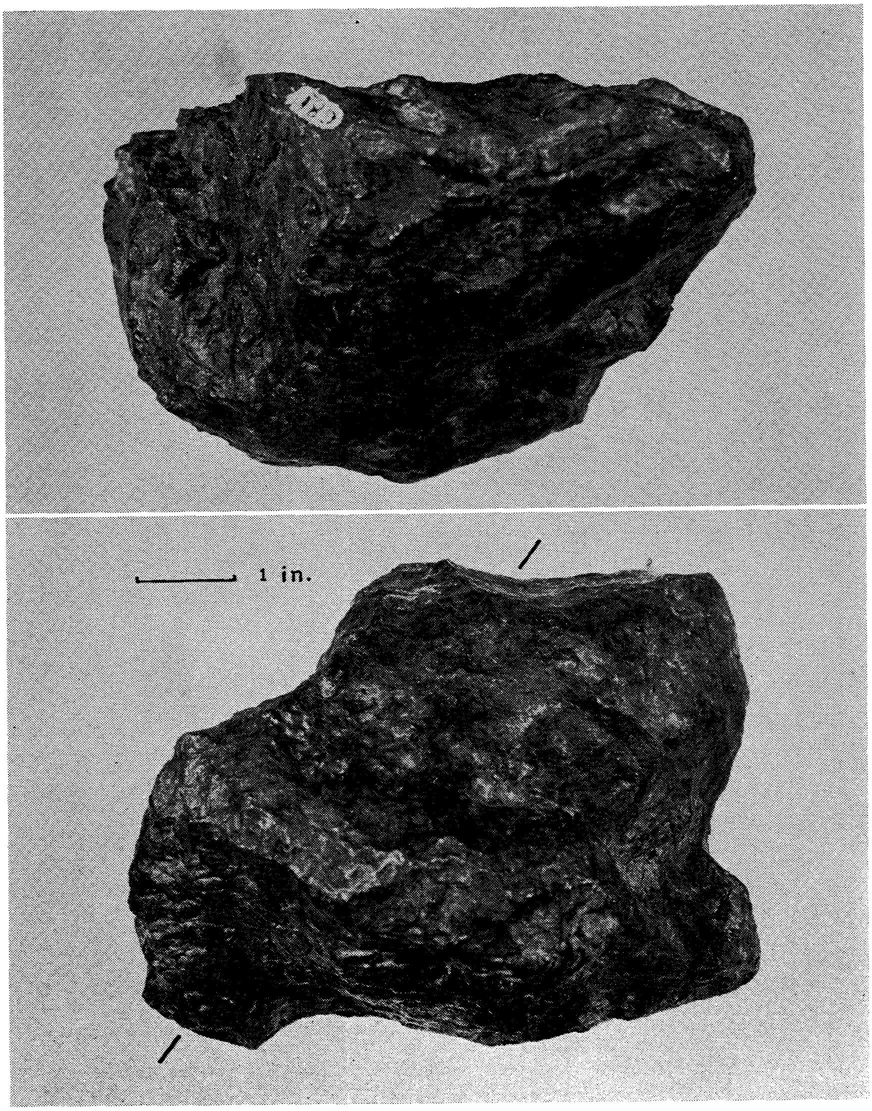

FIGURE 2. Two views of Trenton No. 5. The side shown in the lower photograph is at the bottom in the upper photograph. Short lines indicate the position of the sawcut for the etched surface shown in Fig. 3.

Perry[8] has called attention to the prevalence of "hatching" (regarded by him as a gamma-alpha transformation structure) in the kamacite of Trenton specimens at the U.S. National Museum. This is conspicuous also in the kamacite of Trenton No. 5.

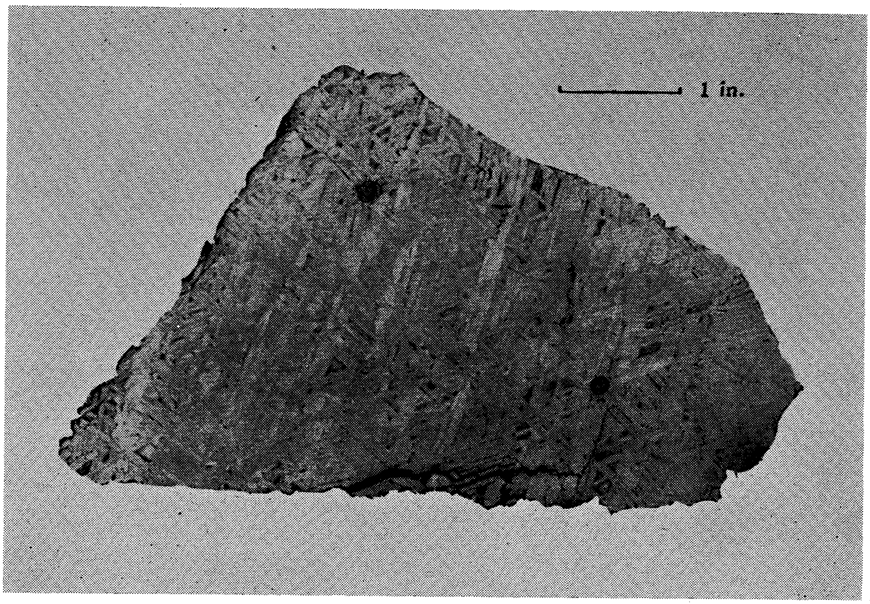

FIGURE 3. Etched face of end piece cut from Trenton No. 5. The black "vein" at the bottom is oxidized material following a fracture.

Plessite fields are numerous and of variable structure. Some—usually the smaller ones—consist of "dense", apparently homogeneous material etching dark grey. Some contain abundant small granules of kamacite in a dark grey matrix. And some show fine kamacite bands instead of the granules, the bands running in one or more directions conforming to the surrounding Widmanstätten pattern. When bands and granules occur in the same field, the bands tend to be disposed around the borders with granules toward the center.

Troilite occurs in Trenton No. 5 as nodules, thin plates, and small, irregular grains (See Fig. 4). The nodules (Fig. 4 shows two) lack a continuous envelope of swathing kamacite, but are surrounded by irregular kamacite grains that stand out clearly from the adjacent Widmanstätten pattern. It is well known that troilite undergoes a considerable volume increase by inversion at 130° C. This may explain the fact that some of the oxide-blackened fractures visible in Fig. 3 seem to be roughly radial to the troilite nodules. Note especially how the large fracture along the bottom edge turns upward at its right-hand extremity and terminates against the nodule in this vicinity. The thin plates of troilite may be straight or distinctly curved. They grade into more or less lenticular bodies. Some of the plates and small grains may have failed to show up

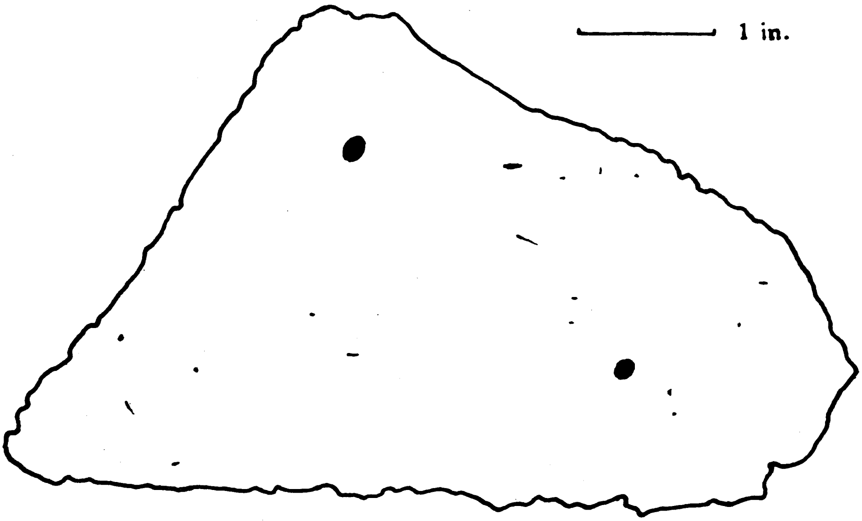

FIGURE 4. Distribution of troilite in the etched face shown in Fig. 3. The smaller particles were located by means of a sulfur print.

on the sulfur print from which Fig. 4 was taken. For example, the straight, black line extending toward the upper left from the left-hand nodule in Fig. 3 appears to be a completely oxidized thin plate of troilite.

TRENTON NO. 13

As noted above, Trenton No. 13 was discovered by W. F. Read and his son in August 1964. It lay at a depth of about 1½ ft., where the oxide crust was undisturbed by cultivation. The surface which appears at the top of the upper photograph in Fig. 5 is smoothly convex and was probably shaped by ablation. The opposite surface, shown in the lower photograph, is extremely irregular. It is heavily encrusted with limonite, locally forming short, finger-like protuberances. The surface of the metal underneath is apparently quite jagged, probably indicating a rupture surface formed by pulling apart. Trenton No. 13, which has not yet been sectioned, remains for the present at Lawrence University.

ACKNOWLEDGMENT

The *West Bend News* was most helpful in paving the way for Stockwell's collecting work. Reuben Gauger, who then occupied the Gaedke farm, and Carl Gauger kindly permitted Stockwell to work parts of their farms with his metal locator. Subsequently Robert Gaedke and Carl Gauger extended similar hospitality to Read. For

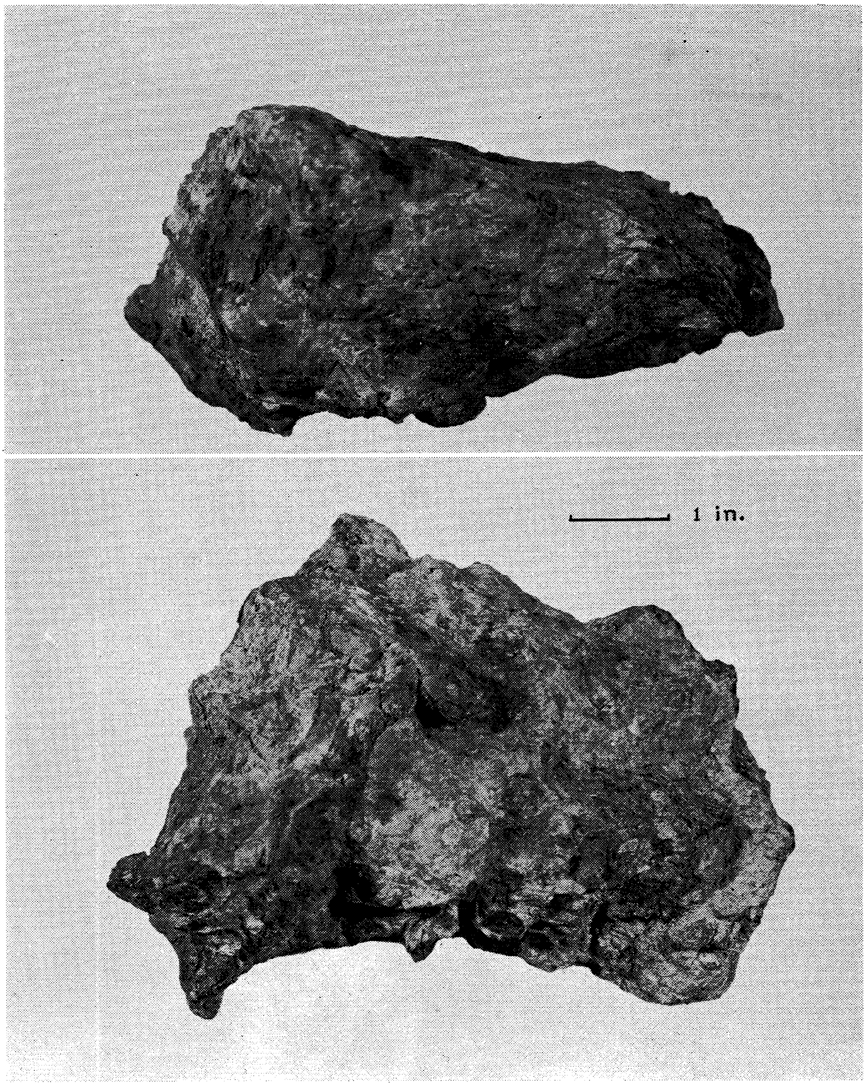

FIGURE 5. Two views of Trenton No. 13. The side shown in the lower photograph is the bottom of the specimen as shown in the upper photograph.

the loan of Trenton No. 5, described in this paper, Read is indebted to Prof. R. A. Paull of the Geology Department at the University of Wisconsin–Milwaukee. Mr. R. A. E. Morley of Salem, Oregon, furnished valuable information on the history of Trenton finds. For data derived from Lapham's manuscript notes, the writers are indebted to Mr. Walter E. Scott of Madison.

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FISHES OF SOUTHWESTERN WISCONSIN

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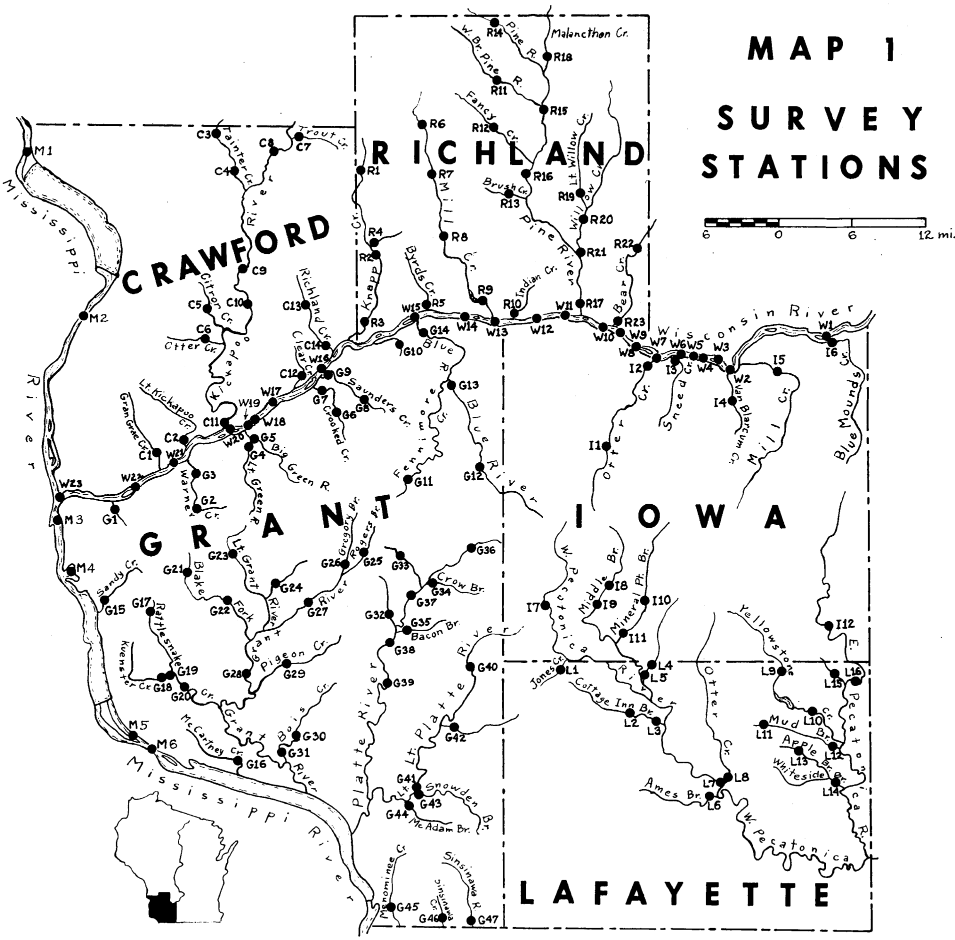
The last extensive sampling of the fish fauna of southwestern Wisconsin was made by C. Willard Greene during the late 1920's. In 1935 he published *The Distribution of Wisconsin Fishes.* Although many studies on game fish have been made in southwestern Wisconsin since Greene's time, no inventory of fish species has appeared since. The present study includes inland and boundary waters of the counties of Richland, Crawford, Grant, Iowa, and Lafayette. The stations sampled appear on Map 1.

From June 27 to June 30, 1960, eleven stations (L6–16) were sampled on the Pecatonica River and its tributaries in the eastern half of Lafayette County and one station (I12) in Iowa County. From June 20 to August 18, 1962, 135 stations were sampled along the lower Wisconsin River, the inland waters of the counties of Richland, Crawford, Grant, Iowa, and Lafayette counties, and one station on the Mississippi River (M4). From July 15 to 18, 1963, four samples (M2, M3, M5, M6) were taken from Pools 10 and 11 of the Mississippi River. On June 27, 1964, a sample (M1) was taken from Pool 9.

One hundred species and more than 90,000 individuals were seen or handled. Readily identified species were returned to the water. Those whose identification was questionable were preserved in 5% formalin, sorted, and identified later. Examples of all species have been transferred to 40% isopropanol and are stored at the Biology Museum, Wisconsin State University, Stevens Point.

In medium-sized streams to large rivers the most useful collecting device was a nylon seine 25 feet long, 6 feet deep, with 3/16-inch bar measurement. It was used almost exclusively on the Wisconsin and Mississippi Rivers along sand and mud bottoms in water 4 feet deep or less. Because over shallow rocky bottom the seine was less effective in capturing darters, at stations W12 and W15 (see Map 1) we used an alternating current shocker with 100 feet of cable. The darters were extracted from between the rocks with scape nets. A boom shocker, powered by a direct current generator, was used to capture the deep-water fish from the Wisconsin River. The direct current drew fish momentarily to the electrodes, from which they were removed with scape nets. We found the boom shocker ineffective against fish less than 4 inches long.



One to two hours were devoted to collecting fishes at each collection site. An attempt was made to sample from all possible habitats. On the Wisconsin River, for instance, we collected from sloughs, riffs over sand flats, island pools, isolated overflow pools, swift water, slow-moving water, and seepage bayous. A 12-foot boat powered by a 5-horsepower outboard motor carried us to a wide variety of habitats at each station.

Geology of the Region

The counties of Richland, Crawford, Grant, Iowa, and Lafayette (except for a small area in the southeastern corner) fall within the unglaciated portion of Wisconsin. This region, spared the level-ing effect of glaciation, is uniquely beautiful, with craggy bluffs, pillars, and natural bridges carved out by wind, rain, and other forces. The high relief of the terrain has deep valleys or coulees alternating with high knolls. Loose rocks, irregular and sharp-edged, are of the same material as the bedrock of the region. Caves and sink holes are common and frequently quite large.

Streams, largely devoid of falls or rapids, follow regular courses and show a dendritic pattern. Marshes and lakes are scarce and are found only in the valley bottoms. The region is well known for its flash floods, particularly the Kickapoo River.

Most of the soil of the region is derived from the underlying bedrock and is referred to as residual soil (Martin 1916). The residual material in the limestone belts is chiefly a fine brown or reddish clay, representing the more or less insoluble residue from the decay of the limestone. Much of this fine soil is carried down the steep slopes and into streams, frequently raising turbidity.

On the higher and more level areas of this section there is a layer of light or buff-colored silt soil called loess, which was brought there by the wind (Whitson 1927). Part of it came from the far western plains, although some of it was probably derived from rock flour exposed around the borders of the glacial area where streams flowed out from under the ice. The loess forms a blanket varying from a few inches to several feet thick.

Although most of this portion of the state was originally wooded and the soils are of a comparatively light color, some portions, especially belts along the tops of the ridges, were prairies and had darker soil. The soils of this character were formed largely from the loess.

Recent Changes in Distribution

Southwestern Wisconsin is a strategic crossroads in fish distribution. With the Mississippi River as a distribution route, this part of the state is frequently the first to show the movement northward of southern species and the movement eastward of the western plains fishes.

Some species which have come into Wisconsin in the recent past are the Ozark minnow, the pirateperch and the warmouth. Thus far these species appear to be common nowhere, but there is evidence that they are spreading gradually into state waters from which they had not previously been taken. Greene (1935) captured the Ozark minnow in Iowa and Lafayette counties. Our survey has disclosed several colonies in the Platte River and its tributaries in Grant County.

Our four collections of the pirateperch from three stations on the lower Wisconsin and one station on Bear Creek, one of its tributaries, indicate a firm establishment of this species in the inland waters of the state. Greene took this species at only five stations in Wisconsin. One was Mill Creek, 6 miles southwest of Stevens Point, indicating that at an early date it had migrated up the Wisconsin River to the middle of the state.

The warmouth had been reported by Greene from southwestern Wisconsin only from the Mississippi River. My collection from Mill Creek, a tributary of the lower Wisconsin in Richland County, indicates the presence of this species in the Wisconsin River drainage. Wisconsin Conservation Department personnel report the warmouth as common in the region. Since it is a desirable panfish, a considerable amount of minnow pail stocking may have taken place. Hence the problem of evaluating natural distribution of this species is the same as for yellow bass, which in recent years has been captured in many new waters (Helm 1958).

In comparing our findings with Greene's we observe that the following species at least have increased in numbers and have extended their ranges during recent years in southwestern Wisconsin: silver redhorse, golden redhorse, longnose dace, brassy minnow, Ozark minnow, grass pickerel, western sand darter, orange-spotted sunfish, pumpkinseed, and rockbass. The intrusion of the rockbass, considered a glacial lake species, into the driftless area is an example of adaptation.

Although the slimy sculpin was expected in southwestern Wisconsin, this glacial relict was not until recently found in Citron Creek, Crawford County. The starheaded topminnow, previously collected infrequently from southeastern Wisconsin, has appeared in a recent collection from an Iowa County lagoon of the Wisconsin River.

The skipjack and blue catfish seem to have become exceedingly rare or may even be absent. Greene examined collections of these species from the upper Mississippi River, but we have no recent reports from there. A 1963 survey showed both species far downstream in the vicinity of the Kentucky–Tennessee line (pers. comm. —Nord, Jan. 10, 1964.) The ghost shiner, formerly common in the Wisconsin and Minnesota portions of the Mississippi River, has not been collected there since 1944.

Species with drastic reduction in numbers are the paddlefish and the channel catfish, probably because of the rapidly deteriorating conditions on the Mississippi. Many commercial fishermen report the catfish industry in jeopardy. On the same river the channel mimic shiner appears to be decreasing and is rarely found today.

Brook trout, even in the smaller colder streams, find little suitable habitat. If the brown trout were not stocked on a put-and-take basis, trout fishing in southwestern Wisconsin would be an activity of the past.

What is the opportunity of adding new species to our Wisconsin fish fauna? Over 30 species of fish known from Illinois have not been found in Wisconsin (Forbes and Richardson 1920). Some of these may find conditions suitable here. The recent shift northward of some of our Wisconsin species indicates a trend that may apply to Illinois species.

I anticipate that the red shiner, *Notropis lutrensis* (Baird & Girard), will soon be listed from Wisconsin. It has been reported from a small stream in Dubuque County, Iowa, opposite Grant County, Wisconsin (Harlan and Speaker 1956), and again from the Mississippi River a few miles below the Wisconsin line (pers. comm.—Nord Jan. 10, 1964).

Species of Fishes

Southwestern Wisconsin, because of the Mississippi and Wisconsin Rivers, is rich in species number. Our collections contained 82 species from the Wisconsin River; 60 species from the Missippi River; 64 from the inland waters of Richland County; 53 from Iowa County; 49 from Grant County; 44 from Crawford County; and 36 from Lafayette County. A report from Nord (September 24, 1962) lists 74 species of fish collected from or seen in Pool 10 of the Mississippi River during Upper Mississippi River Conservation Committee surveys. Pool 10 extends from Gutenberg (Grant County) lock and dam to Lynxville (Crawford County) lock and dam (U.S. Army Engineer Division, 1963).

The present survey captured 29 species of minnows (Cyprinidae); 15 species of suckers (Catostomidae); 15 species of perch-like fishes and darters (Percidae) and 10 species of sunfishes and allies (Centrarchidae). These four families of fishes were the best represented in these waters, and in numbers of individuals captured. In addition to my collections and observations I have included in the following list reliable reports from the literature and from informants.

Map 1 indicates those waters in which collections were made. The sampling stations are designated by a letter followed by a number. The letters have the following values:

W—Wisconsin River
M—Mississippi River
R—Richland County
C—Crawford County
G—Grant County
I—Iowa County
L—Lafayette County

The Mississippi River, Wisconsin River and the counties have separate numbering systems, each beginning with the number 1. Station numbers are assigned from west to east in the county; i.e., in Crawford County the westernmost stream sampled was Gran Grae Creek, which received a station designation of C1, followed by the Little Kickapoo with C2. On a stream with a system of tributaries, such as the Kickapoo River, numbers were assigned as follows: first the stations on the tributaries of the west side of the Kickapoo; then the Kickapoo itself with upstream stations being followed by downstream stations; and then the tributaries on the east side of the Kickapoo River.

After the species names which follow, I have indicated by key letters and station numbers all of the stations where those species were captured. If one species appeared at several consecutive stations, the first and last station number are separated by a hyphen; e.g., M2–5 (after the longnose gar) means that it was captured at stations 2, 3, 4, and 5 on the Mississippi River. Numbers within parentheses, such as W(2–8), refer to a capture or captures somewhere between station 2 and station 8 on the Wisconsin River. This was a boom shocking float trip in which no attempt was made to pinpoint the site of capture of a particular species. Other boom shocking collections are represented by the following designations: W(12–13), W(18–19), W(20–22).

Silver lamprey—*Ichthyomyzon unicuspis* Hubbs and Trautman. W16. A single adult was collected from the Wisconsin River at Boscobel by Mr. Larry Bolchen on June 28, 1962. It has been preserved and placed in the State University collections. Several records from the Iowa side of the Mississippi River are reported by Harlan and Speaker (1956). This species of lamprey as well as those that follow are probably more abundant than the collections records seem to indicate. Electric currents drive them out of the mud and sand. The ammocetes seldom are taken with the seine because of their burrowing habits.

Chestnut lamprey—*Ichthyomyzon castaneus* Girard. Nord (pers. comm.—Sept. 24, 1962) lists this species as uncommon on the Mississippi. Greene (1935) believes that this species may be common in the larger rivers of the Mississippi system. Harlan and Speaker (1956) report it from the Mississippi River opposite Allamakee County, Iowa.

American brook lamprey—*Lampreta lamottei* (LeSueur). R4, R11, R14–16, R18, R20, R23, G12, G34, G36, I2, I5 (13 collections; 157 + individuals). This species seems to be distributed commonly in the smaller, clear-water streams in the region.

Paddlefish—*Polyodon spathula* (Walbaum). The paddle fish is reported from the Wisconsin River upstream to the Prairie du Sac dam. John Truog, Wisconsin Conservation Department, reports that in recent years schools of paddlefish have been observed in spring below the dam. The Wisconsin Conservation Bulletin of March 1937, carries the following item: "Prairie du Sac—A 80 pound spoonbill catfish was imprisoned by the swift current at the power dam here. The fish was four feet long." Troug examined a 57-inch paddle fish found dead in the Wisconsin River at the mouth of Blue River (Grant County) on Oct. 28, 1962. Robert Searles, Biology Department, Wisconsin State University, Stevens Point, found a partially decomposed paddlefish under the bridge crossing the Wisconsin River at Muscoda (Grant County) in August 1960.

The paddlefish is today greatly reduced in the Mississippi River, from which it was taken in great numbers during the early 1900's (Coker 1930). Nord (pers. comm.—Feb. 27, 1964) reports that 44,857 pounds of this species were taken commercially in 1961. Only 801 pounds came from Pool 10 and none from Pool 11. Harlan and Speaker (1956) write that the paddlefish in the boundary waters of Iowa is not considered an important angling fish. Only occasional specimens are caught, whereas most of them are illegally hooked by snagging, largely below dams or obstructions on the Mississippi River.

Lake sturgeon—*Acipenser fulvescens* Rafinesque. This species is rare to uncommon on the lower Wisconsin River and the Mississippi River opposite Crawford and Grant Counties. Greene (1935) records a report from the Wisconsin River at Prairie du Sac. Nord (pers. comm.—Sept. 24, 1962) reports it as rare in the Mississippi River in Pool 10. Harlan and Speaker (1956) list several collections from the Mississippi River opposite Crawford and Grant Counties, and report that it is rarely, if ever, caught on hook and line.

Shovelnose sturgeon—*Scaphirhynchus platorynchus* (Rafinesque). W(2–8), W(12–13), W16, W19 (4 collections; 5 individuals). The shovelnose sturgeon is commonly taken on hook and line in the lower Wisconsin and the upper Mississippi Rivers. I have examined several specimens between two and three feet long. A specimen caught at Boscobel (W16) weighed just two pounds and was 27⅛ inches in total length (part of caudal filament was missing for which no allowance was made in measurement). The specimens captured during the summer of 1962 were taken in deep water either by hook and line or with boom shocker.

Longnose gar—*Lepisosteus osseus* (Linnaeus). W4, W8, W16, W17, W19, W(20–22), W21, M3–6, C8 (13 collections; 35 individuals). The longnose gar is common in the Wisconsin and Mississippi

Rivers and the lower reaches of their larger tributaries. With the seine we took these frequently in very shallow, sand-bottomed bays on downstream sides of islands in both the Wisconsin and Mississippi Rivers. A longnose gar captured at W17 with total length of 26⅛ inches weighed 22.1 ounces.

Shortnose gar—*Lepisosteus platostomus* Rafinesque. W14, W(20–22), W21, R9, C11 (5 collections; 8 individuals). In southern Wisconsin the shortnose gar is found in the same habitat as the longnose gar. Nord (pers. comm.—Sept. 24, 1962) reports the shortnose gar as abundant in the Mississippi River at the confluence of the Wisconsin River and the longnose as common. The shortnose is heavier-bodied than the longnose gar. A shortnose captured at W14 with a total length of 22⅛ inches weighed 23.7 ounces.

Bowfin—*Amia calva* Linnaeus. W19, M3 (2 collections; 3 individuals). The bowfin is present in both the Wisconsin and Mississippi Rivers. Greene (1935) examined specimens from Knapp Creek, Richland County, and Pine River, one mile west of Gotham, Richland County. My specimens were taken from sloughs. Nord (pers. comm.—Sept. 24, 1962) reports this species as abundant from the Mississippi at the mouth of the Wisconsin River.

Mooneye—*Hiodon tergisus* LeSuer. W(2–8), W(12–13), W18, W(20–22), M5, C9, C10 (7 collections; 11+ individuals). The mooneye appears to be common in the Wisconsin River and occasionally found in the lower reaches of its larger tributaries. Nord (pers. comm.—Sept. 24, 1962) reports this species as common in the Mississippi River.

Goldeneye—*Hiodon alosoides* (Rafinesque). Greene (1935) examined collections from Lake Pepin of the Mississippi River, somewhat north of the area under consideration. Nord (pers. comm.—Sept. 24, 1962) reports the goldeneye as uncommon in Pool 10 of the Mississippi River.

Gizzard shad—*Dorosoma cepedianum* (LeSueur). W16, W19, W20–23, M1–6, R9 (13 collections; 521+ individuals). This species is abundant on the Wisconsin River from Boscobel down to its juncture with the Mississippi River. Large numbers of young were taken in the quiet and shallow waters of both the Wisconsin and Mississippi Rivers. We found a number of shad in a landlocked pool (25 feet wide, 30 feet long and 4 feet in greatest depth) on an island on the Mississippi River about ¾ mile below the Lynxville Dam, Crawford County.

Skipjack herring—*Alosa chrysochloris* (Rafinesque) Greene (1935) writes: "Since the construction of the Keokuk Dam, the skipjack is said by fishermen to have become very much less common if not extinct in Wisconsin waters." Nord (pers. comm.—Sept. 24, 1962) writes that the skipjack herring has not been seen or collected from the Mississippi River in recent years by survey parties. His knowledge of this species in Wisconsin is confined to citations in the literature. Coker (1929) gives evidence that the construction of the hydroelectric dam across the Mississippi River at Keokuk, Iowa, may have been responsible for the marked reduction of the river herring in the Upper Mississippi River. Of the Mississippi River opposite Iowa, Harlan and Speaker (1956) write: "The fish has not been taken in the last twenty years and is now thought to be rare or absent."

Brown trout—*Salmo trutta* Linnaeus. R1, R6, R11, R18, R20, C3, C5, C13, G2–4, G6, G8, G9, G27, G34, G36, I4, L1 (19 collections; 95+ individuals). The head-waters of the many streams in this region are frequently suited to hold this species. Reproduction is to a large degree limited. The trout fishery in southwestern Wisconsin is largely dependent on a continued stocking program. Truog (in conversation) reported that early in the spring trout have been taken from the Wisconsin River at Spring Green.

Rainbow trout—*Salmo gairdneri* Richardson. R1, R20, C3 (3 collections; 3+ individuals). The rainbow has been stocked in these waters on a put-and-take basis. Because of its migratory habit, this species, unless caught during the season when stocked, may be altogether lost to the trout fisherman. Natural reproduction is limited.

Brook trout—*Salvelinus fontinalis* (Mitchill). C5 (1 collection; 7 individuals). Truog has records of small wild populations of brook trout from the headwaters of the following streams: Fancy Creek (6/5/58), Malancthon Creek (6/19/58), and Hawkins Creek (7/22/60). All three streams are tributary to the Pine River in Richland County. He also found small wild populations of brook trout in Crooked Creek, Grant County (4/13/61). The trout ranged from 3.9 to 10.3 inches.

The brook trout does poorly in southwestern Wisconsin. Water from springs cold enough to support brook trout quickly warms up, precipitating conditions unfit for this species. Although southwestern Wisconsin was originally brook trout range (Brasch, *et al.*, 1958), today trout species tolerant of higher temperatures must fill the niche vacated by them.

Quillback—*Carpiodes cyprinus* (LeSueur). W(2–8), W2–5, W7–10, W12–13, W15–23, M1–3, M5, G14, I10 (28 collections; 512+ individuals). The quillback is common on both the Wisconsin and Mississippi Rivers. It may also be taken in their larger, heavily silted tributaries. Reproduction is especially high in the Wisconsin and Mississippi Rivers, where the young were taken in dense schools from quiet water, often no more than six inches deep, over silty bottom.

River carpsucker—*Carpiodes carpio* (Rafinesque). W(2–8), W2, W8, W9, W(12–13), W15–18, W(20–22), M1, R3, R17, G7, I2, I5 (17 collections; 69+ individuals). The range and habitat of this species appear to be similar to those of the quillback. Nord (pers. comm.—Sept. 24, 1962) lists it as abundant in the Mississippi River. Although adults are often mistaken for the quillback, the river carpsucker has a distinct tubercle in the middle of the lower lip which is absent in the quillback. Adult river carpsuckers reach large size. One specimen from the Wisconsin River weighed four pounds 15½ ounces and was 20⅛ inches in total length.

Highfin carpsucker—*Carpiodes velifer* (Rafinesque). W(2–8), W(12–13), W16, W17, M5 (6 collections; 57+ individuals). The highfin carpsucker is confined to the Wisconsin and Mississippi Rivers and usually in moderate to swift currents. Its distribution along these waterways is probably more extensive than the collections indicate. Many carpsucker young were taken which are impossible to distinguish between *C. velifer* and *C. carpio*. Not until they reach a length of 75 to 100 mm. can these species be told apart.

Bigmouth buffalo—*Ictiobus cyprinellus* (Valenciennes). W18, W20, W21, W22, M4, R9, G14, I7, I10, L8 (10 collections; 18+ individuals). This species is common locally in medium to large-sized rivers in large holes where the current is sluggish.

Smallmouth buffalo—*Ictiobus bubalus* (Rafinesque). W(2–8), W8, W11, W16, W(20–22), M3, M5, C14 (8 collections; 20 individuals). The smallmouth buffalo is a large-water species, although occasionally taken from the mouths of small streams. A single specimen, 44 mm. long, was captured near the mouth of Richland Creek (C14) where it was only 10 to 15 feet wide. Most of this species captured during the summer of 1962 were young-of-the-year.

Black buffalo—*Ictiobus niger* (Rafinesque). W(2–8). The single specimen Truog and I captured with boom shocker from the Wisconsin River was 22 inches in total length and weighed six pounds, ½ ounce. Nord (pers. comm. Sept. 24, 1962) reports this species as uncommon in the Mississippi River.

Blue sucker—*Cycleptus elongatus* (LeSueur). W(2–8), W13, W(20–22). A limited population of this interesting sucker is present in the lower Wisconsin River. On a boom shocking trip

W(2–8) between Spring Green (W2) and Lone Rock (W8), six individuals were brought to net and three more were seen at the electrodes. The smallest fish captured measured 22.8 inches in total length and the largest 29.0 inches. The latter weighed just eight pounds. These fish were all taken from deep water adjacent to islands where the banks were badly eroded and a great number of trees had toppled into the water. At W13 with seine I captured a single young-of-the-year 34 mm. long. Harlan and Speaker (1956) report it as uncommon to rare in the Mississippi.

Northern redhorse—*Moxostoma macrolepidotom* (LeSueur). W(2–8), W2, W3, W6, W8, W10, W(12–13), W14–16, W18, W(20–22), W21, M3, R9, R16, R17, R20, R21, C7–10, C14, G13, G14, G16, G28, G30, G31, G41, G43, I1–3, I7–11, L1, L2, L4, L8, L14, L16 (49 collections; 323+ individuals). Harlan and Speaker (1956) write that the northern redhorse is the most common species of sucker in the Mississippi River. It is abundant in the Wisconsin River and in medium to large-sized tributaries to the Wisconsin and Mississippi Rivers. Occasionally this species is taken in the lower reaches of small streams opening into these rivers. A specimen from the Wisconsin River, 17⅝ inches in total length, weighed two pounds five ounces.

Golden redhorse—*Moxostoma erythrurum* (Rafinesque). W(2–8), W2, W7, W11, W(12–13), W14–18, M1–2, M6, R9, C7, G16, I2, I7–12, L2, L7, L16 (26 collections; 184 individuals). The golden redhorse is frequently taken with the northern redhorse, although its distribution is more spotty. Where encountered on the Wisconsin and Pecatonica Rivers, it appears abundant.

Silver redhorse—*Moxostoma anisurum* (Rafinesque). W1, W10, W14, W16, W18, W(20–22), W23, R9, R13, R16, C8, I8–12, L3, L4, L6, L16 (20 collections; 66+ individuals). The silver redhorse was encountered less frequently on the Wisconsin River than the northern and golden redhorses. Where found, only one or two specimens were captured per station. On the Mississippi River it is considered uncommon (pers. comm.—Nord, Sept. 24, 1962). It is common on the Pecatonica River and its medium-sized tributaries.

Greater redhorse—*Moxostoma valenciennesi* Jordan. W(2–8). A single specimen 51 mm. long was captured from the Wisconsin River somewhere between Spring Green (W2) and Lone Rock (W8). This species is rare in southwestern Wisconsin. There is no record of it from the Mississippi River opposite Crawford and Grant Counties.

Black redhorse—*Moxostoma duquesnei* (LeSueur). Although ascribed to southern Wisconsin (Hubbs and Lagler 1958), this species has never been recorded from counties in the present study. Greene (1935) captured a single specimen from Black Earth Creek, Dane County, close to the Iowa County line (Black Earth Creek flows through the extreme northeastern corner of Iowa County, where it joins the Wisconsin River). This sucker is extremely rare on the western edge of its range, which includes southern Minnesota and northeastern Iowa. Its presence in southwestern Wisconsin is probable.

Spotted sucker—*Minytrema melanops* (Rafinesque). W11, W18, W19, M4, R17 (6 collections; 20 individuals). Nord (pers. comm.—Sept. 24, 1962) lists this species as common for the Mississippi River in Pool 10. We encountered the spotted sucker in sloughs and backwaters of the Wisconsin River. It prefers little or no current. Ten individuals were collected from station R17 on the lower Pine River (Richland County), by far the largest collection made.

Lake chubsucker—*Erimyzon sucetta* (Lacépède). W19, R10. This species was taken only from the Wisconsin River (one individual) and the lower extremity of Indian Creek (one individual). Greene (1935) captured it from the Wisconsin River at Boscobel and at Blue River. A young-of-the-year captured from a slough at station W19 was 33 mm. long.

Northern hog sucker—*Hypentelium nigricans* (LeSueur). W(2–8), W(12–13), W14, W(20–22), R11, R14, R16, R18, R20, C1, C3, C4, C6–10, C14, G1, G5, G15, G31, I1, I2, I7–11, L2, L4, L8 (32 collections; 201+ individuals). This species is abundant locally in medium to large streams, especially in swift water. It is uncommon on the Mississippi River (pers. comm.—Nord, Sept. 24, 1962).

White sucker—*Catostomus commersoni* (Lacépède). W13, W16, W19, W20, M4, R1–23, C1, C3–8, C12–14, G1–9, G11–12, G14–47, I1–5, I7–12, L1–2, L4, L6, L8–15 (107 collections; 4,679 individuals). The white sucker is the most ubiquitous sucker in Wisconsin. In southwestern Wisconsin its distribution is general. Although abundant in small to medium-sized streams, it is less common in a large river like the Wisconsin and extremely rare in the Mississippi.

Carp—*Cyprinus carpio* Linnaeus. W(2–8), W8, W(12–13), W18, W(20–22), W21–22, M2, M5–6, R7–9, R11, R16, R20, R23, C9, C11, G14–15, G28, G31, G41, I2, I7, L2–4, L16 (31 collections; 170 individuals). The carp is commonly taken in most medium-sized streams or large rivers. It is abundant in the Mississippi River (pers. comm.—Nord, Sept. 24, 1962).

Central stoneroller—*Campostoma anomalum pullum* (Agassiz). W19, M3, R1–2, R4–14, R16, R18–19, C1, C3–8, C10, C12–14, G1–4, G6–7, G9, G11–26, G28–30, G32–38, G40–42, G44–47, I1, I4, I7–12, L1, L4, L6–16 (90 collections; 8,198+ individuals). The central stoneroller was the most abundant fish found in smaller streams: several hundred individuals were taken at many stations. It is generally found in large schools in riffle areas, although in a few instances I have encountered considerable numbers in quiet pools.

Largescale stoneroller—*Campostoma anomalum oligolepis* Hubbs and Greene. M5–6, I9, I11, L2, L6, L13 (7 collections; 16+ individuals). The largescale stoneroller, although extremely common in central and northern Wisconsin, is seldom taken in southern Wisconsin, where it is supplanted by the central stoneroller.

I have noted both *Campostoma a. pullum* and *Campostoma a. oligolepis* from the collections at stations I9 and I11, with single specimens from each station showing intergrade characters. Nybakken (1961) has found intergrades from my collections at I12, L6 and L13. He has recently found both forms of *Campostoma* and intergrades in the Dodge Branch of the W. Pecatonica River from southeastern Iowa County.

Campostoma prefers swift waters in medium to small-sized streams. In southern Wisconsin the greatest numbers were taken in streams only a few feet wide.

Longnose dace—*Rhinichthys cataractae* (Valenciennes). R19, R20, C1, C3, C5, C7, C8, C13, G1–5, G7, G12, G13, G15, G16, G20, G29, G30, G32, G33, G35, G37, G44, G45, I1 (28 collections; 274 individuals). The longnose dace is common in the small and medium-sized streams of Crawford, Richland and Grant Counties. Greene (1935), although sampling heavily in the same counties during the late 1920's, failed at that time to find this species. This suggests that an expansion of the range may have occurred in the interim. The longnose dace from the northeastern corner of Iowa may have assisted in this extension of range. Our record from Menominee Creek (G45) is so close to Illinois that we may expect to find this species in the northwestern corner of that state. Forbes and Richardson (1920) report this minnow as rare in Illinois, with a single individual captured near Waukegan and three individuals from Big Creek in the extreme southern part of the state.

Blacknose dace—*Rhinichthys atratulus* (Hermann). R1, R4, R6–8, R10–14, R18–20, C1, C3, C5, C7, C10, C13, G2–8, G11, G12, G29, G33, G41, G42, I1 (33 collections; 1,365+ individuals). The blacknose dace is a common inhabitant of small, spring-fed streams throughout the region. It is frequently taken with the preceding species, although it is less tolerant of high water temperatures.

Hornyhead chub—*Hybopsis biguttata* (Kirtland). W15, C14, G12, G15–47, I1, I7–12, L1, L2, L4, L6–9, L16 (50 collections;

997+ individuals). For some peculiar reason this species, which appears to adapt itself to a variety of conditions, is rare to occasional in the streams tributary to the Wisconsin River, but it is abundant and widely distributed in the streams of Grant, Iowa, and Lafayette Counties, which flow southward into the Mississippi River. Greene (1935) speculates that the hornyhead chub finds unsuitable this large central portion of the driftless area because it is underlain with potsdam sandstone. The absence of pebbles, required for spawning, may be the limiting factor.

Silver chub—*Hybopsis storeriana* (Kirtland). W(2–8), W(12–13), W16, W(20–22), W23, M1–3, M5–6, R16, I2, I3, I5 (15 collections; 50+ individuals). The silver chub is a large-water form. We captured it only from the Wisconsin and Mississippi Rivers and the lower extremities of their large tributaries. The large adults of the silver chub are taken generally in deep water, can effectively be collected with boom shocker, and will readily take earthworms on a hook.

Speckled chub—*Hybopsis aestivalis* (Girard). W1–6, W(2–8), W(12–13), W22, M5, R17, I2 (12 collections; 574+ individuals). The speckled chub is locally abundant in large rivers. We captured it in considerable numbers from shallow riffs over sand on the Wisconsin River between Arena (W1) and the mouth of Sneed Creek (W6). Elsewhere on the river it was uncommon.

Creek chub—*Semotilus atromaculatus* (Mitchill). W14–16, W19, M1, R1–16, R18–20, R22, R23, C1, C3–8, C10, C12–14, G1–27, G29, G32–47, I1–4, I7, I8, I12, L1, L2, L4, L8–9, L11–16 (98 collections; 3,190+ individuals). The creek chub is abundant in small to medium-sized streams but uncommon in the large rivers. It is a minnow adapted to a wide variety of habitats and a wide range in water temperatures. Next to the bluntnose minnow it is the most widely distributed minnow in the region.

Southern redbelly dace—*Chrosomus erythrogaster* (Rafinesque). R10, G4, G11, G12, G15–18, G21–27, G29–30, G32, G33, G35–36, G42, G45–46, I1, I4, I12, L1, L7, L9, L11, L13, L15 (33 collections; 1,542+ individuals). The southern redbelly dace is abundant in small clear streams up to ten feet wide and common in some medium-sized streams. We failed to capture this species in many likely-looking streams of Crawford and Richland counties.

Redside dace—*Clinostomus elongatus* (Kirtland). R11, R12, R14, R18 (5 collections; 117+ individuals). The redside dace is abundant locally in the tributaries of the Pine River (Richland County), in small streams, most of which have trout populations. We encountered it nowhere else in the region. Some hybridization with the northern common shiner was noted.

Golden shiner—*Notemigonus crysoleucas* (Mitchill). W11, W14, W16, W19–20, W22, M1–5, R9, R17, G14 (15 collections; 467+ individuals). The golden shiner was taken primarily in the sloughs and backwaters of the Wisconsin and Mississippi Rivers and in the lower extremities of the larger tributaries of the Wisconsin River. Seldom was it taken from water with current. Several collections came from landlocked pools adjacent to the large rivers.

Bullhead minnow—*Pimephales vigilax* (Baird and Girard). W1–11, W13–17, W19–23, M1–3, M5–6, R9, R17, R23, G14, I2, I3 (37 collections; 4,289+ individuals). The bullhead minnow is found commonly in the Wisconsin and Mississippi Rivers, in large tributaries to these rivers, and in the lower extremities of small streams flowing into them. It is more abundant than any other fish, with the exception of the spotfin shiner, in the larger river. It has been taken from sloughs and from water with moderate current.

Bluntnose minnow—*Pimephales notatus* (Rafinesque). W1–2, W6, W9–22, R2–3, R5–21, R23, C1, C4–8, C10, C14, G1, G3, G5, G7, G9, G11–47, I1–9, I11, I12, L2, L6–16 (113 collections; 6,770+ individuals). The bluntnose minnow is probably the most successful fish in its distribution. It is adapted to great variations in water size, temperature and quality. Although most abundant in small streams, large numbers were taken from several stations on the Wisconsin River, where it occurred with the bullhead minnow. Although I did not find the bluntnose in the Mississippi River, Harlan and Speaker (1956) report several records from the river opposite Crawford and Grant counties.

Fathead minnow—*Pimephales promelas* Rafinesque. W4, W6, W16, W19, M5, R2, R6–9, R13, R15, R17, C4–6, C8, C12–14, G3–4, G12, G16–17, G23–26, G33, G36, G40, I2, L15 (35 collections; 245 individuals). The fathead is most commonly taken in moderate-sized streams which are silty. It seems to be generally distributed in the region, occurring in small streams to large rivers but seldom abundant. The largest collection (114 individuals) was taken from Rattlesnake Creek (G17). In numbers this species is far less successful than the other species in this genus.

Pugnose minnow—*Opsopoeodus emiliae* Hay. W11, W18–21, M3–4, R9 (9 collections; 120 individuals). This small minnow was taken from sloughs of the lower Wisconsin River where the bottoms were covered with dead leaves and other organic debris. Seventy-two young-of-the-year were captured near the west end of Newton Island (W20). A more intensive survey of quiet waters in the lower reaches of large tributaries to the Wisconsin and Mississippi Rivers would undoubtedly disclose a greater distribution than the present survey indicates. In another paper I have reported the presence of this species on the western end of Lake Poygan in eastcentral Wisconsin (Becker 1964). The pugnose minnow, a southwestern form, appears to have extended its range in Wisconsin since Greene made his survey.

Suckermouth minnow—*Phenacobius mirabilis* (Girard). M5–6, R3, R10–12, R16–17, R19–20, C7, G12, G14–16, G18–20, G21, G23, G26, G28–35, G37, G39–42, G44–45, G47, I1–2, I7, I10, I12, L2, L6, L8 (45 collections; 389 individuals). The suckermouth minnow, a southern form, has established itself well in the driftless area of the state. It is a common minnow in rivers of all sizes, but the largest collections were made in medium-sized streams. It prefers swift-running water over a gravel bottom, although we have taken it from a wide variety of habitats.

Brassy minnow—*Hybognathus hankinsoni* Hubbs. W2–3, W6–9, R2–4, R7–11, R15, R17, R19–22, C1, C4, C7–8, I2, I4 (28 collections; 334 individuals). The distribution of the brassy minnow in these counties is spotty. It is generally taken in moderate-sized streams or small rivers. The collections of this species in the upper section of the Wisconsin River were unexpected. Where it was taken, we generally did not find the silvery minnow *(Hybognathus nuchalis)*. Greene (1935) has pointed out that these closely-related species are complementary; i.e., their ranges are separate and adjacent. Fair numbers were found in Knapp Creek, Mill Creek, Willow Creek (Richland County streams), in the Kickapoo River (Crawford County) and in Otter Creek (Iowa County). Greene (1935) has only two records of this species in the area covered by this survey. It appears that in recent years this minnow has become more successful in the driftless area.

Silvery minnow—*Hybognathus nuchalis* Agassiz. W(2–8), W2, W10, W13–17, W19–22, M1, R5, R10, R16, R20, C1, C6, C9, C14, G3, G5, G7, G9, G12–14 (31 collections; 626 individuals). The silvery minnow inhabits medium to large rivers and the lower extremities of small streams opening into such waters. In the last, many adults were captured. The smaller waters may serve as spawning areas for this minnow. Young-of-the-year numbering 230 were captured from the Blue River near its mouth. (G14).

Ozark minnow—*Dionda nubila* (Forbes). G32, G34, G37 (3 collections; 37 individuals). The Ozark minnow has been reported from streams in Iowa and Lafayette counties (Greene, 1935). The present survey adds the upper end of the Platte River and its tributaries, Grant County. The Ozark minnow was taken in clear small to medium-sized streams where it travels in fairly dense schools near the surface of the water. Because of the schooling habit, this species would be easy to miss.

Common shiner—*Notropis cornutus* (Mitchill). W7, W16, W(18–19), W19, W23, M6, R6–9, R11, R12, R14, R18, C1, G1, G5, G7, G12–47, I1, I2, I7–10, I12, L1–4, L6–10, L12, L14–16 (76 collections; 4,621+ individuals). The common shiner prefers streams of small to medium size. It is captured over a wide variety of bottom types and found in greatest numbers in clear water, although it can tolerate considerable turbidity. Recently it has become extremely rare in the Mississippi River.

Emerald shiner—*Notropis atherinoides* Rafinesque. W1–10, W12–23, M1–3, M5–6, R3, R9, R17, R20, R21, R23, C9–10, C14, G5, G14, G16, G31, G43, I2, I5 (50 collections; 1,636+ individuals). The emerald shiner occurs commonly in large streams and rivers and at the lower extremities of small streams opening into rivers. Although abundant on the Wisconsin River, it is outstripped in numbers by the spotfin shiner, another member of the same genus. Our records indicate that on the Mississippi River the situation is just reversed, with the emerald shiner more abundant than the spotfin shiner.

Rosyface shiner—*Notropis rubellus* (Agassiz). G19–22, G25, G27–30, G36–40, G43–44, G47, I1, I7, I9–10, I12, L2–3, L5–8, L14, L16 (30 collections; 658+ individuals). The rosyface shiner generally inhabits medium-sized streams, although several populations were located in small streams. This shiner travels in schools near the surface of the water. Its apparent absence from the streams of Crawford and Richland Counties is difficult to explain.

Spotfin shiner—*Notropis spilopterus* (Cope). W1–23, M1–6, R3, R5, R7–9, R13, R16–17, R19–21, R23, C1, C4, C7–10, C14, G5, G14–15, G43, I2–3, I5, I12, L2, L5–8, L10, L12, L14, L16 (74 collections; 27,238+ individuals). The spotfin shiner is encountered in moderate-sized streams and rapidly increases in abundance with the increase in stream size. It was by far the most abundant fish captured from the Wisconsin River and one of the most common in the Mississippi. The spotfin prefers a moderate current and is generally taken in shallow water over sand bottom. It is far less common in the quiet waters of sloughs.

Spottail shiner—*Notropis hudsonius* (Clinton). W(2–8), W2, W11, W14–16, W19–23, M1–6 (19 collections; 2,103+ individuals). We collected the spottail only from the main channel and backwaters of the Wisconsin and Mississippi Rivers. It is uncommon to common in the Wisconsin River. For most stations it was recorded with the collection of a single specimen. At Boscobel (W16) we collected 95 individuals in a single collection. It is one of the most abundant fish species in the Mississippi River, where hundreds were seined at each station. It was common in sloughs and abundant in moderate currents.

Weed shiner—*Notropis texanus* (Girard). W2, W11, W16, W19, W(20–22), W21–22, M4, C1, G1, I6 (14 collections; 87 individuals). The weed shiner is an inhabitant of the quiet or sluggish sections of medium-sized streams to large rivers. Occasionally it may be taken from the lower reaches of small streams emptying into a large river. The distribution of this southern minnow is spotty. It appears to be rare to uncommon on the Wisconsin River, where collections were small; i.e., from one to seven individuals per collection. Fifty-six individuals were taken in a single collection (C1) from near the mouth of Gran Grae Creek.

River shiner—*Notropis blennius* (Girard). W1–4, W6–7, W9–10, W(12–13), W14, W16–23, M1–3, M4–5, G5 (27 collections; 1,606+ individuals). The river shiner is found commonly in the Wisconsin and Mississippi Rivers and occasionally in the lower extremities of their tributaries. It occurs in fair numbers on the Wisconsin River and is abundant on the Mississippi, where it comprises a large percentage of the catch. Our records show hundreds taken from the Mississippi River where the waters sampled had a moderate to fast current. Next to the spottail shiner, it was the fish most commonly captured from the Mississippi.

Blacknose shiner—*Notropis heterolepis* Eigenmann and Eigenmann. This minnow was not collected during the survey, although Greene (1935) reports it from Bear Creek in the southeastern corner of Richland County.

Sand shiner—*Notropis stramineus* (Cope), W1, W5–10, W(12–13), W13–19, W21, W23, M3, M5–6, G14–16, G22, G28, G37–41, G43–45, G47, I7–9, I12, L2, L6–8, L12, L14, L16 (46 collections; 1,631+ individuals). The sand shiner is rare in small streams, fairly common in medium-sized streams and small rivers, and appears to diminish in numbers in large rivers except locally where large concentrations may be found. This species prefers running water and is most frequently taken over a sand bottom.

Northern mimic shiner—*Notropis volucellus volucellus* (Cope). Harlan and Speaker (1956) record several collections of this subspecies from the Iowa County side of the Mississippi River opposite Allamakee and Clayton counties. Its occurrence on the Wisconsin side opposite Grant County is probable. Christenson and Smith (1965) report this form from a backwater of the Mississippi River west of Fountain City, Buffalo County, Wisconsin.

Channel mimic shiner—*Notropis volucellus wickliffi* Trautman. M2–3 (2 collections; 4 individuals). Three collections of the channel mimic shiner taken July 1944, by John D. Black, from the Mississippi River in Pool 9 opposite Crawford County are in the Museum of Zoology, University of Wisconsin, Madison. This subspecies is present only in the Mississippi River, where it is uncommon.

Ghost shiner—*Notropis buchanani* Meek. Three collections of this species taken in July 1944, from Crawford County and Allamakee County (Iowa) by John Greenbank and Melvin Monson are in the Museum of Zoology, University of Wisconsin, Madison. Nord (pers. comm.—Jan. 10, 1964) reports that during the 1963 Mississippi River small fishes survey this species was not encountered in the Mississippi River opposite Wisconsin, but it appeared downriver in the collections between Pools 13 (Bellvue, Iowa) and 26 (Beechridge, Alexander County, Illinois).

Bigmouth shiner—*Notropis dorsalis* (Agassiz). W1–3, W6, W9, W13, W17, W19, W22–23, M1–3, R2–4, R6–8, R10–14, R16, R19–21, C1, C3–8, C14, G4–5, G7–9, G11–15, G17–20, G22–23, G25–27, G29–30, G32–35, G39–42, G45–46, I1–2, L6 (71 collections; 1,330+ individuals). The bigmouth shiner occurs commonly over sand bottoms in streams of small to medium size. In large rivers this species is rare to uncommon. On the Wisconsin and Mississippi rivers its presence was based on the capture of single individuals at stations where found.

Pallid shiner—*Notropis amnis* Hubbs and Greene. M3, W21. I captured a single specimen from the Mississippi River at Wyalusing and another from the Wisconsin River between the mouths of Gran Grae Creek and Little Kickapoo Creek. Three specimens were collected by John Kennedy from the mouth of Big Green River at its juncture with the Wisconsin River (Grant Co.) on Aug. 15, 1960. Seven collections from the Mississippi River opposite Crawford County were made by Greenbank, Monson and Black in July to August 1944. These and additional collections from the Upper Mississippi River are in the Museum of Zoology, University of Wisconsin, Madison. Nord (pers. comm.—Jan. 10, 1964) reports that this species was captured from Pools 9 and 13 during the 1963 Mississippi River small fishes survey.

Flathead catfish—*Pylodictis olivaris* (Rafinesque). James Kincannon of Blue River, Wisconsin, caught 12 flathead catfish from the Wisconsin River between the Blue River bridge and a point about a mile upstream (vicinity of W15). These fish were caught on set lines using bullheads and catfish as bait. The average size of the fish caught was 14.6 pounds, the smallest weighing five pounds and the largest 35 pounds. He writes:

> They were all taken along steep, grassy banks which displayed a predominance of hard clay or dirt rather than sand. Old tree roots and logs were also in evidence at each site. A large majority of the fish contained spawn. Although I made sets at areas of unstable (sand) banks no fish were taken in this type of place. Once again I noticed that unseasonably cool weather has an adverse effect on the number of fish taken. Also as in the past the catch tapered off near the middle of June.

Two flathead catfish were seen by Truog on August 18, 1962, on a boom shocking run near Bridgeport (W22). According to commercial fishermen on the Mississippi River, this species in the vicinity of Prairie du Chien has been on the decline in recent years.

Blue catfish—*Ictalurus furcatus* (LaSueur). Greene (1935) examined a collection from the Mississippi River near Lansing, Iowa, opposite Crawford County. Eddy and Surber (1947) write that it formerly occurred in the Mississippi River and larger tributaries from Minneapolis southward but that it is now very rare in Minnesota waters with no specimens taken in recent years. Nord (pers. comm.—Sept. 24, 1962) does not list this species from Pool 10 of the Mississippi River.

Channel catfish—*Ictalurus punctatus* (Rafinesque). W1, W(2–8), W15–16, W18–19, W(20–22), W22, R9, R17, C10, I3, L14 (12 collections; 18 individuals). This species is common in medium to large-sized rivers and is occasionally taken in smaller tributaries to such streams. The channel cat is perhaps the most important game fish on the Wisconsin and Mississippi Rivers. From the Mississippi River Nord (pers. comm.—Feb. 27, 1964) reports that in the commercial catch this species ranked third in numbers after bluegills and crappies in 1962–63, although it has dropped in recent years. The channel catfish recently has been the object of considerable research on the lower Wisconsin and the Mississippi Rivers.

Yellow bullhead—*Ictalurus natalis* (LeSueur). W12, G15–16 (3 collections; 4 individuals). The yellow bullhead is uncommon in this region. Nord (pers. comm.—Sept. 24, 1962) reports this species from the Mississippi River in Pool 10. Greene (1935) captured it from several stations on the Mississippi opposite Crawford County. Harlan and Speaker (1956) report that this species is taken occasionally in the Mississippi River.

Brown bullhead—*Ictalurus nebulosus* (LeSueur). M3. Greene (1935) captured this species from the Mississippi River in the vicinity of Lynxville (Crawford County). Several collections in the University of Wisconsin Museum of Zoology were made by Greenbank and Monson from the Mississippi River opposite Allamakee

County, Iowa, in July and August 1944. Other records in the same vicinity are recorded by Harlan and Speaker (1956), who write that it inhabits the sloughs and river lakes.

Black bullhead—*Ictalurus melas* (Rafinesque). W14, W16, W19–20, R17, G26 (6 collections; 139 individuals). This species is found principally in the backwaters and sloughs of the Mississippi and Wisconsin Rivers, and in large quiet pools in their tributaries. In a sand-bottomed pool about 100 feet from the Wisconsin River we captured hundreds of black bullheads (W20). The pool was approximately 60 feet long, 15 feet wide and had a maximum depth of two and one-half feet. These fish must have been trapped in this pool during high water.

Stonecat—*Noturus flavus Rafinesque.* W12, W15, W18, G14, G18–21, G30, G32, G34, G36–37, G40, G47, I3, I7–11 (21 collections; 68+ individuals). This species is locally abundant in swift waters over stony bottoms. It has been taken from the Mississippi and Wisconsin Rivers and their tributaries. Nord (pers. comm.—Sept. 24, 1962) considers it uncommon in Pool 10 of the Mississippi River. I have frequently captured the stonecat while electrofishing among the boulders and rocks under highway bridges.

Tadpole madtom—*Noturus gyrinus* (Mitchill). M2–5, G31 (5 collections; 9 individuals). Nord (pers. comm.—Sept. 24, 1962) lists the tadpole madtom as common on the Mississippi River. Elsewhere this species appears rare. Greene (1935) captured this species from the Wisconsin River in the vicinity of Boscobel (W16).

American eel—*Anguilla rostrata* (LeSueur). Greene (1935) examined collections of the American eel from the Mississippi River at Lynxville, Crawford County, and near Lansing, Iowa, opposite Crawford County. Harlan and Speaker (1956) report only a single collection since 1945 in the vicinity of Lansing. Nord (pers. comm. —Sept. 24, 1962) lists the eel as uncommon. Greene (1935) ascribes the decrease of the eel from Wisconsin waters to dam construction on the Mississippi River.

Central mudminnow—*Umbra limi* (Kirtland). W11, W16, W19, R4, R17, R22, C1–2, C6, G6, G10, I2–3, I5–6, I12 (16 collections; 64 individuals). I have found the mudminnow under a wide variety of conditions: small streams to large rivers, clear to turbid water, cold, spring-fed to warm waters.

Grass pickerel—*Esox americanus vermiculatus* LeSueur. W11, W14, W16, W18–19, W(20–22), W21, M4, R10, R17, C1, C13, I5–6 (16 collections; 43 individuals). The grass pickerel is found in the quiet backwaters of the Wisconsin and Mississippi Rivers, where it is frequently taken with the northern pike. It is also found in the lower reaches of tributaries of the Wisconsin River. Nord (pers. comm.—Sept. 24, 1962) considers it uncommon in Pool 10 of the Mississippi River. Contrary to its name, in many of the backwaters from which we have taken the grass pickerel, there was practically no vegetation. Several specimens were captured from sand-bottomed pools which were entirely devoid of vegetation. It is my opinion that this species has extended its range considerably in southwestern Wisconsin since Greene made his survey in the late 1920's, when he reports a single collection from the Mississippi River in the vicinity of Ferryville.

Northern pike—*Esox lucius* Linnaeus. W8, W11, W16, W18–22, M3–4, R9–10, C1, C14, G9 (18 collections; 59 individuals). The northern pike is found in the sloughs and backwaters of the Wisconsin and Mississippi Rivers and in the lower reaches of their tributaries. Nord considers it common in the Mississippi River and writes (pers. comm.—Feb. 27, 1964) that a 1956 to 1958 study showed lamprey scars on 68 fish, 25 of which were northern pike.

Muskellunge—*Esox masquinongy* Mitchill. Harlan and Speaker (1956) consider the muskellunge as rare in the Mississippi. Nord (pers. comm.—Feb. 27, 1964) reports that he knows of none taken from the Mississippi below Minneapolis–St. Paul in recent years. I have no authentic records of this species from the lower Wisconsin River, although fishermen I have spoken to maintain that there are a few large muskellunge in the vicinity of Blue River (Grant County). Possibly a few may escape from Lake Wisconsin (Sauk County), which gets an annual fingerling stocking program (Poff and Threinen 1965).

Blackstripe topminnow—*Fundulus notatus* (Rafinesque). W19. The three specimens which I took from a debris-filled lagoon were the first of this species reported from the unglaciated portion of Wisconsin and point up the possibility that this species did cross over into the Great Lakes watershed of Wisconsin via the Fox–Wisconsin waterway at Portage, Wisconsin. Greene (1935) believed this species found the unglaciated area ecologically unsuitable and was unable to explain its presence on the upper Fox River.

Starhead topminnow—*Fundulus notti* (Agassiz). About 18 specimens were collected by Marlin Johnson, University of Wisconsin–Madison, from a lagoon of the Wisconsin River, T8N R5E Sec. 9 N½, Iowa County, on June 31, 1965. Five specimens from this collection have been placed in the Museum at Wisconsin State University, Stevens Point.

Burbot—*Lota lota* (Linnaeus). G1, G9. Three small specimens were taken at station G1 and one at station G9. Truog records this species from Rush Creek, Crawford County, T11N R6W Sec. 27, April 27, 1963, and also from Blue River, Grant County, T7N R1W Sec. 4, July 12, 1963. Nord (pers. comm.—Sept. 24, 1962) considers the burbot as rare in the Mississippi.

Trout-perch—*Percopsis omiscomaycus* (Walbaum). W21, M1 (2 collections; 2 individuals). Nord (pers. comm.—Feb. 27, 1964) lists this species as uncommon for the Mississippi River but says that "fairly large numbers" have been captured in the vicinity of La Crosse. I would consider it rare on the lower Wisconsin River.

Pirate perch—*Aphredoderus sayanus* (Gilliams). W16, W19, R23 (4 collections; 5 individuals). The pirate perch is rare to uncommon in the Mississippi and Wisconsin Rivers and the lower extremities of some of their tributaries. The specimens from the Wisconsin River were taken from quiet backwaters. Two individuals, 83 mm. and 88 mm. long, were taken from Bear Creek (Richland County) in water with moderate current.

White bass—*Roccus chrysops* (Rafinesque). W(2–8), W2, W4–5, W8–11, W16–23, M1–6, R9 (25 collections; 557+ individuals). The white bass is common to abundant on the lower Wisconsin and on the Mississippi Rivers, occasionally taken in the lower extremities of their larger tributaries.

Yellow bass—*Roccus mississippiensis* (Jordan and Eigenmann). W2, W6, M2–5 (6 collections; 40+ individuals). The yellow bass is uncommon on the lower Wisconsin River and uncommon to common on the Mississippi River opposite Crawford and Grant Counties. We encountered this species in small numbers at five of the six stations which we sampled on the Mississippi River. Greene (1935) took this species only twice on the Mississippi River opposite Crawford County and listed it as rare in Wisconsin. Today the yellow bass is found in many lakes and larger rivers of southern and eastcentral Wisconsin (Helm 1964). Although this extension of range may result from the Fox–Wisconsin canal at Portage, it is more likely that stocking programs are responsible for the rapid range extension.

Yellow perch—*Perca flavescens* (Mitchill). W(2–8), W2, W6, W8, W10–11, W13–16, W19–21, W23, M1–4, R23 (22 collections; 302+ individuals). The yellow perch is common locally in the Mississippi and common along the lower Wisconsin River. Two specimens were captured from the lower end of Bear Creek (R23).

Sauger—*Stizostedion canadense* (Smith). W(2–8), W(12–13), W18, W(20–22), M2–3, C9, C11, I2, I6 (9 collections; 34 individuals). The sauger was readily taken with the boom shocker from the Wisconsin River, where it appears to be common. It is also found in the lower extremities of its larger tributaries. Nord (pers. comm.—Feb. 27, 1964) reports it as abundant in the Mississippi and more frequently taken than the walleye. He reports that in a recent creel census 4,299 saugers were observed as compared to 1,406 walleyes. With the seine we failed to pick up any young-of-the-year. By contrast walleye fry were captured in numbers from both the Wisconsin and Mississippi Rivers.

Walleye—*Stizostedion vitreum vitreum* (Mitchill). W(2–8), W6, W9–11, W(12–13), W13–17, W19, W21–22, M2–4, R17, C1, C9, C14, I3, L14 (25 collections; 219+ individuals). Nord (pers. comm. —Sept. 24, 1962) lists the walleye as common in the upper Mississippi. The present survey captured many young-of-the-year on the Wisconsin River; e.g., 76 at W15, 27 at W16, 19 at W13. Walleyes are also found in the large, deep tributaries to the Wisconsin and Mississippi Rivers.

Western sand darter—*Ammocrypta clara* Jordan and Meek. W1–5, W7, W9–10, W13–14, W16–17, W19, W20–23, M1–3, M5–6 (25 collections; 246+ individuals). This darter is common to abundant on the Wisconsin and Mississippi Rivers. It is captured in moderate to swift currents over fine sand where water depth is from a few inches to 18 inches. It prefers extensive sand flats where frequently it is the only fish taken.

Crystal darter—*Ammocrypta asprella* (Jordan). W(12–13). Six specimens of this rare darter were collected from a rock shelf bottom in water depth of a foot or less. The collecting site was 2.5 miles east of Orion on the Richland County side of the river. This is the first time this species has been collected within state waters. Length of these specimens ranged between 4⅞″ and 6½″. Greene (1935) captured the crystal darter from the Mississippi River at Cassville, the only other record of this species from the region.

River darter—*Percina shumardi* (Girard). W(2–8), W(12–13), W12, W15, W(20–22), M2–3, M5–6 (9 collections; 95 individuals). This is a common darter of large rivers such as the Wisconsin and Mississippi. It is generally captured over gravel and rock bottoms. The river darter is probably more common on the Wisconsin River than our collections indicate. Twenty-three specimens were captured at station W12 and 43 at station M6.

Gilt darter—*Percina evides* (Jordan and Copeland). Although this species has not been recorded from the waters within or bordering the area studied, the area lies within the range for this species (Trautman 1956). The gilt darter has been taken from the Rock River of Illinois (Forbes and Richardson 1920) and from the Black and St. Croix Rivers of Wisconsin (Greene 1935). Gerking (1945) suggested that in recent years this darter has decreased greatly in Indiana.

Blackside darter—*Percina maculata* (Girard). W2, W12, W14–16, M6, R5, R13, R16, R20–21, R23, C4, C7, I7–9, I11, L16 (20 collections; 53 individuals). The blackside darter occurs within streams and rivers of all sizes in clear to turbid water. Although it appears frequently, it is nowhere abundant. I have taken this darter over soft bottoms covered with organic debris, but it favors a gravel bottom.

Slenderhead darter—*Percina phoxocephala* (Nelson). W1, W(2–8), W(12–13), W12, W15, C8, I2, L7–8, L16 (11 collections; 58 individuals). On the Wisconsin River this darter was generally taken in company with the river darter. They appear to be equally common. On the Mississippi River the slenderhead is rarely taken. This species is occasionally found in moderate to large-sized streams but because it selects rubble and large gravel for habitat, capture with seine is difficult. In such habitats it is easily collected with electrofishing equipment.

Logperch—*Percina caprodes* (Rafinesque). W1, W(2–8), W2, W4, W6, W10, W(12–13), W12, W14–18, W20–23, M1–6, R20, G15, G31, G41, G43 (33 collections; 209 individuals). The logperch inhabits moderate to large-sized streams and rivers. It is adapted to a wide variety of bottom types, although it prefers a hard bottom of gravel. I have captured it most frequently in moderate currents, although I have taken it from swift currents and from quiet sloughs.

Bluntnose darter—*Etheostoma chlorosomum* (Hay). This southern darter has been collected as far north as the Root River, Houston County, Minnesota (Eddy and Surber, 1947). Records 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 County (Harlan & Speaker, 1956). In the University of Wisconsin–Madison Museum of Zoology are two specimens from this locale collected on August 21 and 23, 1944.

Johnny darter—*Etheostoma nigrum* Rafinesque. W1–6, W8–17, W19–23, M1–6, R1–4, R6–14, R16–20, R22–23, C1, C3–8, C10, C14, G2–3, G5, G7, G9, G11, G27, G29–47, I1–12, L1–2, L6–16 (126 collections; 2,833+ individuals). The Johnny darter is the most successful member of the family Percidae. It is found in the smallest stream and in the largest river over a wide variety of bottom types. In a few stations where it was not captured, it would undoubtedly have been found with more intensive sampling.

Banded darter—*Etheostoma zonale* (Cope). W12, W15, W(20–22), R20, G13–14, I2, I5, I7, L2 (10 collections; 64 individuals). The banded darter is a common darter in some waters where the bottom is strewn with light gravel. It is generally found in clear-water streams of medium to large size. Over a rock shelf in the Wisconsin River 22 were captured at W15 and 14 at W12, the largest collections made of this species during the survey. Harlan and Speaker (1956) record this darter from the Mississippi River north of Dubuque, Iowa.

Iowa darter—*Etheostoma exile* (Girard). R15. The Iowa darter is uncommon in southwestern Wisconsin. We captured a single individual from the Pine River at station R15. Greene (1935) records two collections from the Wisconsin River (Richland County), one collection from the Mississippi River at Lynxville and several collections from the Pecatonica River in the vicinity of Argyle.

Rainbow darter—*Etheostoma caeruleum* Storer. W12, W14–16, R10, I6 (8 collections; 16 individuals). The rainbow darter, normally an inhabitant of moderate-sized streams, is like the banded darter, generally taken over gravel. It appears in several small populations in the Wisconsin River, but it is rare to uncommon in this part of the state.

Mud darter—*Etheostoma asprigene* (Forbes). W15, M4, C1, I3. Only one specimen was captured at each of the four stations. This small species must be considered rare in the sloughs of the Wisconsin and Mississippi Rivers and in the lower extremities of their tributaries. It prefers turbid water over a soft bottom.

Least darter—*Etheostoma microperca* Jordan and Gilbert. Greene (1935) captured the least darter from the Pine River at Richland Center (Richland Co.). It was not encountered in the present survey.

Fantail darter—*Etheostoma flabellare* Rafinesque. W12, W15, R1, R11–12, R14, R16, R18, G13–14, I2, I5, I7, L2 (47 collections; 1,016 individuals). The fantail darter is generally taken over rock or gravel. It occurs in small to moderate-sized streams and is especially abundant in the streams of the Pine River watershed in Richland County. On the Wisconsin River it is common locally over rock shelves in shallow water, where it is easily collected by electrofishing. Greene (1935) has reported it from several stations on the Mississippi below the mouth of the Wisconsin River in Grant County.

Smallmouth bass—*Micropterus dolomieui* Lacépède. W1, W(2–8), W2, W4–6, W8–10, W12–16, W18–22, M2–3, G16, G25–26, G35, I2, I5, I7–11, L1, L4, L6, L8, L16 (52 collections; 314+ individuals). Fair numbers of smallmouth bass, ten inches and larger, are found in moderate to swift current along the rocky banks of the lower Wisconsin River. Many young-of-the-year were captured from eddies along sand banks. On the Mississippi River the smallmouth is uncommon (Nord, pers. comm.—Feb. 27, 1964). Nord writes: "Much of the favored habitat . . . has been altered or destroyed since the inception of the 9-foot navigational channel. The distribution of this species now appears to be quite spotty."

An interesting phenomenon was called to my attention by Truog. Grant County is traversed from east to west by a ridge. North of this ridge, the streams draining into the Wisconsin River contain no smallmouth bass, although there appears to be ample stream gradient, rubble bottom and clear water. South of the ridge, the streams, even small ones less than ten feet wide, contain good populations of smallmouth bass.

Largemouth bass—*Micropterus salmoides* (Lacépède). W4–7, W10–11, W13–14, W16, W18–23, M1–6, R9, R17, R20, R23, C14, G1, G16, G25–26, G35, I2, I5, L10 L14, L16 (40 collections; 694+ individuals). The largemouth bass is common in the sloughs, backwaters, and occasionally is trapped in the landlocked pools of the Wisconsin and Mississippi Rivers. Hundreds of young-of-the-year were taken at some stations. This species occurs in moderate to large tributaries of the large rivers and is occasionally found in the lower extremities of small streams opening into them.

Warmouth—*Chaenobryttus gulosus* (Cuvier). C1, R9. I captured a single young-of-the-year from Gran Grae Creek on September 23, 1966. The only specimen captured in the survey came from a quiet widespread of Mill Creek below the millpond. According to Harlan and Speaker (1956) and Nord (pers. comm.—Sept. 24, 1962) it is rare to uncommon in the Mississippi River. Because of its preference for weed-filled ponds or lakes with mud bottom, the warmouth in southwestern Wisconsin should occur more frequently in artificial lakes and their backwaters than in streams. Truog reports the warmouth as common.

Green sunfish—*Lepomis cyanellus* Rafinesque. W7, R2–3, R9, R11, R17, R20, R23, C2–3, C6, C8, G16–17, G20, G25–26, G31, G37–38, G40, G43, I2, I5, I7, I12, L14 (26 collections; 129+ individuals). The green sunfish is a common species in moderate-sized waters with soft bottom and sluggish current, rare to uncommon in the Wisconsin and Mississippi Rivers.

Pumpkinseed—*Lepomis gibbosus* (Linnaeus). W4, W11, W14, W16, W20–21, W(20–22), M2–3, R9, R16–17, I6 (13 collections; 51+ individuals). The pumpkinseed is nowhere abundant in the unglaciated region. It occurs occasionally in the Wisconsin and Mississippi Rivers and their tributaries.

Bluegill—*Lepomis macrochirus* Rafinesque. W1–6, W8, W11, W14–16, W18–20, W(20–22), W22–23, M1–6, R17, R23, C10, G36–38, I5–6, L9–10, L12, L14, L16 (40 collections; 790+ individuals). The bluegill is abundant in the Wisconsin and Mississippi Rivers and is occasional in their medium and large-sized tributaries. Large numbers were captured from the Pecatonica River and its tributaries in Lafayette County.

Orange-spotted sunfish—*Lepomis humilis* (Girard). W16, W19, M1–3, M5, R9, R16, I7–8, L6–8 (15 collections; 56+ individuals). This small sunfish is found in quiet waters of moderate-sized streams to large rivers. Nord (pers. comm.—Sept. 24, 1962) reports this species as uncommon in the Mississippi River. It appears to be extending its range into the inland waters of these counties. Thirty years ago Greene (1935) captured this species only from the Mississippi River and the Galena River (Lafayette Co.) near the Illinois line.

Rock bass—*Ambloplites rupestris* (Rafinesque). M3, I7, I9–11, L6 (6 collections; 10+ individuals). The rock bass is seldom encountered in the driftless region. Nord (pers. comm.—Sept. 24, 1962) considers it as uncommon in the Upper Mississippi River. Truog reports this species as quite numerous in Pool 9 of the Mississippi and frequently captured around old tree roots and stumps. Interestingly enough Greene (1935), although sampling heavily, had no capture from these counties. The records of the present study indicate a recent adaptation to streams in the unglaciated area.

Black crappie—*Pomoxis nigromaculatus* (LeSueur). W(2–8), W4–5, W8, W10–12, W14, W16–23, M2–6, R9, R17 (27 collections; 1,272+ individuals). The black crappie is abundant in the sloughs and backwaters of the Wisconsin and Mississippi Rivers. It is occasionally captured in the lower extremities of the larger tributaries of the Wisconsin River.

White crappie—*Pomoxis annularis* Rafinesque. W14, W16, W18–22, M2–4, R9, C8, G38 (17 collections; 63+ individuals). This species is common in the lowermost parts of the Wisconsin River and in the Mississippi River. It is occasionally captured in their larger tributaries. The white crappie is now found in the larger rivers and lakes of eastcentral Wisconsin, which are parts of the Great Lakes drainage basin (Becker, 1964). Since Greene (1935) encountered this species only in the Mississippi drainage, it is possible that the Fox–Wisconsin canal at Portage may in part be responsible for this extension in range.

Brook silverside—*Labidesthes sicculus* (Cope). W1–6, W11, W14–16, W19–21, W23, M2–6, R9 (21 collections; 361+ individuals). The brook silverside is common in the Wisconsin and Mississippi Rivers. A single specimen was captured from Mill Creek (R9). This species is found primarily in quiet water and over a variety of bottoms.

Freshwater drum—*Aplodinotus grunniens* Rafinesque. W1, W(2–8), W12, W16, W18–23, M2–3, M4–5, R9 (16 collections; 89+ individuals). The freshwater drum or sheepshead is abundant in the lower Wisconsin and in the Mississippi Rivers. It is frequently caught on hook and line.

Mottled sculpin—*Cottus bairdi* Girard. R6, R18, R20, R22, C3, G11, I4, L13, L15 (10 collections; 154+ individuals). The mottled sculpin is common in the headwaters of many small streams of the region, frequently the most common fish in the sample. It prefers cool waters over heavy gravel with vegetation, often in the same locale as trout.

Slimy sculpin—*Cottus cognatus* Richardson. C5. Marlin Johnson, University of Wisconsin–Madison, collected this species from Citron Creek at the Hwy E bridge (T9N R5W Sec. 36 NE¼, Crawford County) on October 24, 1964. Specimens were sent to Dr. Reeve Bailey at the University of Michigan Museum to verify identification. Although this species is common in springs and spring runs of northeastern Iowa, this is the first record of this species from southwestern Wisconsin. I sampled the same station on Sept. 24, 1966, and captured over 40 specimens. The sculpin was the most common fish, followed by the brook trout.

Brook stickleback—*Culaea inconstans* (Kirtland). R2, R13, R15, R22, C5–7, G42, I4, I12, L11–16 (15 collections; 68+ individuals). The brook stickleback is uncommon to common in small to moderate-sized streams. I have taken it from clear water but more frequently from turbid water that had been roiled by cattle.

Acknowledgment

I wish to thank Kenneth Derr, John R. Truog, James Kincannon and C. W. Threinen, all of the Wisconsin Conservation Department, who provided me with working space and materials, and fish collections and records. Two species were recorded from the collections of Marlin Johnson, University of Wisconsin–Madison. My gratitude also to Robert C. Nord, Survey Director of the Upper Mississippi River Conservation Committee, Bureau of Sport Fisheries and Wildlife, who supplied me with recent unpublished records from the Mississippi River. I am indebted to my sons Kenneth and Dale, who provided yeoman service behind electrodes and seine for many hours beyond the normal work day. The paper was read critically by Threinen, Truog and Nord. I have used their suggestions when feasible. If I have not followed their suggestions and the paper suffers error, I assume full responsibility. Dr. Reeve M. Bailey, Curator, University Museums, University of Michigan, was kind enough to help me unravel some of the knottier problems in identification. Funds for carrying on the survey were supplied in part through a research grant from the Board of Regents, Wisconsin State Universities.

(Corrections and additions to be made in Becker, George C. 1959. Distribution of Central Wisconsin Fishes. Trans. Wis. Acad. Sci. Arts & Letters 48: 65–102.

p. 84, l. 2—Insert "*Campostoma anom. oligolepis*" in lieu of "*Campostoma anom. pull.*"

p. 89, l. 18 & 19—Crss out "T 12; P 13, 14"

p. 90, l. 20—Insert "Largescale Stoneroller—*Campostoma anomalum oligolepis* Hubbs & Greene" in lieu of "Central Stoneroller—*Campostoma anomalum pullum* (Agassiz)"

p. 96, l. 14—Add "T 7" at end of line

p. 96, l. 20—Cross out "7" in "T 6, 7"

p. 102—Add to the list of species: "*Moxostoma erythrurum* (Rafinesque) T12; P 13, 14. *Chrosomus neogaeus* (Cope) T 1; LW 1; Eske Creek outlet (T24N R10E Sec. 19) Portage Co., IV:23:60. *Notropis heterodon* (Cope) Eske Creek outlet (T24N R10E Sec. 19) Portage Co., IV:23:60.")

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THE SEASONAL DISTRIBUTION OF FISHES IN VERMILION BAY, LOUISIANA

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Vermilion Bay is one of several shallow estuaries along the north shore of the Gulf of Mexico. The fish fauna of a number of these bays, from Texas to Florida, have been investigated by other workers (Gunter 1938a, 1938b, 1945; Suttkus *et al.* 1953–54; Reid 1955a, 1955b; Simmons and Hoese 1959; Arnold *et al.* 1960). Except for a study of nearby White and Grand Lakes by Gunter and Shell (1958), Vermilion Bay has received little attention from ichthyologists and fishery biologists.

For a three-year period, monthly trips were made to Vermilion Bay in order to assess the fish fauna inhabiting the area. A primary objective of the study was to obtain an inventory of the fishes in the bay and to determine their seasonal movements. A second objective was to interpret the seasonal changes of the fish fauna in relation to hydrological conditions.

Materials and Methods

Fish collections were made each month from October, 1960, to August, 1963. Samples were collected during 32 of the 35 months and all months were sampled at least twice during the study period.

A variety of collecting gear was used in order to sample as wide a size range as possible of the fish population. The gear consisted of three 125-foot gill nets with 1½- and 2-inch mesh, a 300-foot trammel net with 3-inch mesh, a 16-foot shrimp otter trawl, 10-, 25-, and 50-foot nylon minnow seines, plankton nets with number 6 and 12 meshes, a 6-foot beam trawl, developed by the Galveston Laboratory of the U. S. Bureau of Commercial Fisheries to sample post-larval shrimp, dip nets, trot lines, and hook and line.

Most of the collecting was done in three general areas, around Southwest Point, Redfish Point, and Cypremort Point. On Redfish Point the University of Southwestern Louisiana has a small laboratory which was used as a base for operations, and the greatest amount of sampling was done in that area.

Generally, the fishes were collected over a two-day period, with one or more water samples taken and salinity determined by silver nitrate titration (Marvin *et al.* 1960), reported as parts per thousand of salinity. From the same water samples, values for pH were obtained by using a Beckman Model G pH meter. Temperatures of air and water were procured by standard centigrade thermometer. The Secchi disc was used as an index of turbidity.

The large specimens taken with gill and trammel nets were weighed, measured, sexed, and discarded. Total length measurements were made with a measuring board for the larger specimens, dividers and a millimeter ruler for the smaller specimens. Total length is to the nearest millimeter. The common names given follow Bailey *et al.* (1960).

In some instances, particularly in collections made with the trawl or seines, certain species were so abundant that not all specimens could be preserved and returned to the laboratory. In such cases, random samples of the abundant species were taken along with the rare specimens specifically selected from the catch. A large number of the fishes were preserved in ten percent formalin and are stored at the University of Southwestern Louisiana or at the University of Wisconsin–Milwaukee.

Certain limitations are inherent in the study, primarily because of weather conditions and a shortage of personnel. It was not always possible to sample all areas of Vermilion Bay with equal frequency. Over the three-year period, however, each month was sampled quite consistently with gear that was selective for the different size–age groups.

ACKNOWLEDGMENTS

Special thanks are extended to Dr. Lewis T. Graham, head of the Department of Biology at the University of Southwestern Louisiana, and to the following students who assisted in making the collections: Donald Burney, Lewis T. Graham, Jr., William Mason, Anthony Romano, Samuel Riche, David Williams, and especially to Semmes Lynch, who made available some of the most recent data. Mr. Kenneth Lantz of the Louisiana Wild Life and Fisheries Commission also contributed data and assistance. Dr. Reeve M. Bailey, Curator of Fishes, University of Michigan, verified the identification of several species. Drs. Rezneat M. Darnell, Marquette University, and Gordon Gunter, Gulf Coast Research Laboratory, read the manuscript and offered many helpful suggestions. The help of all these people is greatly appreciated. The work during the 1963 season was subsidized in part by Contract No. 14–17–0002–48 from the U. S. Bureau of Commercial Fisheries.

Description of Vermilion Bay

Vermilion Bay (Fig. 1) is located at about 92°W., 29° 40′ N. It is a shallow body of water with a surface area of approximately 208 square miles and an average depth of about five feet. Except for Southwest Pass, its greatest depth is ten feet.

It is surrounded by marshland on three sides, to the north, east and west. The marsh consists of extensive areas of typical salt-marsh vegetation, such as white cord grass, *Spartina patens,* big cord grass, *S. cynosuroides,* black rush, *Juncus roemerianus,* and three-cornered grass, *Scirpus olneyi.* Remains of this marsh vegetation have resulted in the deposition of humic materials along the shores and at the bottom of Vermilion Bay.

Numerous small bayous empty into the bay. The largest is the Vermilion River, entering in the northwest corner. The Intracoastal Waterway borders the north and eastern margins of the bay. To the south, Vermilion Bay is connected to the Gulf of Mexico at two points. The western channel is narrow, over 90 feet deep, and lies between Southwest Point and Marsh Island. During tidal exchange, a strong current of water flows through Southwest Pass. The eastern channel, East and West Cote Blanche Bay, is wider and shallower and lies between Marsh Island and Cypremort Point. Thus Marsh Island, with an area of approximately 125 square miles (Orton 1959), partially isolates Vermilion Bay from the Gulf of Mexico.

Hydrography

The water temperatures of Vermilion Bay tend to fluctuate rather closely with atmospheric temperatures. The monthly range of temperatures at the time fish collections were made is indicated in Fig. 2. It will be noted (Fig. 2) that for five months (May through September) the waters of Vermilion Bay were always above 20°C. and that the cold months, when water temperatures were less than 10°C., were December, January, and February. The minimum temperature recorded was 6°C. on December 17, 1960; the maximum was 35° on August 6, 1963. At Redfish Point (Table 1) the monthly averages of surface water temperatures for the three-year period varied between a low of 9°C. in January to a high of 32.7°C. in August. These water temperatures are similar to those reported for Lake Ponchartrain, Louisiana (Darnell 1958), and East Lagoon, Galveston, Texas (Arnold *et al.* 1960).

Vermilion Bay waters generally exhibit lower salinities than those reported from the Texas estuaries (Gunter 1945; Reid 1955a; Simmons and Hoese 1959) or from Tampa Bay, Florida (Springer and Woodburn 1960). This is in part because of the heavy annual

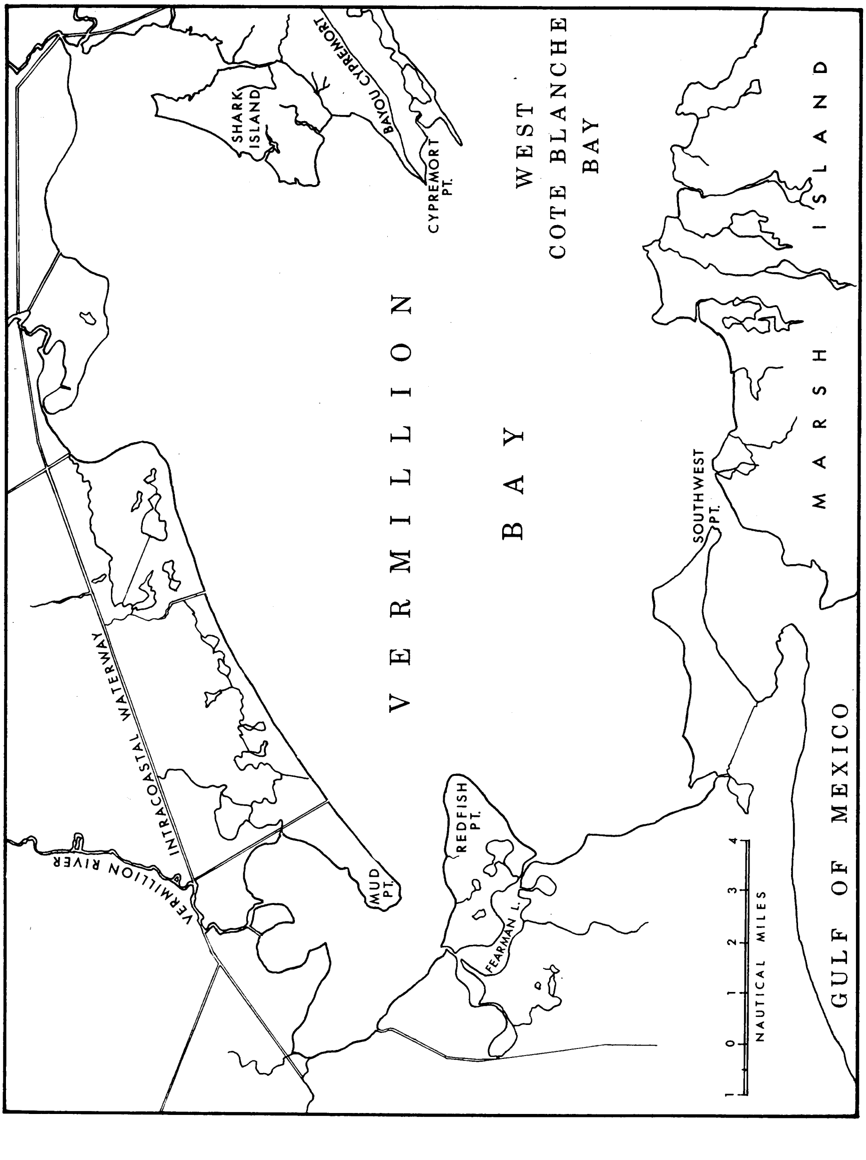

FIGURE 1. Vermilion Bay, Louisiana.

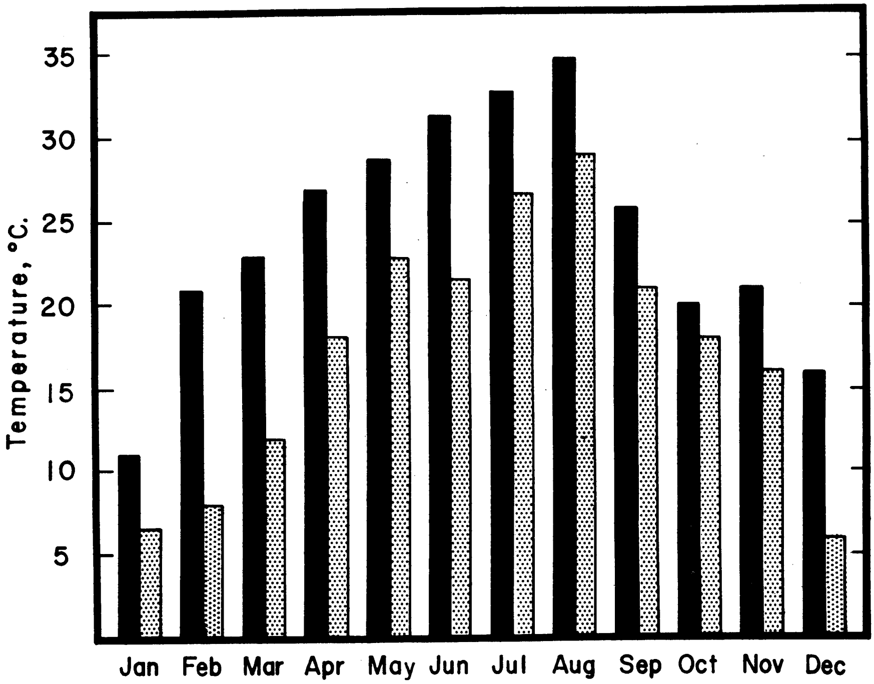

FIGURE 2. Monthly maximum-minimum range of temperatures at which fishes were collected in Vermilion Bay, Louisiana.

rainfall of this section of Louisiana, the greater amounts of fresh water draining into Vermilion Bay, and the influence of the Mississippi–Atchafalaya waters moving from east to west along the Louisiana coast and blocking out the more saline waters from the Gulf of Mexico. The monthly averages measured at Redfish Point ranged from a low of 2. in June to a high of 9.%° in July (Table 1). This is not much different from Lake Ponchartrain, in which Darnell (1962a) reports salinity varying from 3. to 8.%°.

The range of salinities recorded at the time fish collections were made is shown in Fig. 3. The minimum salinity was 0.8%° on April 30, 1963, whereas the maximum during the entire study was 32.8%° on July 13, 1962. This high salinity occurred during a prolonged period of southwest wind from July 10, to July 23, 1962, which blew the more saline waters from the Gulf of Mexico into Vermilion Bay.

Little variation occurs in the pH of Vermilion Bay waters. The monthly average at Redfish Point (Table 1) varied between a pH of 7.2 in December to 8.2 in October. The pH probably exerts little influence on the seasonal movements of fishes.

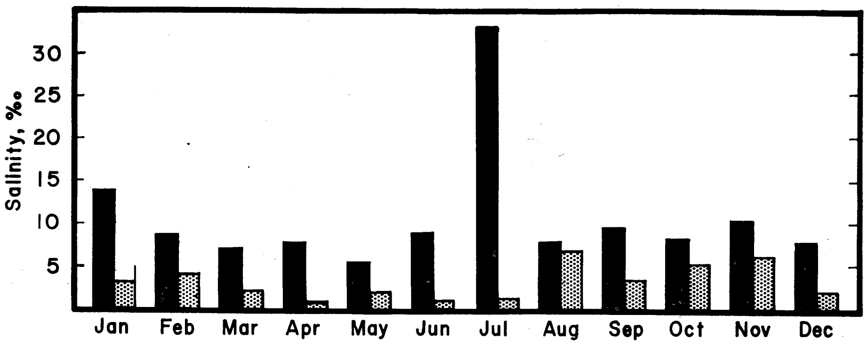

FIGURE 3. Monthly maximum-minimum range of salinities at which fishes were collected in Vermilion Bay, Louisiana.

The bottom deposits of Vermilion Bay consist mostly of fine silt and humic materials, with some sand and an occasional shell reef. Like those of Lake Pontchartrain (Darnell 1958, 1961), these bottom deposits are continually being disturbed by wind action. The waters of Vermilion Bay are highly turbid and the average monthly Secchi disc readings at Redfish Point (Table 1) ranged from a low of 19 centimeters in October to a high of 89 centimeters in September.

THE FISHES OF VERMILION BAY

Eighty species of fish with representatives in 41 families (Table 2) were collected during this investigation. In addition, *Megalops atlantica* was seen in the bay but not collected. Later, in the fall of 1963, *Eleotris pisonis* and *Porichthys porosissimus* were collected by Mr. Semmes Lynch. *Ictiobus bubalus* was collected by Mr. Kenneth Lantz (Lantz 1963) in 1962. Thus 84 species are reported from Vermilion Bay.

As has been pointed out by Gunter (1945, 1956a, 1956b) and others, the fish fauna of an estuary is essentially a marine fauna. Vermilion Bay is typical, because few freshwater fishes invade waters which are even moderately saline. Eight species of freshwater fishes (*Lepisosteus oculatus, L. platostomous, Ictiobus bubalus, Ictalurus furcatus, Roccus mississippiensis, Lepomis macrochirus, L. punctatus,* and *Aplodinotus grunniens*) were collected. Seven of the eight species would be considered rare in the bay. The single important exception is *Ictalurus furcatus,* which is particularly abundant during the winter months. This is not surprising as it has been reported repeatedly from estuarine waters (Gunter 1945; Darnell 1958; Gunter and Shell 1958), and Darnell (1962b) has classified this species as a facultative invader of brackish waters.

TABLE 1. MONTHLY AVERAGES OF HYDROLOGIC DATA AT REDFISH POINT, VERMILION BAY, LOUISIANA. (OCT. 1960–AUG. 1963)

MONTH	WATER TEMPERATURE °C	SALINITY PPT	SECCHI DISC CENTIMETERS	pH
January	9.0	6.47	26.2	7.3
February	17.3	6.73	57.8	7.7
March	18.1	5.51	44.5	7.8
April	22.0	3.73	24.0	7.9
May	24.9	3.71	25.9	7.9
June	29.1	2.22	57.6	7.6
July	30.1	9.15	64.9	7.3
August	32.7	7.25	75.0	7.4
September	25.2	6.55	89.0	7.6
October	19.5	6.74	19.0	8.2
November	19.1	7.42	37.0	7.4
December	11.4	4.84	26.5	7.2

Salinity may influence the age groups of a species which enter an estuary (Gunter 1945, 1956a), and low salinity gradients may keep out certain species altogether. Thus the threadfin, *Polydactylus octonemus,* reported as being very abundant by Gunter (1938b, 1945) in Barataria Bay, Louisiana and Aransas Bay, Texas, was not collected within Vermilion Bay. The same may be said for the butterfish, *Poronotus triacanthus,* the moonfish, *Vomer setapinnis,* and the star drum, *Stellifer lanceolatus.* Gunter and Shell (1958) reported that they collected three specimens of *Polydactylus octonemus* in Little Bay, which is an extension of Vermilion Bay. Therefore, it probably should be added to the check-list (Table 2) as an occasional straggler in Vermilion Bay.

Only six species, *Pristis pectinatus, Synodus foetens, Chloroscombrus chrysurus, Selene vomer, Trichiurus lepturus,* and *Peprilus paru* (Table 3), gave evidence of preferring highly saline waters. All six species were collected during the period of highest salinities (26.9 to 32.8%°) from July 10 to July 23, 1962. As Table 3 indicates, a greater variety of marine and brackish water species is present during the summer than during the winter months. The fish fauna of Vermilion Bay was most diversified during July, when 60 species were collected, whereas only 13 species were collected during January and 18 species in February.

Adults of several marine species are common in Vermilion Bay in the summer (Table 3). Among the more conspicuous of the summer fish fauna are *Carcharhinus leucas, Dasyatis sabina, Bagre marinus,* and *Galeichthys felis.* These species are less com-

TABLE 2. RELATIVE ABUNDANCE OF FISHES COLLECTED IN VERMILION BAY, LOUISIANA. (OCT. 1960–AUG. 1963)

Family	Species	Common Name	Total Number	Percent Composition
Carcharhinidae	*Carcharhinus leucas*	bull shark	67	0.1
Pristidae	*Pristis pectinatus*	small tooth sawfish	1	0.0
Dasyatidae	*Dasyatis sabina*	Atlantic stingray	81	0.1
Lepisosteidae	*Lepisosteus oculatus*	spotted gar	22	0.0
	L. platostomus	shortnose gar	9	0.0
	L. spatula	alligator gar	43	0.1
Elopidae	*Elops saurus*	ladyfish	33	0.0
	Megalops atlantica	tarpon	*	
Clupeidae	*Alosa chrysochloris*	skipjack herring	1	0.0
	Brevoortia patronus	largescale menhaden	12,659	17.9
	Dorosoma cepedianum	gizzard shad	438	0.6
	D. petenense	threadfin shad	18	0.0
	Harengula pensacolae	scaled sardine	9	0.0
Engraulidae	*Anchoa hepsetus*	striped anchovy	11	0.0
	A. mitchilli	bay anchovy	23,711	33.6
Synodontidae	*Synodus foetens*	inshore lizzardfish	3	0.0
Catostomidae	*Ictiobus bubalus*	smallmouth buffalo	3	0.0
Ariidae	*Bagre marinus*	gafftopsail catfish	225	0.3
	Galeichthys felis	sea catfish	556	0.8
Ictaluridae	*Ictalurus furcatus*	blue catfish	471	0.7
Anguillidae	*Anguilla rostrata*	American eel	2	0.0
Ophichthidae	*Myrophis punctatus*	speckled worm eel	81	0.1
Belonidae	*Strongylura marina*	Atlantic needlefish	112	0.2
Cyprinodontidae	*Adinia xenica*	diamond killifish	6	0.0
	Cyprinodon variegatus	sheepshead minnow	89	0.1
	Fundulus confluentus	marsh killifish	17	0.0
	F. grandis	gulf killifish	2,148	3.0
	F. jenkinsi	saltmarsh topminnow	9	0.0
	F. similis	longnose killifish	3	0.0
	Lucania parva	rainwater killifish	60	0.1

TABLE 2. RELATIVE ABUNDANCE OF FISHES COLLECTED IN VERMILION BAY, LOUISIANA. (OCT. 1960–AUG. 1963)—Continued

Family	Species	Common Name	Total Number	Percent Composition
Poeciliidae	*Gambusia affinis*	mosquitofish	92	0.1
	Mollienesia latipinna	sailfin molly	48	0.1
Gadidae	*Urophycis floridanus*	spotted hake	2	0.0
Syngnathidae	*Syngnathus louisianae*	chain pipefish	3	0.0
	S. scovelli	gulf pipefish	22	0.0
Serranidae	*Roccus mississippiensis*	yellow bass	1	0.0
Lobotidae	*Lobotes surinamensis*	tripletail	1	0.0
Centrarchidae	*Lepomis macrochirus*	bluegill	3	0.0
	L. punctatus	spotted sunfish	2	0.0
Carangidae	*Caranx hippos*	crevalle jack	143	0.2
	Chloroscombrus chrysurus	bumper	33	0.0
	Oligoplites saurus	leatherjacket	93	0.1
	Selene vomer	lookdown	6	0.0
	Trachinotus carolinus	pompano	70	0.1
Gerridae	*Eucinostomus gula*	silver jenny	2	0.0
Sciaenidae	*Aplodinotus grunniens*	freshwater drum	10	0.0
	Bairdiella chrysura	silver perch	43	0.1
	Cynoscion arenarius	sand seatrout	2,629	3.7
	C. nebulosus	spotted seatrout	239	0.3
	C. nothus	silver seatrout	12	0.0
	Larimus fasciatus	banded drum	2	0.0
	Leiostomus xanthurus	spot	2,190	3.1
	Menticirrhus americanus	southern kingfish	79	0.1
	Micropogon undulatus	Atlantic croaker	17,043	24.2
	Pogonias cromis	black drum	19	0.0
	Sciaenops ocellata	red drum	10	0.0
Sparidae	*Archosargus probatocephalus*	sheepshead	1	0.0
	Lagodon rhomboides	pinfish	67	0.1
Ephippidae	*Chaetodipterus faber*	Atlantic spadefish	24	0.0
Trichiuridae	*Trichiurus lepturus*	Atlantic cutlassfish	52	0.1
Scombridae	*Scomberomorus maculatus*	Spanish mackerel	23	0.0

TABLE 2. RELATIVE ABUNDANCE OF FISHES COLLECTED IN VERMILION BAY, LOUISIANA. (OCT. 1960–AUG. 1963)—Continued

FAMILY	SPECIES	COMMON NAME	TOTAL NUMBER	PERCENT COMPOSITION
Eleotridae	*Dormitator maculatus*	fat sleeper	12	0.0
	Eleotris pisonis	spinycheek sleeper	5	0.0
Gobiidae	*Gobioides broussonneti*	violet goby	2	0.0
	Gobionellus hastatus	sharptail goby	11	0.0
	G. shufeldti	freshwater goby	35	0.0
	G. stigmaticus	marked goby	19	0.0
	Gobiosoma bosci	naked goby	1,324	1.9
	Microgobius sp.		2	0.0
Triglidae	*Prionotus tribulus*	bighead searobin	15	0.0
Blenniidae	*Chasmodes saburrae*	Florida blenny	1	0.0
	Hypsoblennius ionthas	freckled blenny	1	0.0
Stromateidae	*Peprilus paru*	northern harvestfish	3	0.0
Mugilidae	*Mugil cephalus*	striped mullet	1,946	2.8
Atherinidae	*Membras martinica*	rough silversides	1,116	1.6
	Menidia beryllina	tidewater silversides	936	1.3
Bothidae	*Citharichthys spilopterus*	bay whiff	8	0.0
	Paralichthys lethostigma	southern flounder	312	0.4
Soleidae	*Trinectes maculatus*	hogchoker	853	1.2
Cynoglossidae	*Symphurus plagiusa*	blackcheek tonguefish	27	0.0
Gobiesocidae	*Gobiesox strumosus*	little clingfish	44	0.1
Tetraodontidae	*Sphaeroides nephelus*	southern puffer	13	0.0
Batrachoididae	*Opsanus beta*	gulf toadfish	1	0.0
	Porichthys porosissimus	Atlantic midshipman	1	0.0
Totals 41	84		70,539	99.3

*Observed but not collected.

TABLE 3. SEASONAL DISTRIBUTION OF FISHES IN VERMILION BAY, LOUISIANA. (OCT. 1960–AUG. 1963)

SPECIES	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Carcharhinus leucas	—	1	1	10	11	7	35	—	2	—	—	—
Pristis pectinatus	—	—	—	—	—	—	1	—	—	—	—	—
Dasyatis sabina	—	—	—	(1)	—	6	15	23	35	—	1	—
Lepisosteus oculatus	—	5	4	—	(1)	4	5	—	—	1	2	—
Lepisosteus platostomus	—	—	—	—	—	—	—	—	—	8	1	—
Lepisosteus spatula	—	4	4	1	(1)	8	6	1	1	4	10	3
Elops saurus	—	—	4	21	—	2	6	—	—	—	—	—
Megalops atlantica	—	—	—	—	—	—	‡	‡	—	—	—	—
Alosa chrysochloris	—	—	—	—	—	—	—	—	—	—	1	—
Brevoortia patronus	172	29	2,680	4,611	1,075	1,535	357	124	47	11	9	9
Dorosoma cepedianum	14	17	12	53	5	109	75	38	33	40	12	30
Dorosoma petenense	2	—	1	—	1	5	8	—	—	—	—	1
Harengula pensacolae	—	—	—	—	—	—	9	—	—	—	—	—
Anchoa hepsetus	—	—	—	—	—	—	8	3	—	—	—	—
Anchoa mitchilli	134	129	1,141	305	882	8,036	8,535	2,936	1,115	188	117	143
Synodus foetens	—	—	—	—	—	—	1	—	—	2*	—	—
Ictiobus bubalus	—	—	(1)	—	(1)	(1)	—	—	—	—	—	—
Bagre marinus	—	—	—	53	22	16	48	26	51	9	—	—
Galeichthys felis	—	—	35	58	64	51	183	36	47	76	5	1
Ictalurus furcatus	45	78	38	23	16	13	64	—	—	9	22	163
Anguilla rostrata	—	—	—	1	1	—	—	—	—	—	—	—
Myrophis punctatus	—	29	38	11	2	—	—	1*	—	—	—	—
Strongylura marina	—	—	—	—	32	64	14	2	—	—	—	—
Adinia xenica	—	2	1	3	*	*	*	—	—	—	—	—
Cyprinodon variegatus	*	1	28	2	13	1	16	6	*	17	5	*
Fundulus confluentus	—	—	10	—	—	—	3	—	—	4	—	—
Fundulis grandis	—	13	111	129	121	398	896	112	169	183	10	6
Fundulus jenkinsi	—	—	*	2	*	*	—	—	—	7	—	—
Fundulis similis	—	—	—	—	—	2	—	—	—	—	1	—
Lucania parva	—	—	—	1	*	*	59	*	—	—	—	—
Gambusia affinis	—	15	29	24	—	—	—	—	—	24	—	—

TABLE 3. SEASONAL DISTRIBUTION OF FISHES IN VERMILION BAY, LOUISIANA. (OCT. 1960–AUG. 1963)—Continued

SPECIES	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Mollienesia latipinna	—	1	13	22	*	—	6	*	—	6	—	—
Urophycis floridanus	—	—	2	—	—	—	—	—	—	—	—	—
Syngnathus louisianae	—	—	—	—	—	1	2	—	—	—	—	—
Syngnathus scovelli	—	—	—	4	1	8	4	*	—	5	—	—
Roccus mississippiensis	—	—	—	—	—	—	—	—	—	—	—	1
Lobotes surinamensis	—	—	—	—	—	—	1	—	—	—	—	—
Lepomis macrochirus	—	—	1	1	—	—	—	—	—	—	—	1
Lepomis punctatus	—	—	—	1	—	—	—	1*	—	—	—	—
Caranx hippos	—	—	—	—	1	64	19	23	36	—	—	—
Chloroscombrus chrysurus	—	—	—	—	—	—	33	—	—	—	—	—
Oligoplites saurus	—	—	—	—	—	15	71	1	4	2	—	—
Selene vomer	—	—	—	—	—	—	6	—	—	—	—	—
Trachinotus carolinus	—	—	—	—	—	8	62	—	—	—	—	—
Eucinostomus gula	—	—	—	—	—	—	2	—	—	—	—	—
Aplodinotus grunniens	—	1	(1)	—	—	(1)	1	—	—	(3)	3	—
Bairdiella chrysura	—	—	—	—	—	31	12	—	—	—	—	—
Cynoscion arenarius	—	—	—	16	148	882	1,209	131	117	112	—	14
Cynoscion nebulosus	5	—	8	1	1	31	23	31	12	53	18	56
Cynoscion nothus	—	—	—	—	—	—	—	—	—	12	—	—
Larimus fasciatus	—	—	—	—	—	—	—	—	—	2	—	—
Leiostomus xanthurus	5	1	55	12	12	821	752	528	—	—	(1)	3
Menticirrhus americanus	—	—	—	—	—	4	74	1	—	—	—	—
Micropogon undulatus	166	140	1,687	2,278	1,165	4,246	3,505	2,259	1,215	119	117	146
Pogonias cromis	2	—	2	4	2	1	1	—	2	(1)	3	1
Sciaenops ocellata	—	—	1	(1)	(1)	1	2	*	—	—	—	4
Archosargus probatocephalus	—	—	—	—	—	—	1	*	*	—	—	—
Lagodon rhomboides	—	—	4	3	8	32	16	2	*	(2)	—	—
Chaetodipterus faber	—	—	—	—	—	1	20	*	2	—	—	1
Trichiurus lepturus	—	—	—	—	—	—	52	—	—	—	—	—
Scomberomorus maculatus	—	—	—	—	—	—	6	16	1	—	—	—
Dormitator maculatus	—	—	—	—	—	—	1	*	*	11	*	—

TABLE 3. SEASONAL DISTRIBUTION OF FISHES IN VERMILION BAY, LOUISIANA. (OCT. 1960–AUG. 1963)—Continued

SPECIES	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Eleotris pisonis	—	—	—	—	—	2*	3*	—	—	—	—	—
Gobioides broussonneti	—	—	—	1	1	—	—	—	—	—	—	—
Gobionellus hastatus	—	—	5	—	2	1	3	—	—	—	—	—
Gobionellus shufeldti	—	—	*	22	*	7	*	*	*	—	1	5
Gobionellus stigmaticus	—	—	—	15	—	1	3	—	—	—	—	—
Gobiosoma bosci	*	*	36	34	263	188	498	253	18	12	18	4
Microgobius sp.	—	—	—	2	—	—	—	—	—	—	—	—
Prionotus tribulus	—	—	2	—	1	—	3	—	1	2	1	5
Chasmodes saburrae	—	—	—	—	1	—	—	—	—	—	—	—
Hypsoblennius ionthas	—	—	—	—	1	—	—	—	—	—	—	—
Peprilus paru	—	—	—	—	—	—	1	—	—	2*	—	—
Mugil cephalus	117	216	237	148	166	469	249	84	114	12	22	112
Membras martinica	—	12	—	14	12	466	396	88	99	11	11	7
Menidia beryllina	*	5	7	81	8	384	129	188	50	69	15	*
Citharichthys spilopterus	—	—	6	—	—	—	—	*	*	2	—	—
Paralichthys lethostigma	12	3	100	23	28	30	52	56	—	1	4	3
Trinectes maculatus	—	—	17	37	257	281	115	60	14	13	47	12
Symphurus plagiusa	—	—	—	—	—	5	13	1	—	1	7	—
Gobiesox strumosus	—	—	1	1	1	5	20	11	3	—	1	1
Sphaeroides nephelus	—	—	—	—	2	—	8	—	1	2	—	—
Opsanus beta	—	—	—	—	1	—	—	—	—	—	—	—
Porichthys porosissimus	—	—	—	—	—	—	—	—	—	1*	—	—

‡ Observed.
() Collected by K. Lantz (1963).
* Collected by Semmes Lynch (1963).

mon in cooler waters and tend to migrate out of the bay as the water gets colder (Gunter 1945; Simmons and Hoese 1959; Darnell 1961). The adults of only three species, *Dorosoma cepedianum, Ictalurus furcatus,* and *Mugil cephalus* could be considered very abundant at cold temperatures.

Adults of a number of species which are fished in Vermilion Bay are rather sparsely represented in the collections, particularly *Cynoscion nebulosus, Pogonias cromis, Sciaenops ocellata,* and *Paralichthys lethostigma.* It has been suggested (Gunter 1945; Simmons and Hoese 1959) that these fishes tend to elude the collecting gear rather effectively.

Of the 84 species recorded from Vermilion Bay, 26 species or nearly 31 percent were collected at all seasons of the year. Only eight species or 9.5 percent were prsent every month of the year. In contrast to these data, 26 species of marine fishes and 6 species of freshwater fishes (Table 3), about 38 percent of the species complex, are represented as occasional stragglers and comprise only a small portion of the fish population of the bay.

The young of marine species tend to be more abundant in an estuarine environment, and a number of investigators (Gunter 1957, 1961) have noted that an estuary serves as a nursery for many marine species. The larvae and young of one or more marine species may be collected in Vermilion Bay during every month of the year; a greater variety, however, is present during the spring and summer (Table 4).

Larval menhaden begin appearing in November (Table 4) and continue into April, which is consistent with the findings of Suttkus and Sundararaj (1961). These larvae have been assigned to *Brevoortia patronus* because only juveniles and adults of that species have been collected from Vermilion Bay. The finescale menhaden, *B. gunteri,* however, is present in the nearby Gulf (Suttkus 1958; Christmas and Gunter 1960), and some of the larvae may belong to that species. The same may be said for the larval anchovies (Table 4), which appear from April to August. Some of the smaller individuals may be *Anchoa hepsetus,* although this species is rare in Vermilion Bay, whereas *A. mitchilli* is very abundant.

Many of the larvae were cleared and stained for identification purposes and the larval sciaenids were identified by using the criteria of Hildebrand and Cable (1930, 1934). These data for *Bairdiella chrysura, Leiostomus xanthurus, Menticirrhus americanus,* and *Micropogon undulatus* are consistent with the findings of Hildebrand and Cable (1930, 1934) and Suttkus (1954). The appearance of *Cynoscion nebulosus* in June, July, and August is not surprising in view of the work of Sundararaj and Suttkus

TABLE 4. SEASONAL APPEARANCE OF LARVAL MARINE FISHES IN VERMILION BAY, LOUSIANA.

SPECIES	TOTAL LENGTHS OF LARVAE COLLECTED											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Dasyatis sabina	—	—	—	—	—	75–78	200–275	—	—	—	—	—
Elops saurus	—	—	38–43	30–40	—	—	25	—	—	—	—	—
Brevoortia sp. (*patronus*)	12–25	24–28	17–49	12–57	—	—	—	—	—	—	15–25	12–25
Anchoa mitchilli	—	—	—	13–33	13–25	10–29	10–38	9–30	—	—	—	—
Synodus foetens	—	—	—	—	—	—	37	—	—	—	—	—
Galeichthys felis	—	—	—	—	—	—	35–37	—	—	—	—	—
Myrophis punctatus	—	49–88	42–65	43–61	59–63	—	—	—	—	—	—	—
Syngnathus scovelli	—	—	—	—	—	—	X	X	—	—	—	—
Bairdiella chrysura	—	—	—	—	—	6–32	6–46	—	—	—	—	—
Cynoscion arenarius	—	—	—	—	15–25	12–23	17–29	15–27	—	—	—	—
Cynoscion nebulosus	—	—	—	—	—	11–12	10–13	7–11	—	—	12–15	12–15
Leiostomus xanthurus	—	—	13–45	—	—	—	—	—	—	—	—	—
Menticirrhus americanus	—	—	—	—	—	18–19	12–25	—	—	—	—	—
Micropogon undulatus	16–17	15–35	14–18	14–34	15–44	—	—	—	—	18–30	18–22	18–27
Lagodon rhomboides	—	—	15–17	—	—	—	—	—	—	—	—	—
Gobionellus sp. (*hastatus*)	—	—	14–37	—	10–12	11	—	—	—	—	—	—
Gobiosoma sp. (*bosci*)	—	—	—	—	5–11	5–11	8–10	6–17	—	—	—	—
Microgobius sp.	—	—	—	11	—	—	—	—	—	—	—	—
Membras martinica	—	—	—	—	—	—	—	—	17–27	—	—	—
Citharichthys spilopterus	—	—	13–20	—	—	—	—	—	—	—	—	—
Paralichthys lethostigma	—	—	11–30	13–51	—	—	—	—	—	—	—	—
Trinectes maculatus	—	—	12–17	—	—	15–21	—	—	—	—	—	—

Total lengths in millimeters.
X Males carrying eggs and young.

(1962). The appearance of larvae in November and December (Table 4) may indicate two spawning peaks, as suggested by Gunter (1945).

Only a few larvae corresponding to the descriptions of *Gobionellus* and *Microgobius* (Hildebrand and Cable 1938) were collected; larvae with characteristics of *Gobiosoma bosci,* however, were abundant during May, June and July.

Many of the young, metamorphosed *Myrophis punctatus* were captured with a dip-net and nightlight as they swam near the surface. Springer and Woodburn (1960) captured young worm eels in a similar manner in Tampa Bay during April. As pointed out by Gehringer (1959), the leptocephalus of *Elops saurus* shorten before they metamorphose. Thus, the specimen collected in July was more advanced than the earlier specimens. Except for this single exception, however, their seasonal appearance agrees with that of Arnold *et al.* (1960) for Galveston, Texas.

Males of *Galeichthys felis* and *Syngnathus scovelli* were collected carrying eggs and young, the former in July and the latter in both July and August. During both June and July pregnant *Dasyatis sabina* were caught in trawl hauls and the young born alive in the boat.

Evidence from this work as well as from work of others (Hildebrand and Cable 1930, 1934, 1938; Gunter 1938b, 1945) indicates that few species actually spend their entire life cycles within an estuary. Examination of sexually mature adults, observations of breeding colors and behavior, and the fact that larvae, young and adults were collected at all seasons of the year suggest that five species *(Cyprinodon variegatus, Fundulus grandis, Gobiosoma bosci, Menidia beryllina,* and *Gobiesox strumosus)* remain to spawn and complete their life cycles within the confines of Vermilion Bay. In addition, small populations of *Adinia xenica, Lucania parva, Gambusia affinis, Mollienesia latipinna,* and *Gobionellus shufeldti* may be self-sustaining in scattered areas along the edge of the bay.

In comparing the total number of individuals collected, it was found that three species (Table 2) contributed over 75 percent of the total. A large portion of these consisted of small individuals, less than 100 millimeters in total length, and therefore this is an estimate of numbers, not of weight.

Gunter (1945) in his work in Capano Bay and Aransas Bay, estimated that *Micropogon undulatus, Anchoa mitchilli,* and *Menidia beryllina* comprised the largest species mass in that area and Suttkus *et al.* (1953–54) in his work on Lake Ponchartrain, reported that *Micropogon undulatus* and *Anchoa mitchilli* comprised 80 percent of the trawl catches and that *Micropogon undulatus* and *Brevoortia patronus* accounted for 47 percent of the seine catches. Further estimates from Louisiana waters, Barataria Bay, Grand Lake, and White Lake (Gunter 1938b, Gunter and Shell 1958), indicate that the Atlantic croaker, bay anchovy, and largescale menhaden were the most abundant species in those areas. These three, plus an additional eight species (Table 2), *Fundulus grandis, Cynoscion arenarius, Leiostomus xanthurus, Gobiosoma bosci, Mugil cephalus, Membras martinica, Menidia beryllina* and *Trinectes maculatus,* made up more than one percent of the total catch by number. Four of these eight species, *Cynoscion arenarius, Leiostomus xanthurus, Menidia beryllina,* and *Trinectes maculatus,* comprised between one and ten percent of the catch in Lake Ponchartrain (Suttkus *et al.* 1953–54). The eleven species named contributed nearly 95 percent of the total individuals collected from Vermilion Bay during the three-year period. The remaining 73 species taken made up only five percent of the total catch.

SUMMARY

Some 70,000 specimens of fishes were collected during the investigation. Eighty-four species with representatives in forty-one families comprised the fish fauna of Vermilion Bay, Louisiana.

Three species, *Anchoa mitchilli, Micropogon undulatus,* and *Brevoortia patronus,* comprised over 75 percent of the total individuals collected. These three, plus an additional eight species, account for nearly 95 percent of the total number collected. The remaining 73 species contributed about five percent of the total.

Vermilion Bay is a nursery ground for marine fishes, with the larvae of 22 (Table 4) and the young of 16 other species (Table 3) appearing at various seasons of the year.

Only eight species of freshwater fishes were taken in Vermilion Bay and of these eight only *Ictalurus furcatus* appeared in any numbers.

Salinity in Vermilion Bay is rather low, less than 10%° during most of the year, which may tend to reduce the numbers of some species and keep others out of the bay altogether. Six species indicated a preference for the highly saline waters recorded in July 1962, although subsequently (in October, 1963) the harvest fish and the lizardfish were collected by Mr. Semmes Lynch in waters of 7.1%° salinity.

Water temperature, rather than salinity, appears to exert a greater influence on the seasonal movements of fishes in and out of Vermilion Bay. Twenty-six species were present at all seasons of the year, but only eight were collected every month of the year. The adults of three species were common at cold temperatures, whereas the adults of 16 species were common at high temperatures.

This study and evidence from other investigations, indicates that five and probably not more than ten species complete their entire life cycles within the confines of Vermilion Bay.

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EVOLUTIONARY TRENDS OF THE MUCROSPIRIFER

*LeRoy R. Peters**

ABSTRACT

The Brachiopods Mucrospirifer mucronatus and Mucrospirifer thedfordensis from the Silica formation of the Devonian of Ohio were studied and were shown to be in the process of evolving from a compact form to a long narrow form and to two flattened varieties of the original form. Through this study of the Mucrospirifer of the Devonian of Ohio, the Devonian of Wisconsin may be more closely correlated with the Devonian of Ohio after a similar study is made of the Devonian of Wisconsin.

In 1964 John R. Tilman of Ohio Wesleyan University studied the Mucrospirifer of Ohio and on the basis of considerable overlap in variation, reclassified the Mucrospirifer into two species and described a third new species. Over 500 specimens were studied, all of them collected from the North Quarry of the Medusa Portland Cement Company near Sylvania in Lucas County, Ohio, SE 1/4 Sec. 7, T. 9 S., R. 6 E. The graphs in this paper were plotted with only a few points in order to show trends more clearly.

The present study is based on the external features because "... the shape and the general proportions of the whole shell seem to be characters of the greatest value in distinguishing between species" (Tillman 1964). The characteristics studied here are the width of the fold, length, thickness, and the width of the shell.

In the past, ratios based on the width of the shell have been of doubtful value since both cardinal extremities are rarely preserved. In this study an effort was made to collect specimens that had retained at least one cardinal extremity. Because Brachiopods are bilaterally symmetrical, on specimens that had only one cardinal extremity the measurement was taken from the center of the pedical opening to the end of the existing cardinal extremity and doubled without loss of accuracy.

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* The author at the time this paper was written was a senior majoring in geology at the University of Wisconsin–Milwaukee. At the present time he is a second lieutenant in the United States Army.

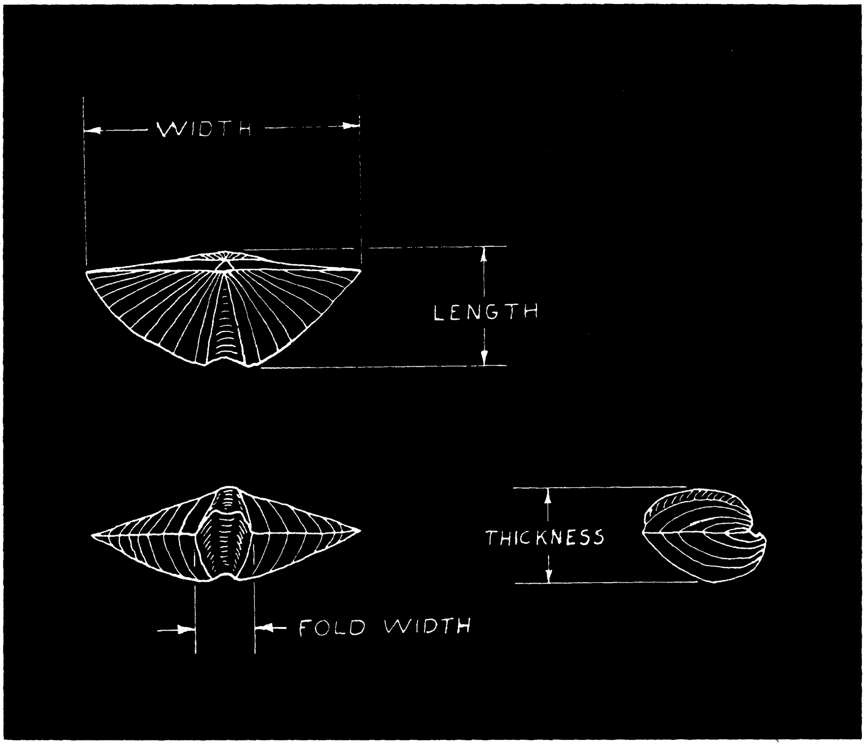

FIGURE 1. Features of the Mucrospirifer used in this study.

Since the size of each specimen varied, it was necessary to find a way to compare them. This was accomplished by setting the shell width equal to one and comparing it with the other features in a simple ratio similar to the method used in crystallography to compare lengths of crystal axes.

EXAMPLE:

$$\frac{\text{Length}}{\text{Width}} = \frac{X}{1}$$

X = Ratio of Length to Width

$$\frac{14}{55} = \frac{X}{1}$$

$$X = 0.25$$

In figures 2 and 3, three main divisions are present, each extending from a central area. This area represents the ancestral form Mucrospirifer mucronatus variety I found in the lower portions this formation. Extending from this area are Mucrospirifer mucronatus variety II, Mucrospirifer thedfordensis variety I, and Mucro-

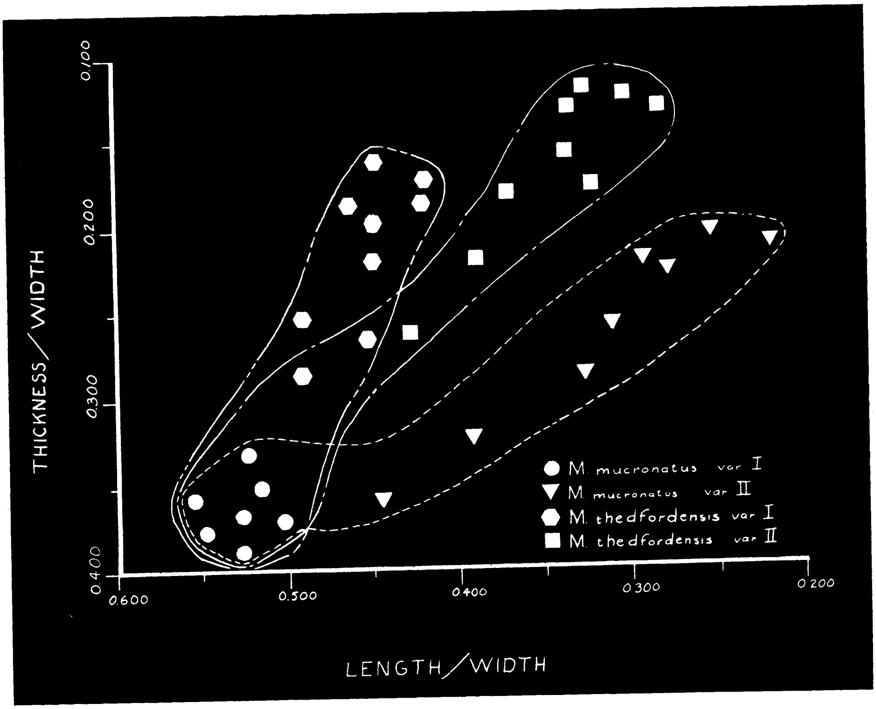

FIGURE 2.

spirifer thedfordensis variety II, which are found in the upper portions of the formation. The farther a specimen lies from the central area the higher in the formation it is found.

Mucrospirifer mucronatus variety I is a compact form which widens while retaining its thickness/length ratio to form M. muronatus variety II. M. mucronatus variety I reduces the thickness/length ratio by about one half ,while retaining approximately the width/length ratio to form M. thedfordensis variety I. M. mucronatus variety I reduces the thickness/length ratio by about one half while increasing the width/length ratio to form M. thedfordensis variety II.

These evolutionary trends continue until the thickness/width ratio reaches about 20% in the three advanced forms. This appears to be the most effective shape for this environment.

A later study will be made of the relationship of lithology to the evolutionary trends, because there was a change of environment. After these studies are finished, similar studies will be made on the Mucrospirifer of Wisconsin with the hope of more closely correlating the Devonian of Ohio with that of Wisconsin.

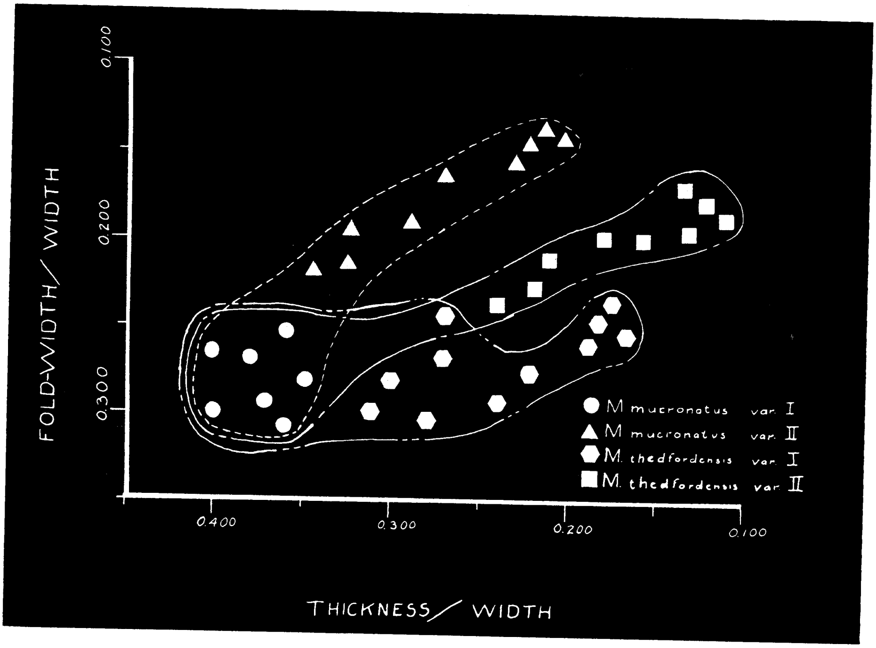
0.100
0.200
0.300
FOLD-WIDTH/ WIDTH
0.400
0.300
0.200
0.100
THICKNESS/ WIDTH
M mucronatus var. I
M mucronatus var. II
M. thedfordensis var. I
M. thedfordensis var. II

FIGURE 3.

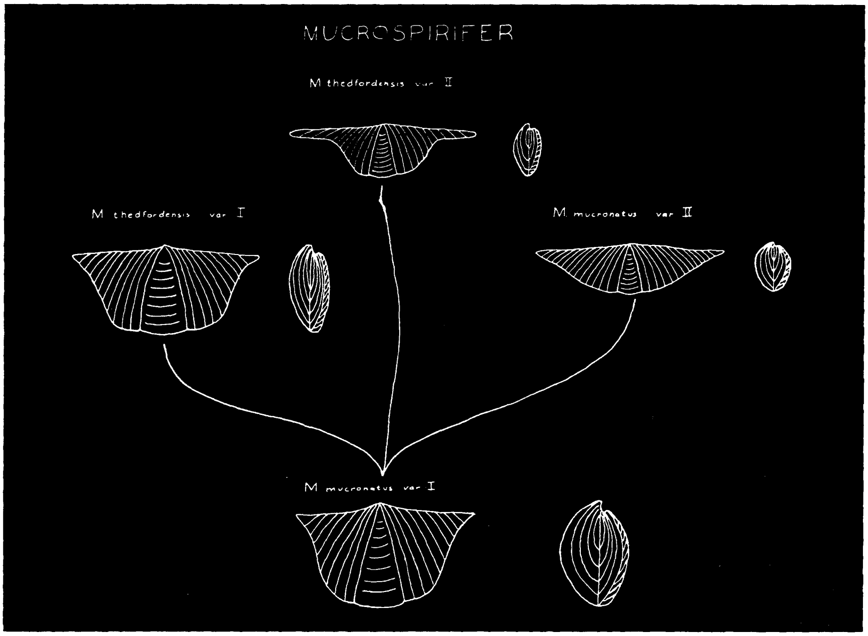

FIGURE 4. The changes in the shape of the Mucrospirifer as indicated by this study.

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INTERACTION OF PHAGE T1 WITH STRAINS OF *ESCHERICHIA COLI*

*Marvin D. Whitehead and J. Roger Christensen**

In an effort to find strains of *Escherichia coli* for which page T1 exhibits the phenomenon of host-controlled variation, we treated for susceptibility to the phage 290 cultures of this organism isolated by the Bacteriological Laboratories of Strong Memorial Hospital, Rochester, N. Y.

Each culture was streaked on a nutrient agar plate and the streak spotted with a loopful of T1 lysate having a titer of 10^{10} per ml. The lysate designated as T1-B had been made on *E. coli* B. Three of the cultures designated as Wh24, Wh57 and Wh96 showed lysis, and when further tested, each of these strains showed different responses to T1.

Phage T1 had a plating efficiency of 10^{-4} to 10^{-5} on *strain Wh24*. Phage was isolated from these plaques, plated again on Wh24 and reisolated.

This reisolated phage, designated as T1-24, gave about one-tenth as many plaques on Wh24 on *E. coli* B. The phage isolated from the plaques of T1–24 when plated on B had reverted to possess properties of T1-B. This is considered to be a typical case of host-controlled variation.

Phage T1 produced only tiny, dim plaques on strain Wh24 by the two-layer technique. More distinct plaques were obtained by spreading the phage and bacteria on the surface of nutient agar plates, but the plaques formed were still smaller than those obtained by the same technique on strain B.

Strain Wh24 fails to absorb sufficient amounts of T1 from a liquid suspension. Judging from the size of the plaques, conditions in soft agar are probably less conducive for attachment than those on the surface of a solid medium. Variations in the ionic composition of the medium, age of the cells, or the presence of nutrient broth were all without effect on phage absorption.

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Strain Wh24, because of failure of efficient attachment, was considered of little value on the investigation of host-controlled variation.

Because *strain Wh57* showed a plating efficiency approximately equal to that of B with phage T1-B, phage T1–24, and T1–57, it was not investigated further.

A loopful of T1-B at 10^{10} per ml. gave a clear spot on *strain* Wh96, but a loopful of T1-B at 10^8 had no visible effect. With intermediate concentrations, there was a gradual transition in the clarity of the infection spot, but distinct plaques were never observed.

Phage T1-B attached well to Wh96, but the infected cells failed to produce plaques, either on B or on Wh96. A plot of the surviving cells versus the multiplicity of phage irreversibly attached, shows that up to a multiplicity of approximately 10 phage per cell, about one page in five is effective as a cell killer. At higher multiplicities, the apparent killing efficiency decreases, but by using high multiplicities more than 99.9% of the cells are killed. It is apparent that some cells are killed even by a single infection, some resist moderate multiplicities, nearly all are killed by high multiplicities, but none make recognizable phage.

The fact that phage susceptibility is of frequent occurrence in *E. coli* populations of varying sources makes it probable that in a continued search a strain having desired properties for studying host-controlled variation can be obtained.

Summary

Lysing strains of *Escherichia coli* showed differing responses to phage T1. Typical host-controlled variation was demonstrated. Phage T1 lysate of *E. coli* B plated on isolated strain Wh24 and the phage reisolated from developing plaques showed reactions differing from that originally obtained on *E. coli* B.

NOTES ON WISCONSIN PARASITIC FUNGI. XXXII.

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The season of 1965 in southern Wisconsin was not very favorable for the development of parasitic fungi, owing to the continuation of drought conditions up to midsummer. Unless otherwise specified, all collections referred to in the following notes were made in 1965.

General Observations

VENTURIA sp. on *Chamaedaphne calyculata* (L.) Moench., collected in small amount near Trout Lake, Vilas Co., July 17, by J. Medler, does not seem identical with any of the members of this genus reported on Ericaceae in Wisconsin. The perithecia are hypophyllous on dead distal areas, gregarious but not crowded, developing well within the host tissue, but still erumpent, black, globose, thick-walled, up to about 125 μ diam., with stiff black setae approx. 50–60 x 4 μ. The asci are 50–55 x 15–16 μ broadly clavate or subovate, the ascospores about 20 x 7.5–8 μ, greenish hyaline with septum almost median, but with one cell slightly larger than the other.

PHYLLACHORA sp., collected on *Phalaris arundinacea* L. at Madison, October 30, 1964, unfortunately does not have mature ascospores. Orton, in his monographic treatment of North American graminicolous species of *Phyllachora* (Mycologia 36: 39. 1944), described *Phyllachora phalaridis* as a new species, known to him at that time only from the type locality in Massachusetts. The U. S. D. A. Index mentions no other species of *Phyllachora* on this host.

MYCOSPHAERELLA sp. occurs on spots primarily due to *Ramularia plantaginis* on a leaf of *Plantago rugelii* Dcne. collected August 10 near Leland, Sauk Co., and does not correspond to other species of *Mycosphaerella* reported on *Plantago*. Possibly it is connected with the *Ramularia*. The inconspicuous perithecia are grayish-brown, subglobose, about 75–85 μ diam., the slender-clavate asci 36–38 x 6.5–7.5 μ, the hyaline, subfusoid ascospores ca. 8 x 3 μ.

MYCOSPHAERELLA sp. is associated with *Ascochyta compositarum* J. J. Davis on dead areas of leaves of *Heliopsis helianthoides* (L.) Sweet collected at Madison, September 3. The black, thick-walled subglobose perithecia are about 125–150 μ diam., the asci clavate, short-pedicellate, approx. 35–40 x 6–7 μ, the hyaline ascospores subfusoid, about 12 x 3 μ with median septum.

PUCCINIA sp. (or UROMYCES?), represented only by an amphisporic stage, has been noted on a specimen of *Carex comosa* Boott collected by H. H. Iltis near Hope Lake, Jefferson Co., July 28, 1956. The amphispores range from oblong, subellipsoid or subfusoid to more or less broadly ovate, tend to be truncate at base and taper more or less above to a subacuminate apex, are ca. (30–)40–55 x (13–)14–16(–18.5) μ, the wall golden-yellow, .8–1.2 μ thick at base and sides, 3–5(–7) μ above, finely verruculose, the pores 2–3(–4), equatorial or superequatorial. A few of the spores have fragments of pedicels still attached, but in most they have fallen away. Fig. 1 shows some of the amphispores and was provided by G. B. Cummins of the Arthur Herbarium at Purdue University, to whom the specimen was submitted for examination. It seems possible this may be connected with one of the varieties of *Puccinia caricina* DC.

ALEURODISCUS OAKESII (B. & C.) Cooke is the name usually applied to the thelephoraceous fungus associated with, and presumably causing, "patchy bark" of white oak, *Quercus alba* L., and less commonly bur oak, *Q. macrocarpa Michx.*, in Wisconsin. This condition is very prominent on the large, open-grown white oaks in the woods on the University of Wisconsin Observatory

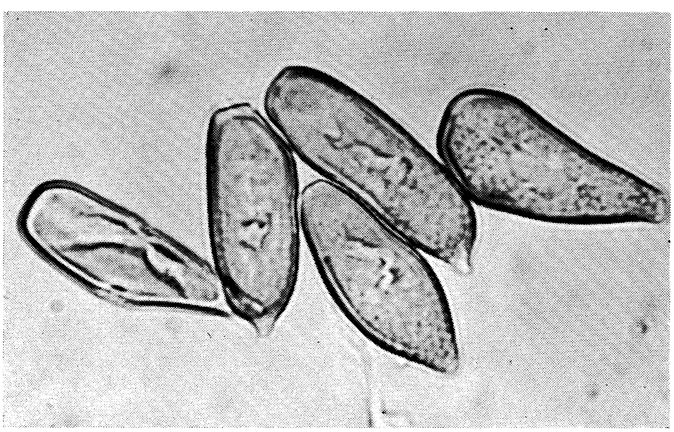

FIGURE 1. Amphispores on Carex comosa. X800

property near Pine Bluff, Dane Co. Some of the trees have lost all, or practically all, the original bark from ground level to 20 feet or more up the trunk. Such trees are noticeably whiter and smoother than uninfected specimens and usually show many of the tiny, cup-like fruiting structures of the organism on the surface of the trunk. Large trees do not appear to be seriously damaged by the fungus, but it gives evidence of being at least mildly parasitic on struggling small oaks in the partial shade of the bigger trees. Some of these small trees are completely covered with the fungus and have died. It seems likely, from examination of cuts made into the trunks, that the cambium layer of the smaller trees has been invaded, thus in effect girdling them.

PHYLLOSTICTA NEBULOSA Sacc. was reported in my Notes 31 as occurring on *Lychnis viscaria* L. in Wisconsin. Reliance was placed on named plants in a botanical garden, but examination of authentic specimens of *L. viscaria* indicates that though the plants so named are some species of *Lychnis,* they cannot be *L. viscaria.*

PHYLLOSTICTA MINIMA Ell. & Ev. has subglobose conidia about 7–8 x 5–6 μ. In a collection of this species on *Acer rubrum* L., made near Denzer, Sauk Co., July 31, a few of the pycnidia have conidia which are cylindric and biguttulate, about (4–)5–6(–6.5) x 1.7–2 μ. The spots are very sharply defined and the infection does not appear to be a mixture of species. *Phyllosticta minutissima* Ell. & Ev., which occurs commonly on maple, has much smaller conidia of a micro-type.

PHYLLOSTICTA DIERVILLAE J. J. Davis on *Diervilla lonicera* Mill. was found in the Madison School Forest near Verona, Dane Co., July 25. All previous collections were made by Davis in extreme northern Wisconsin, the latest in 1923.

PHYLLOSTICTA WISCONSINENSIS H. C. Greene described occurring on *Helianthus occidentalis* Ridd. (Trans. Wis. Acad. Sci. Arts Lett. 53: 211. 1964) has long-cylindric conidia (8.5–)10–13(–16) x 2.5–3.5 μ and large pycnidia, often 200 μ or more in diam. An additional specimen on the same host, collected at Madison in 1965, is practically identical in type of lesion and in microscopic characters. Two specimens on the closely related *Helianthus rigidus* (Cass.) Desf., one collected in 1961 near Cassville, Grant Co., and the other in 1965 near Albany, Green Co., have very similar rounded to fusoid lesions and large pycnidia like those of *Ph. wisconsinensis,* but the conidia are shorter, not more than 8 μ, and somewhat wider, similar to the conidia of *Phyllosticta favillensis* Greene (Amer. Midl. Nat. 48: 50. 1952), described from a specimen on *Silphium integrifolium* Michx. and currently represented in the Wisconsin Herbarium by four specimens on this host. The Albany and Cassville specimens on *H. rigidus* are being filed temporarily with the Phyllostictae indet. They appear, however, to be related to *Ph. wisconsinensis* rather than to *Ph. favillensis.*

Phyllostictae, appearing parasitic, but so far undetermined as to species, continue to be found on diverse hosts, as indicated in the following descriptive notes: 1) On *Pteridium aquilinum* (L.) Kuhn var. *latiusculum* (Desv.) Underw. collected near Leland, Sauk Co., August 31, 1964. On indeterminate, dull reddish-brown areas; pycnidia epiphyllous, black, subglobose, widely ostiolate, pseudoparenchymatous, small, about 60–75 μ diam., tending to be in lines following the venation; conidia hyaline of the micro-type, about 4.5–6.5 x .7–1 μ. 2) On *Quercus ellipsoidalis.* Collected at Madison September 14. Spots very sharply defined, rounded, with rather wide reddish-brown borders and very light brown centers, 4–6 mm. diam.; pycnidia epiphyllous, loosely to closely gregarious, shiny black, deeply seated in tissue, globose or subglobose, approx. 100–150 μ diam.; conidia subglobose to ovoid, 6.5–8 x 9.5–10.5(–12) μ. *Phyllosticta globulosa* Thum., which also occurs on oak, is described as having subglobose or ovate-globose conidia 6–9 μ diam., but plainly differs in other characters. 3) On *Oxybaphus nyctagineus* (Michx.) Sweet collected in Dane Co., near Arena, July 8, 1964. Spots dull brown, small and marginal, usually bearing only one or two pycnidia, but occasionally more; pycnidia amphigenous, mostly epiphyllous, black, subglobose, about 125–175 μ diam., the ostiole delimited by a dense ring of black cells; conidia hyaline, narrow-fusoid, approx. 8-11 x 2.4–2.7(–3) μ. The conidial shape and the rather large black pycnidia suggest that this may prove to be a species of *Phomopsis,* but no scolecospores were seen in the mounts studied. 4) On three specimens of *Caulophyllum thalictroides* (L.) Michx., the first collected July 6 at Gov. Dodge State Park, Iowa Co. The conspicuous spots are ashen with a very narrow yellowish-brown border, orbicular to oblong, .3–.7 cm. in short diam.; pycnidia epiphyllous, scattered, from somewhat flattened to subglobose, thin-walled, pallid yellowish-brown, small, about 50–75 μ diam.; conidia hyaline, subcylindric to subfusoid or broadly subfusoid, straight or slightly curved, about 4.5–8(–10) x 2.4–3.2 μ. The second specimen was taken a few days later, July 14, at the same station. Here the lesions are large, effuse, sordid greenish-brown areas involving the distal portions of leaflets; pycnidia many, flesh-colored, about 100–150 μ diam.; conidia similar in shape to, but slightly larger than, the July 6 specimen. The third specimen was gathered August 28 at Wildcat Mt. State Park, Vernon Co. Here the conspicuous lesions are wedgeshaped, distal in situation, up to 5 cm.

long by 3 cm. at widest point, subzonate, tan, with narrow darker margin; pycnidia loosely gregarious, epiphyllous, rather dark brown and thick-walled, subglobose, about 125–200 μ diam.; conidia similar to those in the other two specimens. Perhaps all represent progressive stages in the development of the same thing. I have found no report on any *Phyllosticta* on *Caulophyllum*. 5) On *Potentilla recta* L. collected at Tower Hill State Park, Iowa Co., October 13. Very much like a *Phyllosticta* which occurred on *Fragaria virginiana* Dcne., as reported in my Notes 26 (Trans. Wis. Acad. Sci. Arts Lett. 49: 89. 1960). In both specimens the zonate banding of the spots is similar, the conidiophores well-developed, the conidia correspond in size and shape, and the pycnidia are erumpent, but lighter in color and less markedly rostrate on *Potentilla*. 6) On *Staphylea trifolia* L. collected at Nelson Dewey State Park, Grant Co., September 19, 1961. The spots are ashen-brown, immarginate, irregular, approx. 1 cm. diam., pycnidia hypophyllous, gregarious, dark brown, subglobose, apparently without ostioles, about 75–90 μ diam.; conidia hyaline, short rod-shaped, 3–3.5 x .8–1 μ. 7) On *Menyanthes trifoliata* L. collected June 12 in Hope Lake Bog near Cambridge, Jefferson Co. The spots are tan with narrow darker border, rounded, about 4–6 mm. diam.; pycnidia epiphyllous, gregarious, light brown, pseudoparenchymatous, subglobose with prominent ostiole, about 80–110 μ diam.; conidia hyaline, rod-shaped, about 2.5–3 x .7–1 μ, very numerous. 8) On *Scrophularia marilandica* L., two specimens, from Gov. Dodge State Park, Iowa Co., August 23, and from near Leland, Sauk Co., August 24. Spots sordid brown, sometimes purple-bordered, ranging from rounded and only 2–3 mm. diam. to large irregular blotches; pycnidia epiphyllous, scattered to gregarious, pallid brownish, thin-walled, subglobose, ca. 90–140 μ diam.; conidia hyaline, ellipsoid to short-cylindric, quite variable in size, seeming to run somewhat smaller in the Sauk Co. specimen, but intergrading, approx. (3.5–)5–7(–8.5) x 1.5–2 μ. Similar to but better developed than specimens on this host reported on in my Notes 30. European species are described on *Scrophularia*, but none correspond in conidial size with the Wisconsin specimens. 9) On *Pentstemon gracilis* Nutt. var. *wisconsinensis* (Penn.) Fassett collected near Lodi, Columbia Co., June 7, 1960. Spots narrow, elongate, subtranslucent, ashen with brownish borders; pycnidia seriately arranged, black, subglobose, approx. 135–175 μ diam., the ostiole delimited by a very thick ring of black, heavy-walled cells; conidia very numerous, hyaline, straight or slightly curved, narrowly cylindric, 4–6 x 1–1.3 μ. 10) On *Aureolaria (Gerardia) pedicularia* (L.) Raf. collected near Leland, Sauk Co., August 14. Spots small, about 2–3 mm. diam., rounded, subzonate, dark brown but often with a paler center; pycnidia epiphyllous, mostly closely crowded in the central portion of the spot, pallid sooty-brown, subglobose, approx. 125–150 μ diam.; conidia hyaline, ellipsoid to broadly ellipsoid, short-cylindric or occasionally subfusoid, biguttulate in some pycnidia, variable in size, (3.5–)5–7(–11) x 2–3(–4) μ. 11) On *Triosteum perfoliatum* L. Two specimens, the first from near Pine Bluff, Dane Co., September 5, 1964. Spots ranging from tiny, angled and ashen, about 1 mm. diam. to larger, indefinite, light reddish-brown areas; conidia hyaline, very small, 2.5–3 x .5–.7 μ. Similar material has been collected in August or later in several localities and twice leaves have been held out-of-doors over winter without any further development. The second specimen was taken September 12, 1964, at Gov. Dodge State Park, Iowa Co. Here the lesions are large, about 2–2.5 cm. diam., ovate and brownish, with a cinereous center; pycnidia epiphyllous, blackish, subglobose, approx. 125–150 μ diam.; conidia hyaline, ellipsoid, small, 3–3.5(–4.5) x 1–1.3 μ. 12) On *Viburnum cassinoides* L. (cult.) collected at Madison, October 5. Spots small, rounded, dark, elevated; pycnidia epiphyllous, black, subglobose, about 125–150 μ diam.; conidia hyaline, subcylindric or subfusoid, approx. 5–8 x 2.5–3 μ. 13) On *Solidago canadensis* L. from the Flambeau State Forest near Oxbow, Sawyer Co., July 23, 1964. Spots rounded and dark-bordered, with cinereous centers, small, about 1–2 mm. diam.; pycnidia epiphyllous, one or two per spot, pallid sooty-brown, thin-walled, globose, about 150–175 μ diam., the ostiole delimited by a ring of dark, thick-walled cells; conidia hyaline, narrow-cylindric, straight or slightly curved, often guttulate, approx. 6–10 x 1.8–2.3 μ. 14) A *Phyllosticta* very similar microscopically to the preceding occurs on *Aster prenanthoides* Muhl. collected near Leland, Sauk Co., August 19, 1964. The fungus is hypophyllous on orbicular lesions 1–2 cm. diam., which are purplish above and dull yellowish below. 15) On *Silphium perfoliatum* L. collected near Leland, Sauk Co., September 19, 1964. Spots rather indefinite, mostly small and somewhat rounded, but becoming confluent over considerable areas, mottled dark gray and ashen; pycnidia epiphyllous, mostly rather closely clustered on, but not confined to, the lighter portions of the spots, small, black, globose, about 50–90 μ diam., without true ostioles, although some pycnidia have rounded, thin areas in the walls; conidiahyaline, short rod-shaped, 3–5 x .6–.8 μ. 16) On *Helianthus giganteus* L. collected near Leland, Sauk Co., August 12, 1964. Spots small, angled and ashen on larger indefinite brown areas; pycnidia epiphyllous, usually only one to a spot, black, subglobose, about 150–175 μ diam.; conidia hyaline, cylindric, 6–7 x 1.5–2 μ. 17) On *Arctium minus* Bernh. from Gov. Dodge State Park, Iowa

Co., October 1. Spots mottled, cinereous through blackish-brown, irregular in shape and size; pycnidia epiphyllous, scattered, dark brown, subglobose, about 150–175 μ diam.; conidia hyaline, cylindric, 4–5.5 x 1.5–1.8 μ, sometimes biguttulate.

CONIOTHYRIUM spp. indet. and possibly parasitic have been noted. 1) On *Salix discolor* Muhl. collected near Leland, Sauk Co., August 4, 1964. Spots small, fuscous, marginal; pycnidia epiphyllous, scattered, black, erumpent, subglobose, approx. 115–125 μ diam.; conidia greenish-gray, oblong or broadly ellipsoid, 5–6.5 x 2.5–3 μ. 2) On *Ulmus americana* from near Leland, Sauk Co., June 18. Spots sharply defined, usually only one or two to a leaf, pallid- to reddish-brown, with narrow darker borders, rounded, about 2–4 mm. diam.; pycnidia epiphyllous, more or less closely gregarious, black, rather thick-walled, subglobose, mostly about 100–150 μ diam.; conidia smooth, clear olivaceous-gray, broadly elliptic, 4–7 x 2.7–3.5 μ. Because many of the leaves in this large collection bear, on rather similar spots, the *Phyllosticta* which has in Wisconsin lists been doubtfully referred to *P. ulmicola* Sacc., it seems possible that the *Phyllosticta* was primary, especially since a few spots show a mixture of *Coniothyrium* and *Phyllosticta*. The form in hand does not in any way correspond to Tharp's *Coniothyrium ulmi* (Mycologia 9: 116. 1917). 3) On *Cotoneaster "melanocarpa"* (cult.) collected at Madison, September 11, 1964. The spots are rounded or angular, about 2–5 mm. diam., essentially sordid- or rufous-brown, but the centers often appear cinereous, due primarily to a loosened and somewhat uplifted cuticle; pycnidia epiphyllous, erumpent and gregarious, appearing intraepidermal in origin, black, thick-walled, subglobose, approx. 100–160 μ diam.; conidia light grayish-olivaceous, oblong to broadly ellipsoid, or sometimes almost globoid, about 2.7–3.8 x 5–5.5 μ. 4) On *Acer negundo* L. from near Leland, Sauk Co., August 10. Spots orbicular, ashen and translucent, with narrow yellow-brown border, about .3–1 cm. diam.; pycnidia mostly epiphyllous, scattered, globose or subglobose, approx. 100–150 μ diam.; conidia very numerous, smooth, clear light gray, 4–5.5 x 2.3–3.5 μ. Evidently not *Coniothyrium negundinis* Tehon & Daniels, which occurred at the bases of twigs, had pycnidia twice as large, and smaller, olivaceous, spherical to ovoid conidia.

PHOMOPSIS sp. was present in profusion on still attached overwintered fruit of a cultivated species of *Rosa* collected June 22 at Madison. The large, crowded, black, globose pycnidia are approx. 175–250 μ diam., the hyaline scolecospores ca. 18–22 x 1.2–1.6 μ, from almost straight to sinuously curved, enlarged at one end, the other conidia subfusoid, 6–9 x 2–2.5 μ. Both types of spores are abundant. Parasitic in origin?

PHOMOPSIS sp.? occurs on cinereous areas of leaflets of *Caragana arborescens* Lam. (cult.) collected at Madison, July 20. Pycnidia black, thick-walled, prominently ostiolate, gregarious to crowded, mostly epiphyllous, subglobose, variable in size, about 100–250 μ diam. Definite scolecospores were not seen, but conidia range from rather broadly fusoid to moderately slender in one group which run 7–10.5 x 3–3.8 μ, to a second group where they are about 12–13 x 2 μ at one end and tapering to 1 μ at the other, thus verging on a scolecosporous condition, with an aspect strongly suggestive of *Phomopsis*. *Phomopsis caraganae* Bond. on stems has fusoid conidia of similar size.

ASCOCHYTA *spp.*, ranging from well-developed to more or less presumptive, have been found on 1) *Apios tuberosa* Moench. collected at Gov. Dodge State Park, Iowa Co., July 6. Well characterized and appearing mature. Spots conspicuous, greenish to pallid brownish with narrow dark brown margin, translucent, orbicular, about .5–1.5 cm. diam.; pycnidia carneous, thin-walled, gregarious to crowded, subglobose, approx. (90–)125–175 μ diam.; conidia hyaline, subcylindric or subfusoid, 7–10(–11) x (2.6–)3–3.5(–4) μ, regularly uniseptate, occasionally slightly constricted at septum. In essentials this seems very similar to an undetermined *Ascochyta* reported in my Notes 29 (Trans. Wis. Acad. Sci. Arts Lett. 52: 236. 1963) and it seems likely that other specimens on both *Apios* and *Amphicarpa* with this type of lesion and pycnidia, referred doubtfully to *Phyllosticta phaseolina* Sacc., in reality belong here. More collections on both hosts would be desirable. 2) on *Convolvulus sepium* L., Madison, July 9, 1964. The blackish subglobose pycnidia are about 125 μ diam., the hyaline, guttulate, uniseptate conidia about 10–12 x 2.5 μ. The pycnidia are on the same type of reddish-brown, zonate spots characteristic of *Stagonospora convolvuli* Dearn. & House, so it seems possible this is merely a somewhat depauperate development of that species. 3) On *Polemonium reptans* L. collected near Leland, Sauk Co., July 15. Spots diaphanous, ashen-brown, orbicular to ovate, about 1 cm. diam.; pycnidia scattered to gregarious or even crowded, pallid brownish and thin-walled, with a well-defined ostiole delimited by a narrow ring of dark cells, subglobose, mostly 125–200 μ diam., even more in a few cases; conidia hyaline, short-cylindric, broadly ellipsoid, or subfusoid, a small number with a median septum, about 5–7.5 x 2.4–3 μ. The specimen appears well-matured, but perhaps more conidia would have developed septa in time. There seem to be no reports of *Ascochyta* or *Phyllosticta* on *Polemonium* in North America. *Ascochyta polemonii Cav.* on cultivated *P. caeruleum* L. in Europe has conidia 12–14 x 3 μ. 4) On *Glecoma (Nepeta) hederacea* L. collected near Albany, Green Co., October 1, 1964. Spots rounded, sordid brownish with darker border, about 5 mm. diam.; pycnidia epiphyllous, gregarious, thin-walled, subglobose, about 100–125 μ diam.; conidia hyaline, cylindric, uniformly and markedly biguttulate, 5–7 x 1.8–2.2 μ. The conidia are much smaller than those of *Ascochyta nepetae* Davis which occurs on *Nepeta cataria* L. 5) On a leaf of *Veronicastrum virginicum* (L). Farw. collected July 15 near Leland, Sauk Co. Spot blackened, strongly zonate, about 4 mm. diam.; pycnidia flesh-colored, subglobose, about 100–125 μ diam.; conidia uniformly uniseptate, hyaline with granular contents, cylindric and obtuse, about 7.5–10 x 3–3.5 μ. Directly centered on the reverse of the spot is a sorus of the microcyclic rust *Puccinia veronicarum* DC. In the same general area on September 11, on the same host, a possible *Ascochyta* was found on orbicular, blackish, zonate areas, about 1–2.5 cm. diam.; pycnidia sooty-brownish, thin-walled, subglobose, approx. 100–125 μ diam., scattered and very inconspicuous; conidia hyaline, cylindric, sparingly uniseptate, about 9–10 x 2–2.3 μ, mostly nonseptate and smaller, about 4.5–7.5 x 1.3–1.7 μ. 6) On *Antennaria parlinii* Fern. collected August 31, 1964, near Leland, Sauk Co. Spots sordid brown with narrow darker margin, irregular in shape and involving the distal portions of the leaves; pycnidia epiphyllous, gregarious, black, subglobose, thick-walled, erumpent, approx. 125–150 μ diam.; conidia hyaline, cylindric, uniformly uniseptate, not constricted at septum, (11–)12–13(–14) x 2.5–2.8 μ. The ratio of length to width of the conidia suggests that this might ultimately prove to be a *Stagonospora*.

Aster prenanthoides Muhl., collected near Leland, Sauk Co., August 12, 1964, bears on the living leaves a possibly parasitic and peculiar sphaeropsidaceous fungus which seems to fall between *Diplodina* West. and *Chaetodiplodina* Speg. There are no spots. The pycnidia are sooty brown, relatively thin-walled and pseudoparenchymatous, globose, about 110–225 μ diam., the ostiole small but sharply outlined by a ring of dark cells, hypophyllous, scattered and superficial on a small, loosely organized subiculoid network, the component hyphae of which are brownish and appear to originate as strands from wall cells at various points on the pycnidium. Conidia are hyaline, straight or slightly curved, cylindric, long-cylindric, or subfusoid, many appearing continuous, but many uniseptate and a few obscurely 3-septate, approx. (15–)17–30(–33) x 3.5–5 μ.

SEPTORIA sp. is strictly confined to the spermogonial surface of aecial sori of *Puccinia dioicae* P. Magn. on leaves of *Solidago patula* Muhl. collected July 1 near Leland, Sauk Co. The sori have a conspicuous blackish-purple margin, quite unlike sori on adjacent leaves which bore the rust alone. The tiny black pycnidia are only about 35–50 μ diam., the hyaline acicular spores approx. 15–20 x 1 μ.

HENDERSONIA sp.—a very large-spored form—occurs on conspicuous spots on leaves of *Spartina pectinata* Link collected at Madison, September 3, 1965. This spotting of *Spartina* has been noted over the years at various stations, and specimens have been preserved. In my Notes 20 (Trans. Wis. Acad. Sci. Arts Lett. 43: 173. 1954) I described the spots of a specimen collected in 1952 near Mazomanie, Dane Co., as "remarkably conspicuous, large, orbicular . . . with grayish centers and wide, purplish-brown borders on the upper surface of the leaves. On the lower surface and coinciding with the spots are wefts of sordid-whitish, largely superficial, yet closely appressed mycelium. Microscopically this mycelium is thin-walled, septate, and somewhat verrucose. . . ." At that time I overlooked the very scanty and inconspicuous development of the *Hendersonia,* as I did in subsequent specimens, until the 1965 Madison collection, where there is a relatively profuse development of pycnidia. Taking all the specimens into account, one finds that the pycnidia are from scattered and very few in some to gregarious and fairly numerous in others. They are subglobose, about 160–200 μ diam., sooty-olivaceous, with a small ostiole delimited by a ring of dark, thick-walled cells. The large conidia are from almost straight to variously curved, widest at or near the middle, ends obtuse, clear yellowish-olivaceous, 6–9, but mostly 7-septate, approx. (60–)75–100(–120) x (11–)12–13(–15) μ. The relation of the superficial hypophyllous mycelium to the *Hendersonia* is not clear, although it occurs in greater or less development on the reverse of all the spots and is confined to them.

CYLINDROSPORELLA (?) sp. occurs on mottled green and brownish areas of leaves of *Podophyllum peltatum* L. collected May 29 near Albany, Green Co. The subcuticular acervuli are most inconspicuous and even in section discernible with difficulty. They are very slightly concave to almost plane and the conidiophores on them very short, almost obsolete. The conidia, which are produced in considerable numbers, are hyaline, cylindric or subcylindric, straight or slightly curved, (6–)8–10(–12) x 1.2–2.6 μ. This plainly has no connection with *Septotinia podophyllina* (Ell. & Ev.) Whetzel, which has much larger septate conidia and lesions of a different aspect.

COLLETOTRICHUM spp. indet. have been noted on several hosts as possible parasites. 1) On leaf midribs of *Corylus americana* Walt. collected near Pine Bluff, Dane Co., September 5, 1964. The leaf adjacent to the midrib is brownish and discolored, suggesting parasitism. The fructifications are elongate and deep-seated in the tissue, the stiff setae black below, somewhat paler toward the tip, 1–2 septate, approx. 65–150 x 5–6 μ (somewhat wider at the very base), a few shorter and narrower, mostly in pairs or small groups. The conidia hyaline, falcate, 20–23 x 2.5–3.2 μ. 2) On *Asarum canadense* L. collected in Wyalusing State Park, Grant Co., June 24. Spots blackened, orbicular, about .5–1 cm. diam.; acervuli epiphyllous, scattered to gregarious; setae rather coarse, fascicled and prominent, clear purplish-brown below to slightly paler above, tapering gradually to the subacuminate tips, slightly to moderately curved, approx. 90–140 x 5–7 μ, 2–5 septate; conidia hyaline, falcate to almost lunate, about 17–23 x 2.5–3 μ. The affected leaves were growing among and surrounded by healthy leaves on a high, deeply shaded bluff where frost damage could scarcely have been a factor. Possibly parasitic, but *Asarum canadense* is notable for lack of parasites, with the only so far determined fungus reported on it from Wisconsin or elsewhere being *Synchytrium asari* Arth. & Holw. 3) On dead upper portions of stems of *Desmodium bracteosum* (Michx.) DC, var. *longifolium* (T. & G.) Rob. from the New Glarus Woods Roadside Park, Green Co., October 1, 1964. The plants were, in the main, still living and it seems probable that the fungus caused the death of the stem tips. No setae were observed, but the organism is perhaps referable to *Colletotrichum* in the usage of von Arx. The acervuli occur in profusion, are dark, subepidermal, small, mostly only about .2 x .1 mm.; conidiophores closely compacted and olivaceous below, but paler above in the free measurable portion where they are from about 8–10 x 2.5–3 μ, appearing to be confined mostly to the margin of the acervulus; conidia subhyaline, cylindric, about 11–15 x 3.5–4.5 μ. 4) On *Asclepias exaltata* (L.) Muhl. collected at Madison, September 11, 1964. Lesions elongate, pallid greenish with wavy black borders, approx. .5 cm. wide by 2–4 cm. long; acervuli epiphyllous and gregarious; setae peripheral, slender, flexuous, uniform clear dark brown, little if any paler at the subacuminate tips, sparingly septate, approx. 60–85 x 3.5–4.5 μ; conidia hyaline, straight, cylindric and obtuse, occasionally subfusoid, about 14–17 x 3.5–5.5 μ.

MARSSONINA (?) sp. occurs on *Quercus velutina* Lam. collected at Madison, October 3, 1964. The flesh-colored acervuli are hypophyllus on elongate brownish areas along the principal veins. In my Notes 26 (Trans. Wis. Acad. Sci. Arts Lett. 49: 95. 1960) I mentioned a very similar fungus on *Quercus alba* L., where the conidia "vary from rarely obclavate to cylindric, broadly cylindric or ellipsoid, or curved *Marssonina*-like, continuous so far as observed, 18–36 x 6.5–9 μ." One would suspect that the great irregularity in conidial size may be the result of late season development, with accompanying wide temperature extremes, but even so this organism does not seem close to any fungus currently reported from this area on either white or black oak.

BOTRYTIS (B. VULGARIS Fr.?) appears strongly parasitic on elongate brownish lesions which encircle the stems of greenhouse-grown tobacco, *Nicotiana tabacum* L., at Madison in September 1965. The fungus is fruiting profusely, with whorls of subhyaline, short-clavate branches produced near the tips of comparatively long, septate, brownish-olivaceous conidiophores. The conidia are grayish, smooth, broadly elliptic, oval or oblong, 8–10(–13) x 6–9 μ.

CLADOSPORIUM sp., appearing parasitic, is epiphyllous on *Andromeda glaucophylla* Link collected in Hope Lake Bog near Cambridge, Jefferson Co., June 12. The spots are rounded, reddish-purple, small, 1–2 mm. diam., or confluent and larger, mostly marginal on the narrow leaves; conidiophores loosely clustered from a substromatic base to fascicled from a well-developed stroma, multiseptate, from almost straight to slightly curved or sinuous, a few subgeniculate, simple, subdenticulate, clear brown below, becoming pallid above, 35–60 x 3–4 μ; conidia ellipsoid to subfusoid, continuous or 1-septate, catenulate, roughened, grayish-olivaceous, about 10–12(–15) x 3–4 μ. I have not found any reports of *Cladosporium* on *Andromeda* or related plants.

CERCOSPORA sp. in small amount, has been observed on *Gaultheria procumbens* L. collected by J. A. Curtis in the Bittersweet Lake Scientific Area near Eagle River, Vilas Co., July 25, 1963. This bears no resemblance to *Cercospora gaultheriae* Ell. & Ev. nor to other species listed on Ericaceae in Chupp's monograph. The fungus is hypophyllous and quite diffuse, the conidiophores clear brown, markedly geniculate and tortuous, often rather intricately branched and intermingled, but not compacted into a stroma, about 4.5–6 μ diam. at the base, several-septate and up to 150 μ long. The conidia are dilute olivaceous, narrowly obclavate to almost acicular, straight to moderately curved, 5–11 or more septate, base subtruncate, 55–105 x 3.5–4.5 μ.

ALTERNARIA sp. in an apparently parasitic condition on *Euphorbia esula* L. was first noted at Madison in 1949 and commented upon briefly in my Notes 14. The material was rather old, however, and not suitable for close study. In 1965, in the same general location, much fresher and quite plainly parasitic *Alternaria* was collected and studied on this host. The spots are sordid brown with a narrow darker border, rounded or angular in basic outline, usually extending from about the midrib up to, and involving, the margins of the narrow leaves, subzonate and approx. 2–5 mm. diam. The conidiophores are amphigenous, but most prominent on the upper leaf surface, and appear to be produced from stomates in a few cases, in broadly diverging groups of half a dozen or more. They are clear olivaceous-brown, 3–4 septate, up to 60 x 4 μ and from almost straight to curved and mildly tortuous-geniculate. The main spore bodies are olivaceous-gray or olivaceous, broadly ovate to clavate, about 28–50 x 12.5–14(–15) μ, the narrow beaks subhyaline to dilute olivaceous, approx. 15–30(–35) x 2–3 μ. The spores with beaks mostly run about (50–)60–70(–80) x 12–15 μ with 3–9 transverse septa and about 2–5 vertical septa. *Alternaria brassicae* (B.) Sacc. is reported in Seymour's Index as occurring on *Euphorbia esula,* but according to Neergaard in his authoritative "Danish Species of *Alternaria* and *Stemphylium*", *A. brassicae* is a much coarser species. The Wisconsin specimen likewise does not correspond with *Macrosporium (Alternaria) euphorbiae* Barthol., which has wider spores and much longer beaks.

GRAPHIOTHECIUM VINOSUM J. J. Davis was described (Trans. Wis. Acad. Sci. Arts Lett. 18(1): 90. 1915) as occurring on *Ribes americanum* Mill. at Madison, with the observation that the fungus reached full maturity only after overwintering. The last previous collection on this host was made nearly 50 years ago, but in September 1964 at Tower Hill State Park, Iowa Co., leaves of *Ribes americanum,* infected with what appeared to be possibly an immature Ascomycete, were gathered and overwintered out-of-doors at Madison. In May 1965 these were found to bear numerous vinous-purplish synemmata characteristic of *Graphiothecium vinosum.*

GRAPHIOTHECIUM sp. developed on leaves of *Lonicera tatarica* L. collected at Madison, October 6, 1964, with the fungus in immature condition, and held out-of-doors until May 1965. The closely gregarious synemmata are amphigenous and deeply seated in the leaf tissue, with a black, bulbous base about 125–150 μ diam. The synemmata proper are approx. 175–200 μ long by 25 μ or more thick, black and compact below, but becoming hyaline and more loosely organized above. The conidia are hyaline, fusoid to subcylindric, about 10–17 x 2.5–4 μ, often produced at right angles to the stalk. Although a late season collection, the fungus appeared to have initiated its development as a parasite. So long as unblighted by frost, Tatarian honeysuckle and similar exotics remain green and active much later in the fall than most native species. At the time of collection the fruiting structures resembled immature pycnidia or perithecia, with no indication of the ultimate synemmatal development which evidently occurred in the spring of 1965.

Lonicera morrowi Gray observed near Ridgeway, Iowa Co., August 5, 1964, bore on the under surface of the leaves a curious, possibly parasitic, presumed fungus which is snowy white and had developed in narrow lines in the form of closed rings, partial rings, and other less regular serpentine patterns. All leaves on any one branch consistently bore the fungus and, except for it, were very clean-appearing with no evidence whatsoever of the debris one would ordinarily expect had the growth accompanied insect infestation. Although superficial in aspect, the organism is very closely appressed and not readily removed. Microscopically it consists of masses of closely interwoven, non-fruiting, hyaline, very slender, hyphae-like threads, about 1 μ wide, which are only obscurely septate, or perhaps even non-septate. These threads quite regularly ascend the trichomes but appear to be superficial on them.

Additional Hosts

The following hosts have not been previously recorded as bearing the fungi mentioned in Wisconsin.

PLASMOPARA VIBURNI Peck on *Viburnum opulus* L. (cult.). Milwaukee Co., Fox Point, September 24, 1962. Coll. & det. J. W. Baxter.

SYZYGITES MEGALOCARPUS Ehr. ex Fr. on *Entoloma* (*grayanum* Peck?). Dane Co., Madison, September 27. Coll. & det. R. J. Boles.

MICROSPHAERA ALNI (Wallr.) Wint. on *Lonicera morrowi* Gray. Iowa Co., near Ridgeway, August 5, 1964.

PHYLLACHORA GRAMINIS (Pers.) Fckl. on *Elymus wiegandii* Fern. Grant Co., Wyalusing State Park, August 28, 1957. Coll. H. H. Iltis.

OPHIODOTHIS HAYDENI (B. & C.) Sacc. on *Aster sagittifolius* Willd. Sauk Co., near Leland, September 11.

METASPHAERIA LEERSIAE (Pass.) Sacc. on *Leersia virginica* Willd. Jackson Co., Gullickson's Glen near Disco, August 21, 1963.

LEPTOSPHAERIA ELYMI Atk. on *Elymus canadensis* L. Sauk Co., near Leland, July 15.

CERATOSTOMELLA ULMI Buisman on slippery elm, *Ulmus rubra* Muhl. E. B. Smalley, Dutch elm disease specialist at the University of Wisconsin, informs me that the disease is now general upon slippery as well as upon American elm in southern Wisconsin, and that he has noted its natural occurrence on *Ulmus pumila* L. in the state, although this species is comparatively resistant.

CRONARTIUM RIBICOLA Fisch. II, II on *Ribes diacantha* Pall. (cult.). Dane Co., Madison, September 22.

MELAMPSORA ABIETI-CAPREARUM Tub. II, III on *Salix adenophylla* Hook. (cult.). Dane Co., Madison, October 5.

PUCCINIA CARICINA DC. II on *Carex comosa* Boott. Oneida Co., near Woodruff, July 5, 1958. Coll. H. H. Iltis.

PUCCINIA DIOICAE P. Magn. I on *Solidago uliginosa* Nutt. Sawyer Co., Flambeau State Forest near Oxbow, July 24, 1964.

PUCCINIA DIOICAE P. Magn. II, III on *Carex annectens* Bickn. var. *xanthocarpa* (Bickn.) Wieg. LaCrosse Co., Town of Farmington, June 29, 1959. Coll. A. M. Peterson. This is the punctate form, *Puccinia vulpinoidis* Diet. & Holw., now regarded as a synonym.

PUCCINIA KARELICA Tranz. II, III on *Carex crinita* Lam. Florence Co., Lost Lake, July 14, 1939. Coll. A. L. Throne. Det. J. W. Baxter.

PUCCINIA ASTERIS Duby on *Aster puniceus* L. Iowa Co., Gov. Dodge State Park, July 14.

UROMYCES SILPHII (Burr.) Arth. I on *Helianthus tuberosus* L. Sauk Co., near Leland, June 16.

UROMYCES SPOROBOLI Ell. & Ev. III on *Sporobolus heterolepis* Gray. Kenosha Co., near Woodworth, August 10, 1954. Coll. P. B. Whitford. Det. J. W. Baxter.

CINTRACTIA CARICIS (Pers.) Magn. on *Carex meadii* Dewey. Iowa Co., near Ridgeway, June 14.

PHYLLOSTICTA HISPIDA Ell. & Dearn. on *Smilax ecirrhata* (Engelm.) Wats. Green Co., New Glarus Woods Roadside Park, September 8, 1951. Although an adequate specimen was placed in the herbarium at the time of collection, it was overlooked and not recorded in these notes.

PHYLLOSTICTA MONARDAE Ell. & Barth. on *Monarda punctata* L. Sauk Co., near Leland, September 11. *P. monardae* is said to be synonymous with *Phyllosticta decidua* Ell. & Kell., but because the description does not fit *P. decidua* as I understand it, on an interim basis I have applied the name *P. monardae* to a species of *Phyllosticta* with *non-translucent* spots which occurs on *Monarda, Blephilia, Lycopus, Mentha* and *Pycnanthemum* in Wisconsin and which corresponds well with the description.

PHOMA POLYGRAMMA (Fr.) Sacc. var. PLANTAGINIS Sacc. on *Plantago rugelii* Dcne. Racine Co., Racine, October 30, 1894. Coll. J. J. Davis. This is labeled *Phyllachora plantaginis* Ell. & Ev. and is presumably a portion of the specimen from which Ellis and Everhart described that species. Except for the fact that the fusoid conidia are slightly longer than in specimens on *Plantago lanceolata* L., discussed by me in my Notes 27 (Trans. Wis. Acad. Sci. Arts Lett. 50: 159. 1961), the overall aspect is very similar indeed, although in *P. rugelii* the fungus is on the leaves, whereas in *P. lonceolata* it is normally confined to the flowering scapes.

RHIZOSPHAEARA KALKHOFFI Bub. on *Picea pungens* Engelm. (cult.). Grant Co., Wauzeka, October 1964. Coll. G. L. Worf.

NEOTTIOSPORA ARENARIA Syd. on *Carex lanuginosa* Michx. Adams Co., Springville Twp., September 13, 1958. Coll. T. G. Hartley (6273).

CONIOTHYRIUM FUCKELII Sacc. on *Rubus strigosus* Michx. Sauk Co., near Leland, August 31, 1964.

ASCOCHYTA VIOLAE Sacc. & Speg. on *Viola sororia* Willd. Sauk Co., near Leland, August 31, 1964.

ASCOCHYTA COMPOSITARUM J. J. Davis on *Ambrosia trifida* L. Iowa Co., Gov. Dodge State Park, July 6. The smaller-spored variety.

STAGONOSPORA ALBESCENS J. J. Davis on *Carex hystricina* Muhl. Florence Co., near Lost Lake, June 14, 1959. Coll. H. H. Iltis. On *C. rostrata* Stokes. Sawyer Co., Flambeau State Forest, June 24, 1959. Coll. E. Beals.

SEPTORIA NEMATOSPORA J. J. Davis on *Carex intumescens* Rudge. Sawyer Co., near Loretta, June 12, 1959. Coll. L. Hathaway.

SEPTORIA CARICINELLA Sacc. & Roum. on *Carex lactustris* Willd. Price Co., Chequamegon National Forest near Park Falls, June 20, 1959. Coll. E. Beals.

SEPTORIA CARICINA Brun. on *Carex pedunculata* Muhl. Sauk Co., Parfrey's Glen, June 8, 1964.

SEPTORIA GLYCINES Hemmi on *Amphicarpa bracteata* (L.) Fern. Dane Co., Madison, August 6, 1964. Hemmi gives the pycnidial diameter as 44–100 μ and the length of spores at 21–52 μ. On *Amphicarpa* they are about 50–65 μ and 20–40 μ respectively and the lesions are dull brownish, cuneate, about .5–3 cm. long by not more than 1 cm. wide, usually involving the tips of leaflets. The pycnidia are epiphyllous and gregarious, mostly concentrated along the principal veins.

SEPTORIA LOBELIAE Peck on *Lobelia kalmii* L. Door Co., Egg Harbor, August 27, 1945. Coll. R. A. McCabe. On basal leaves of a phanerogamic specimen.

SEPTORIA MATRICARIAE Hollos on *Anthemis cotula* L. Dane Co., Madison, June 3.

SPHACELOMA ROSARUM (Pass.) Jenkins on *Rosa rugosa* Thunb. (cult.). Dane Co., Madison, October 5.

HAINESIA LYTHRI (Desm.) Hoehn. on *Rubus deliciosus* Torr. (cult.). Dane Co., Madison, September 22.

COLLETOTRICHUM MADISONENSIS H. C. Greene on *Carex comosa* Boott. Jefferson Co., Hope Lake Bog near Cambridge, July 28, 1956. Coll. H. H. Iltis. On *C. rostrata* Stokes. Sawyer Co., Flambeau State Forest, June 24, 1959. Coll. E. Beals. On *C. vulpinoidea* Michx. Waupaca Co., Clintonville, July 28, 1959. Coll. K. D. Rill.

COLLETOTRICHUM HELIANTHI J. J. Davis on *Helianthus tuberosus* L. Sauk Co., near Leland, June 16.

CYLINDROSPORIUM RUBI Ell. & Morg. on *Rubus odoratus* L. (cult.). Dane Co., Madison, October 5.

MONOCHAETIA DISCOSIOIDES (Ell. & Ev.) Sacc. on *Rosa rugosa* Thunb. (cult.). Dane Co., Madison, October 5. Considerable uncertainty attaches to the nomenclature of these forms, but this is the same entity reported as *M. discosioides* on native roses in Wisconsin.

MYRIOCONIUM COMITATUM J. J. Davis var. SALICARIUM Davis on *Salix petiolaris* Smith. Ozaukee Co., Cedarburg and Waukesha Co., Big Bend. Both specimens collected by Davis in June 1930, but not reported and overlooked until recently.

MONILINIA FRUCTICOLA (Wint.) Honey. *Monilia* stage on fruit of *Prunus nigra* Ait. Sauk Co., near Leland, August 24.

RAMULARIA CANADENSIS Ell. and Ev. on *Carex normalis* Mack. Sauk Co., near Denzer, July 31.

CERCOSPORA CARICIS Oud. on *Carex alopecoidea* Tuckerm. Portage Co., near Junction City, August 21, 1953. Coll. G. Ware.

CERCOSPORA OXALIDIPHILA Chupp & Muller on *Oxalis europea* Jord. Sauk Co., near Leland, August 12, 1964.

CERCOSPORA UMBRATA Ell. & Holw. on *Bidens coronata* (L.) Britt. Columbia Co., Gibraltar Rock County Park, August 13, 1964. In small amount, associated with *Cercospora bidentis* Tharp.

TUBERCULINA PERSICINA (Ditm.) Sacc. on *Gymnosporangium juniperi-virginianae* Schw. III on *Juniperus virginiana* L. Dane Co., Madison, Picnic Point, May 21. Coll. & det. J. L. Cunningham. The spore horns have been aborted and replaced by the sporodochia of *Tuberculina*. The first Wisconsin record on telia of a heteroecius rust.

ADDITIONAL SPECIES

The fungi mentioned have not been previously reported as occurring in Wisconsin.

GIBBERIDEA ABUNDANS (Dobr.) Shear on *Prunella vulgaris* L. Sauk Co., near Leland, August 18, 1962. In my Notes 29 this was erroneously reported as *Linospora brunellae* Ell. & Ev., a species which, so far as I am now aware, has not yet been found in Wisconsin or elsewhere in the Midwest.

USTILAGO TREBOUXII H. & P. Sydow on *Panicum virgatum* L. Dane Co., Madison, July 7. A large clump of this grass in a garden on the University of Wisconsin Campus was heavily infected. The plant was moved several years ago from a spot in Sauk Co., near Lone Rock, Wis. According to Fischer, *U. trebouxii* is fairly widespread on various grasses in the western United States, but he does not list *P. virgatum* as a host. The U. S. D. A. Index of Plant Diseases does mention it (as *U. underwoodii* Zundel) as occurring on *P. virgatum* in New York State.

Phyllosticta cystopteridis sp. nov.

Maculis obscuro-brunneis, immarginatis, plerumque in pinnulis totis; pycnidiis sparsis, pallido-brunneis, muris tenuibus translucidisque, subglobosis, indistincte ostiolatis, mensuris variis, ca. (100–) 125–150 (–225) μ diam.; conidiis hyalinis, angusto-cylindraceis vel subfusoideis, plerumque biguttulatis, (6–) 8–10 (–12) x (1.5–) 1.7–2.5 (–3) μ.

Lesions dull brown, immarginate, usually involving entire pinnules; pycnidia scattered, pallid brownish, thin-walled and translucent, subglobose, obscurely ostiolate, variable in size, approx. (100–) 125–150 (–225) μ diam.; conidia hyaline, narrowly cylindric or subfusoid, mostly biguttulate, (6–) 8–10 (–12) x (1.5) 1.7–2.5 (–3) μ.

On living leaves of *Cystopteris fragilis* (L.) Bernh. Gov. Dodge State Park near Dodgeville, Iowa County, Wisconsin, U. S. A., July 14, 1965.

A very sizable type specimen was obtained and in a number of mounts made from it no conidia with septa were seen, despite the ratio on length to width. Although few sphaeropsidaceous fungi have been reported on ferns, the writer's experience would indicate that they are not so very uncommon on these hosts.

PHYLLOSTICTA ARGILLACEA Bres. on *Rubus strigosus* Michx. Sauk Co., "Hemlock Draw" near Leland, August 14. Since 1958 nineteen specimens of this fungus have been collected .Twelve are on *R. allegheniensis* Porter, all collected in the Madison School Forest near Verona, Dane Co., and 4 on *R. occidentalis* L., one from Madison, one from Abraham's Woods near Albany, Green Co., and two from Gov. Dodge State Park, Iowa Co. An interesting example of a fungus, first described in 1894 on the cultivated European raspberry, *R. idaeus* L. and of which a number of European exsiccati have been distributed, now apparently reported for the first time from North America, yet widespread in southern Wisconsin for almost a decade on native *Rubus*. (*R. strigosus,* it should be noted, is closely related to *R. idaeus* and by some is considered to be but a variety of it). J. J. Davis in his long collecting career seems not to have found this fungus, nor did the writer prior to 1958. Although the pycnidia are flesh-colored and difficult to discern except by transmitted light, the host lesions are very noticeable and it seems unlikely that the organism could have escaped attention over the years had it been present in any considerable amount.

MACROPHOMA FARLOWIANA (Viala & Sauv.) Tassi on *Vitis aestivalis* Michx. Dane Co., near Verona, September 14, 1964.

ASCOCHYTA LEONURI Ell. & Dearn. on *Leonurus cardiaca* L. It appears that various Wisconsin collections on this host which were referred to *Ascochyta nepetae* J. J. Davis are better placed in *A. leonuri* because the conidial dimensions at their upper limit correspond to those of the latter species and are out of the range of *A. nepetae.*

Stagonospora trifidae sp. nov.

Maculis nigris, irregularibus et indefinitis, saepe magnis; pycnidiis hypophyllis, sparsis vel gregariis, vel confertis in venis primis; flavido-brunneis, muris tenuibus, subglobosis, ca. (125–) 150–175 μ diam., conidiis hyalinis, obtusis, cylindaceis vel subcylindraceis. 3-4-septatis, saepe guttulatis, (20)23–33(–37) x 7–8 (–10) μ.

Spots black, irregular and indefinite, often large; pycnidia hypophyllous, scattered to gregarious, or crowded on the principal veins, yellowish-brown, thin-walled, subglobose, approx. (125–) 150 –175 μ diam.; conidia hyaline, obtuse, cylindric or subcylindric, 3-4-septate, often guttulate, (20–) 23–33 (–37) x 7–8 (–10) μ.

On living leaves of *Ambrosia trifida* L. collected in the East Marsh of the University of Wisconsin Arboretum at Madison, Dane County, Wisconsin, U. S. A., September 3, 1965.

Stagonospora ambrosiae Savile (Mycologia 38: 453. 1946) was on lesions primarily produced by *Entyloma compositarum* and has narrow conidia 10–33 x 2.5–3.5 μ.

SEPTORIA LIQUIDAMBARIS Cooke & Ell. on *Hamamelis virginiana* L. Sauk Co., "Hemlock Draw" near Leland, August 31, 1964. On *Liquidambar* in the specimens that I examined, including N. Amer. Fungi 530, the fungus is hypophyllous, contrary to the statement by Cooke and Ellis that it is epiphyllous. On *Hamamelis,* however, the fruiting structures are definitely epiphyllous and most, but not all, are *Cylindrosporium*-like and compressed by the cells of the palisade layer. In *Liquidambar* the more loosely organized mesophyll tissue allows better pycnidial development. The spores are quite characteristic and very similar on both hosts. Instead of scolecospores, a few of the rather imperfect pycnidia on *Hamemelis* contain microconidia, about 3 x 1 μ. On *Hamamelis* the lesions are very striking, with the dark brown spots surrounded by a brilliant salmon-colored halo.

BOTRYTIS BYSSOIDEA J. C. Walker on *Allium cepa* (cult.). Racine Co., Racine, 1918. Coll. Walker. This should have been included in the earlier Wisconsin lists since, as described by Walker (Phytopath. 15: 708–713. 1925), it is definitely parasitic on onion bulbs.

THE PRESETTLEMENT VEGETATION OF IOWA COUNTY, WISCONSIN

*Wayne J. Stroessner and James R. Habeck**

INTRODUCTION

A study of the presettlement vegetation of Iowa County, Wisconsin (Fig. 1), was initiated for the purpose of determining the variety and distribution of vegetation types at the time of white settlement in the 1830's. The original land survey records were employed in this study in the same manner as other workers have in other investigations of presettlement Wisconsin vegetation (Ellarson 1949, Goder 1956, Neuenschwander 1956, and Finley 1951).

Iowa County (Fig. 1) lies in the unglaciated, southwestern corner of Wisconsin (90°00′ W, 43°00′ N). The county is bordered on the north by the Wisconsin River, which flows westward and joins with the Mississippi River. One of the most conspicuous physiographic features of the county is the occurrence of the Military Ridge, which is an elevated ridge of Galena limestone extending across Iowa County in an east-west direction. The Military Ridge dissects the county into two nearly equal halves, a north and south section, which are markedly differentiated from one another in climate, geology, soils, and vegetation. Detailed descriptions of this interesting feature will be discussed in a later section of this paper.

Early settlers were first attracted to the Iowa County area by the presence of lead and zinc deposits occurring throughout much of southwestern Wisconsin. Miners and other white settlers were well established in this region by the late 1820's. Mining remained the major occupation of the first settlers for many years, although in the later decades, during the 1840's and 1850's and up to the present time, agriculture became increasingly more important in the county's economy.

The vegetation in Iowa County, as well as elsewhere in Wisconsin, has no doubt been markedly influenced by man's activities for many hundreds of years, beginning with the first primitive Indian tribes in southern Wisconsin. Indians are known to have exerted

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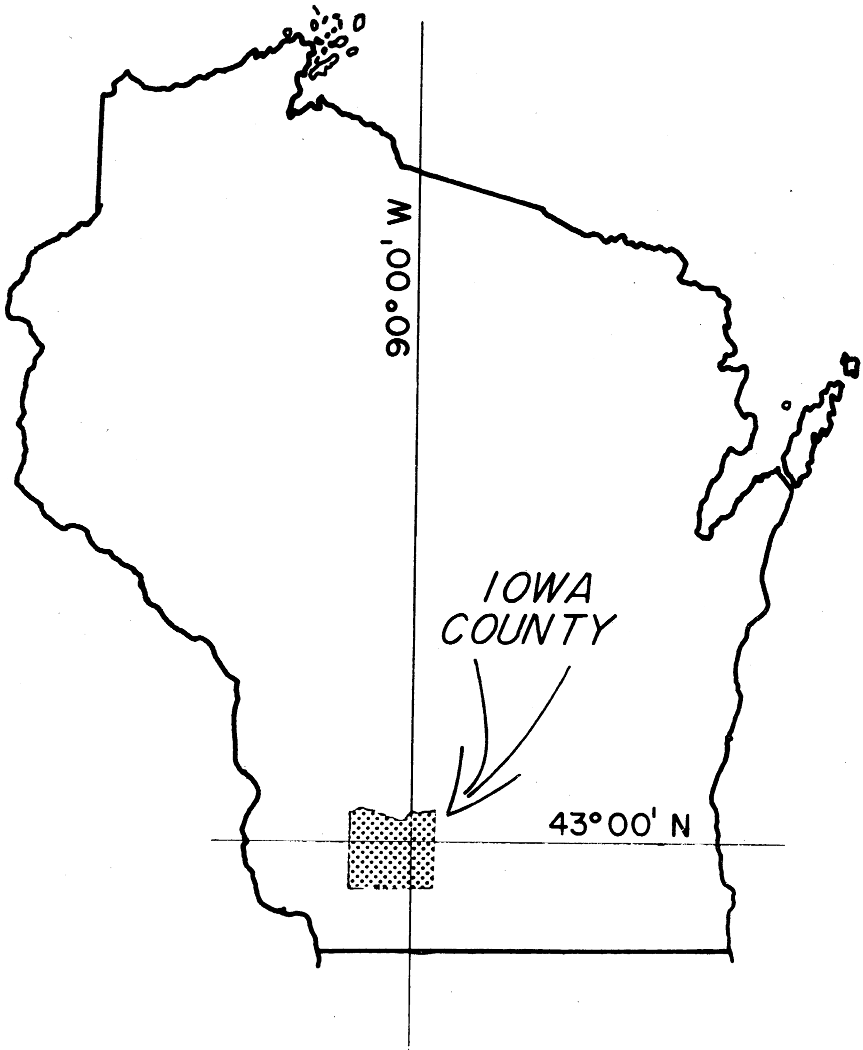

FIGURE 1. The location of Iowa County in southwestern Wisconsin.

a significant influence on the native vegetation through their regular use of fire. Through the purposeful and accidental use of fire, the Indian is thought to have been an effective tool in the establishment and maintenance of grassland and oak opening vegetation in many areas in southern Wisconsin. Curtis (1959) discusses the role of early Indians in Wisconsin in affecting the vegetation of this region.

Miners and early agriculturalists in Iowa County also initiated their own influence on the vegetation as soon as they arrived. Mining activities no doubt created a need for timber for mine shaft construction and other uses. Oak forests in southwestern Wisconsin supplied timber for the mining industry. The prairies and oak openings prevalent in the southern half of Iowa County were the first attraction to farmers settling in this area, since these areas did not require clearing the land.

Since the mid-nineteenth century, when the area was well settled, Iowa County vegetation has been subjected to a wide variety of uses and misuses. Some forests have been cut to various degrees, some of the most select hardwoods have been used for construction of railroads, some have been burned, and others have been used as pastures. Very few areas of vegetation have remained undisturbed since the time of settlement. An analysis of changes in the Iowa County vegetation during the past 130 years will be the subject of future investigation. This present report will confine itself to a detailed description of the vegetation before its severe alteration by white man.

The Original Land Survey Records

One of the most reliable sources for determination of the type of vegetation present during the presettlement period is the invaluable records written by the surveyors during the original land survey of the Northwest Territory made during the 1830's.

Most of the surveying was done between 1831 and 1834. It is assumed that most of this work was not very enjoyable, since the survey crew had to walk approximately 100 miles through uninhabited country for each township surveyed. Not only did they have to contend with the natural elements, but they also had to be on the lookout for Indians. In May and June of 1832, there were several fierce encounters with several of the Indian tribes during which many people were killed, scalped, and sometimes decapitated.

Even though the surveyors' records were not intended to describe the vegetation in great detail, much quantitative and qualitative material can be extrapolated from these field notes. The data which have been most valuable for determining the type of vegetation present during the presettlement period include not only the description of the vegetation, but also the information given for the witness trees. From these data one is able to establish fairly accurately the type, distribution, density, and the basal area of a stand of trees; and, in turn, one can determine the relative frequency, the relative density, and the relative dominance of either a single forest, a township, or the entire county. Importance values can easily be obtained from these known quantities.

The relative frequency is described as the number of occurrences at section and quarter section corners of one species as a percentage of the total number of occurrences of all species at the corners. The relative density is the number of individuals of the species tabulated as a percentage of the number of individuals of all species tabulated within a prescribed area. The relative dominance is the basal area of the species in comparison to the total basal area of all species expressed in per cent. The importance value is only relative and is determined by summing the relative frequency, the relative density, and the relative dominance of each species. This technique is described by Ward (1956).

Discussion of Field Notes

A summary of the data derived from the field notes is provided in Tables 1 and 2. Table 1 includes only those trees that were used as witness trees, either at quarter section or corner section posts. Table 2 is a tabulation of trees that were found directly on the survey line. Since the trees were directly on the line, it was not possible to obtain any absolute values. Absolute values as well as some relative values of these trees could serve no significant function, but their presence was of value in determining whether an area was or was not heavily populated with trees.

From these two tables it is easy to note that most of the trees in Iowa County are species of oak *(Quercus)*. White and bur oak ("Burr Oak" as recorded in the original field notes) are by far the most dominant trees, comprising approximately three-quarters of all trees listed. All of the oaks combined occupy 95.8% of all trees used as witness trees. The common names of the trees are listed here as found in the field notes, along with their probable current scientific names.

Because most of the surveying was done during the winter months, the exact identification of some of the trees may be questioned. Six different oaks were listed in the surveyors' records. It is possible that yellow oak and black oak are the same species, *Quercus velutina* (Ellarson 1949), although there are several instances in which the surveyors used both common names even at the same site, indicating that the surveyors recognized differences between the two. The following entry is one of many by Sylvester Sibley, implying that yellow oak and black oak are two different species:

North between sect 22 and 23

80.00	Y. oak	8	S	87	W	49
	B. oak	7	S	37½	E	31

TABLE 1.

Species	Trees Used as Witness Trees in Iowa County During the 1830's					
	No. of Trees	Tot. No. of Quart.	Rel. Freq. %	Rel. Dens. %	Rel. Dom. %	Imp. Value
White Oak *Quercus alba L.*	1, 524	1, 004	37.7	39.8	52.2	129.7
Burr Oak *Quercus macrocarpa Michx.*	1. 253	820	30.8	32.9	23.5	87.1
Yellow Oak *Quercus muhlenbergii Engelm.*	576	427	16.0	15.1	13.5	44.6
Black Oak *Quercus velutina Lam.*	305	245	9.2	8.0	7.1	24.3
Pinn Oak *Quercus ellipsoidalis E. J. Hill.*	5	4	.2	.1	.1	.4
Red Oak *Quercus borealis Michx. f.*	2	2	.1	.1	.1	.3
Hickory *Carya* spp.	39	39	1.5	1.0	.5	3.0
Elm *Ulmus* spp.	18	18	.7	.5	.8	2.0
Aspen *Populus* spp.	25	25	.9	.7	.3	1.9
Sugar (Maple) *Acer saccharum Marsh.*	13	13	.5	.3	.7	1.5
Lynn (Basswood) *Tilia americana L.*	10	10	.4	.3	.2	.9
Willow *Salix* spp.	8	7	.3	.2	.1	.6
Cherry *Prunus* spp.	3	3	.1	.1	.1	.3
Yellow Pine *Pinus resinosa Ait.*	9	9	.3	.2	.2	.7
White Birch *Betula papyrifera Marsh.*	7	7	.3	.2	.1	.6
Yellow Birch *Betula lutea Michx. f.*	10	10	.4	.3	.2	.9
Ironwood *Ostrya* spp. *Scop.*	2	2	.1	.1	.0	.2
White Ash *Fraxinus americana L.*	11	11	.4	.3	.2	.9
Black Ash *Fraxinus nigra Marsh.*	3	3	.1	.1	.1	.3
Plum *Prunus* spp.	1	1	.0	.0	.0	.0
Hackberry *Celtis occidentalis L.*	1	1	.0	.0	.0	.0
Totals	3, 825	2, 661	100.0	100.2	100.0	300.2

TABLE 2.

Species	Trees Found Directly on Survey Lines in Iowa County During the 1830's			
	No. of Trees	Total Basal Area	Rel. Dens. %	Rel. Dom. %
White Oak *Quercus alba L.*	234	30,059	52.9	54.2
Burr Oak *Quercus macrocarpa Michx.*	53	5,231	12.0	9.4
Yellow Oak *Quercus muhlenbergii Engelm.*	108	14,365	24.4	25.9
Black Oak *Quercus velutina Lam.*	26	3,327	5.9	6.0
Pinn Oak *Quercus ellipsoidalis E. J. Hill*	1	64	.2	.1
Red Oak *Quercus borealis Michx. f.*	1	201	.2	.4
Hickory *Carya* spp.	6	283	1.4	.5
Elm *Ulmus* spp.	4	917	.9	1.7
Aspen *Populus* spp.	3	208	.7	.4
Sugar (Maple) *Acer saccharum Marsh.*	2	355	.5	.6
Lynn (Basswood) *Tilia americana L.*	—	—	—	—
Willow *Salix* spp.	—	—	—	—
Cherry *Prunus* spp.	—	—	—	—
Yellow Pine *Pinus resinosa Ait.*	2	100	.5	.2
White Birch *Betula papyrifera Marsh.*	—	—	—	—
Yellow Birch *Betula lutea Michx. f.*	1	254	.2	.1
Ironwood *Ostrya* spp. *Scop.*	—	—	—	—
White Ash *Fraxinus americana L.*	1	79	.2	.1
Black Ash *Fraxinus nigra Marsh.*	—	—	—	—
Plum *Prunus* spp.	—	—	—	—
Hackberry *Celtis occidentalis L.*	—	—	—	—
Totals	442	55,443	100.0	100.0

The "B. oak" is a black oak, even though it may be misinterpreted by some to be a bur oak. Sibley was consistent in his entries and used the "B." abbreviation only to represent black oak; if the "B." had referred to bur oak, he would not have used the method of recording shown below:

North bet sect 4 and 5

4.00	Stream					
19.20	Stream					
40.00	B oak	7	S	4½	W	66
	Burr oak	8	N	82	E	2.95

also:

West bet sect 16 and 21

39.92	Burr oak	4	S	3	W	.9
	B. oak	6	N	11	W	62

In the first example the B. oak is listed first. If it had been a bur oak, he would not have written the entries in two different ways and he probably would have used "Do" (ditto) to represent the other witness tree. In the second example he again would have used "Do" to represent the second witness tree.

In this study "Yellow Oak" is considered to be *Quercus muhlenbergii,* since this species is commonly called either Chinquapin Oak or Yellow Oak (Grimm 1957). A few of these trees can still be found in Iowa County, generally along the edges of bottomland forests.

Scrub oak was not listed as a witness tree even though it was often recorded as the main type of vegetation in the undergrowth. In a few areas pine trees were found. These relict pine stands are still found today and have been described by McIntosh (1950). At the edges of some clearings and near some mine diggings and along some of the streams, a few aspens were recorded. Hickory trees were sparsely scattered throughout the entire county. Along the bottoms of the Wisconsin River the composition of the wooded areas changed somewhat; yellow oak became more abundant, and white oak became less prominent. A greater variety of species was found in the wooded areas along the river bottoms; namely elm, lynn *(Tilia)*, and maple occurred frequently, with white ash, black ash, yellow birch, plum, and hackberry also present.

North of the center of the county in Township 7 North, Range 3 East (Fig. 2), some stands were quite dense in contrast to those in most of the other townships; however, this township did not have as large a number of trees used as witness trees or as great a total basal area as did several other townships.

Of approximately 2,400 points that were used as quarter section or corner section markers in the entire Iowa County

367 points were in the open prairie. No trees were listed, but mounds were built to mark the locations of the posts;

104 points had only one tree listed, usually because the crew was in a prairie, and as a result no other trees were available; or because the trees were at the north boundary of the county along the Wisconsin River, in which case only one tree's diameter was usually given;

31 points were not listed properly or were not listed at all. On some occasions only the diameters were given without the distances, or the distances and not the diameters;

15 points had trees located exactly at the spot where the stake was to be driven; hence only one tree was listed, giving the name and diameter; and

3 points were in streams or in a lake, and again no trees were listed.

This indicates that the remaining 1,880 of the 2,400 points were used to determine the types of forest cover present in Iowa County.

Method for Construction of a Map from Survey Records

To determine the nature of the vegetation present in Iowa County at the time of settlement, it was believed useful to construct an accurate map for that period. It seemed evident after preliminary investigation that the most suitable and accurate source of information is the record of the original land survey. Since the original surveyors' field notebooks could not be removed from the Public Land Office, it was necessary to transcribe all needed information directly from the field notes. Descriptions of vegetation vary considerably from one surveyor to the next. It became apparent that there were very few "dense" stands of trees anywhere in the entire county, and it was difficult to determine precisely the density of these wooded areas. All surveyors apparently agreed on the descriptions of the prairies, since no trees were available as witness trees within a grassland area, as shown in the following entry:

North bet sections 11 and 12
40.00 when raised a mound for ¼ section corner
56.50 Stream 9 S.E.
57.40 Spring brook 4 S.W.
80.00 Where raised a mound for cor sections 1, 2, 11, 12
Land 1st rate rolling prairie

It is considerably more difficult to determine the density of certain forests, since the descriptive terminology is general and variable. For example: "Very thinly timbered with . . .", "very thinly scattered with . . .", and "broken prairie with some timber . . ."

usually meant that this area was prairie or opening. When the terminology is "thinly timbered . . .", "tolerably well timbered with . . .", or "barrens", it is very difficult to ascertain exactly what was meant by the description; hence it seemed that some method was necessary to convert the available data in the records to quantitative values to determine the densities of various stands in the county. In order to accomplish this, the diameters and basal areas, as recorded by the surveyors, were transferred to specially designed tally sheets with a color code for identifying the density for the various stands of trees. Usually two trees were selected as witness trees at each site. Occasionally a surveyor would list four trees at a section corner. Two of the four trees were insufficiently described for use in this study, since only their diameters and the sections in which they were located are listed.

Because of minor discrepancies in comparisons of surveyor descriptions and quantitative values determined from the spacing of the witness trees as recorded on the tally sheets, a differentiation was made concerning terminology used by the surveyors in describing "prairie", "oak opening" and "oak forest". To distinguish between these three classifications, it was necessary to convert the quantitative values from the field notes to some usable values. The arbitrary values were established in order to have consistency. The basic values were derived from descriptions of communities already used by other authorities in the field. In the study made by Curtis and others (Curtis 1959), a minimum of one tree per acre separates savanna from prairie. Brown (1950) considered areas with 2 to 8 trees per acre with an average distance of about 100 feet between pine trees to be pine savannas. The "oak openings" used in this project are equivalent to the "savannas" mentioned above. Habeck (1961) differentiates between "oak opening" with trees 50 feet or more apart and "oak forest" with trees less than 50 feet apart. The problems associated with the definition and recognition of savanna vegetation are discussed in detail by Dyksterhuis (1957). To establish values similar to those used in other forest community studies, and for the convenience of converting the survey data into usable form on the tally sheets for the construction of the vegetation map, the following vegetational divisions were established to differentiate between various tree densities.

Prairie: Prairies are defined as having less than one tree per acre. It is necessary to have trees separated by a minimum distance of 209 feet in order to have less than one tree per acre. This value can easily be obtained from the field notes by determining the distance from the point to the two witness trees. It has been found that the average link distance from post to tree gives a reasonably close value for the average distance in feet between the survey trees (Cottam 1953). Therefore an average distance that is greater than or equal to 209 links from the point to the witness tree indicates that the area is prairie. In this study, if either witness tree is more than 300 links from the point, the area is also considered to be prairie. This serves as a correction factor for any situation in which, by chance, one of the trees happens to be very near to the post and the other one extremely far away.

Oak Opening: The oak opening is characterized by having from 50 to 209 feet between trees or an average of from 50 to 209 links from the point to the two witness trees. These values were selected to correspond with those selected by other authorities. Simple mathematics shows that such an area has from one tree per acre to 17.4 trees per acre. If any of the witness trees are located at a distance greater than 80 links from the point, then this area might also be considered as oak opening.

Oak Forest: An oak forest has a density of 17.4 or more trees per acre. This means that there are fewer than 50 feet between trees or an average distance of less than 50 links from the point to the two witness trees.

Bottomland Forest: Bottomland forests are found along river bottoms and near marshy areas. The trees found in this area are the same as those mentioned earlier in this paper.

On the map (Fig. 2), differentiation is made between "upland prairie" and "wet prairie and marsh". This division of the two types of prairies is necessary in order to distinguish between the various types of plant communities generally associated with each habitat.

In the preparation of the map, three preliminary maps were constructed by various methods. One map was made from the quantitative data which was organized on the survey record tally sheets. A second map was made by using the surveyors' qualitative descriptions of the vegetation. At the end of each mile covered by the survey team, the surveyor entered a brief written description of the topography and vegetation of the land similar to the following notation:

	North bet sect 33 & 34				
7.50	Stream 8 east				
8.30	Road E & W about 8 chs. E from this line is a recently evacuated log house				
40.00	set ½ mile post				
	B. Oak	12		S 59	E 4.16
	Do	12	Marked ¼ S	S 3	W 3.46
44.00	enter prairie				
80.00	Where raised a mound in prairie cor to sect 27, 28, 33, 34				

Land 1st ½ mile 2nd rate hilly & thinly timbered, Oak and
2nd ½ mile 1st rate rolling prairie

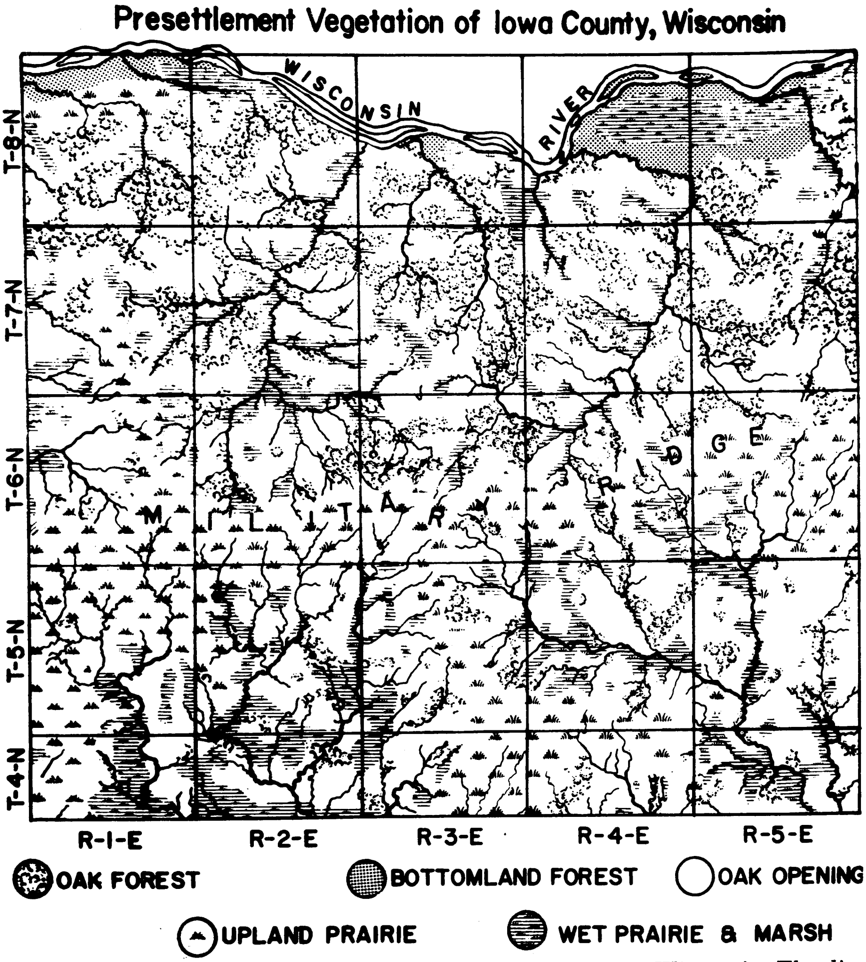

FIGURE 2. Map of presettlement vegetation in Iowa County, Wisconsin. The distribution of the five major vegetation types in the county as well as the location of the Military Ridge are illustrated. The Range and Township lines enclose areas which are each 36 square miles.

For the construction of this latter map, a color key similar to the one used for the first map was used. The divisions for the vegetation types were grouped according to the descriptions used by the surveyors:

PRAIRIE—Described as "prairie".

OAK OPENING—Described as "scattered", "thinly timbered", "barren", "well timbered", "reasonably well timbered", and "forest" (only when witness trees were distantly located).

OAK FOREST—Described as "forest" (providing witness trees were quite close together), "heavy" or "dense forest", and "dense thicket".

Other terms which are descriptive of the areas surveyed are: "bottoms"—referring to the lowland regions along a river or stream bed, and "marsh"—which is self-explanatory.

According to Mr. Tester Bakken of the Public Land Office, Madison, Wisconsin, governmental personnel in Washington, D. C., drew up maps of each township after the surveyors' notebooks were completed and sent to Washington. Each map was constructed from the original field notes, which usually included a page containing a very brief and simplified sketch of the township made by the surveyor while he was collecting data in the field. On some occasions the map was quite different from the surveyor's sketch, but in the final analysis, the resulting maps corresponded quite closely to present maps of the same area. A third map showing the results of their findings was prepared by photographing and reproducing their maps so that a clearer outline for this study could be made. By combining the observable features of the above three maps, a fourth and final map was constructed, which contains a compilation of all of the material and original information available concerning the presettlement period.

Discussion and Conclusions

The northern half of Iowa County is by far the most heavily forested portion. It is separated from the southern half by stretches of true prairie where the old "Military Ridge" road was once located. Military Ridge is the trail which army troops and supplies once traversed in the late 1800's when traveling between Madison and various military points in the western part of the state, Iowa, and Minnesota. The terrain is quite level, the land is high, and streams are not numerous; therefore east-west traveling was not difficult across this stretch of land.

All sizable streams and rivers recorded by the surveyors are shown on the map. The location and size of these streams compare quite favorably with present maps of the same areas. Therefore it can be assumed that not only the listings of the rivers and streams were accurate, but the data concerning witness trees and the descriptions of the land may be assumed to be accurate also.

Most forested areas are near a river or stream. The trellis drainage system, characteristic of both the northern and southern halves of the county, apparently does not permit a suitably moist environment for forest development in the central portion. The southern half of the county has more acreage in marsh than does the northern half. Some oak forests are found in the southern half, but the stands are few and small in comparison to the forests of the northern half. The surveyors generally described the southern portion as rolling prairie with only a few hilly areas, whereas the northern portion was generally described as rather uneven or rolling and hilly. Some rather deep ravines were found along some of the rivers and streams in the northern part of the county, but most of the river banks in the southern portion apparently were not as prominent. In the extreme northern portions of the county the lowlands or river bottoms were generally described as flat, with "first rate soil" where there was prairie, or "second rate soil" where trees were thinly scattered.

Throughout the county, oaks are by far the most prevalent species except in the lowland regions along the Wisconsin River on the northern border. In these lowland areas a larger variety of other hardwood species appear, as has been described earlier. Upland prairies, which occupy a major portion of the southern half of the county, are nearly absent from the northern half.

Some of the first settlers to inhabit Iowa County were miners, the first mine operations being located in the southern part. Shortly after the miners moved into the county in the latter part of the 1820's, some of the first homesteads became established. Because of the occurrence of upland prairie, farming in this southern portion of the county was perhaps much easier to initiate than in the northern half, since much of the land did not necessitate forest clearing before crops could be planted.

It is concluded that Iowa County during the 1830's consisted of large areas of prairie, oak opening, and oak forests. Very few other species of trees or types of vegetation were present in the county during the presettlement period. What has happened to these areas since presettlement will be a subject of future investigation.

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REAPPRAISAL OF THE GROWTH POTENTIAL OF JACK PINE AND RED PINES ON DIFFERENT SOILS OF WISCONSIN[1]

S. A. Wilde, R. R. Maeglin, and Ch. Tanzer[2]

Under the influence of Mayr's monograph (1890) and other reports dealing with natural forest distribution, foresters of the Lake States adopted a credo that jack pine is better suited for reforestation of coarse sandy soils than is red pine. The advanced growth of Wisconsin plantations of the two tree species provides a constantly increasing evidence that this thesis has notable exceptions, a disregard of which leads to large losses in the volume of produced timber. As revealed by soil and mensuration analyses, the relative performance of jack and red pine does not depend on soil texture alone, but is strongly influenced by the mineralogical composition and root permeability of soils.

Years ago, Mr. F. G. Wilson, a member of the Wisconsin Conservation Department, had shown the senior writer windbreaks established simultaneously on coarse sandy soils in which red pine produced a much faster growth than did jack pine. A study by Voigt (1951) explained this "deviation from the assumed norms of behavior" by a higher capacity of the roots of red pine to penetrate previously farmed soils in which the root channels have undergone a deterioration. Similar observations were later reported by Wilde (1961).

The recent survey of Wisconsin plantations has indicated another digression in the soil-growth relationship of jack and red pine. On coarse-textured soils enriched in silicate minerals, such as feldspar, mica, and hornblende, red pine shows an appreciably better performance than does jack pine (Fig. 1).

The survey encountered five pairs of adjacent or closely-located plantations of the two tree species, supported by feldspathic sandy soils of nearly identical state of fertility (Plainfield and Omega sands). The results of the growing stock analyses show that red pine attained a significantly higher increment than did jack pine, in some instances yielding nearly a 40% higher volume of wood (Table 1).

Information of broader significance on the growth potential of the two species is provided by the average data derived from ran-

[1] Contribution from Soil Science Dept., Univ. of Wisconsin, and the U. S. Forest Products Laboratory, in cooperation and supported in part by the Wisconsin Conservation Department. Publication approved by the director of the Wis. Agric. Expt. Station.

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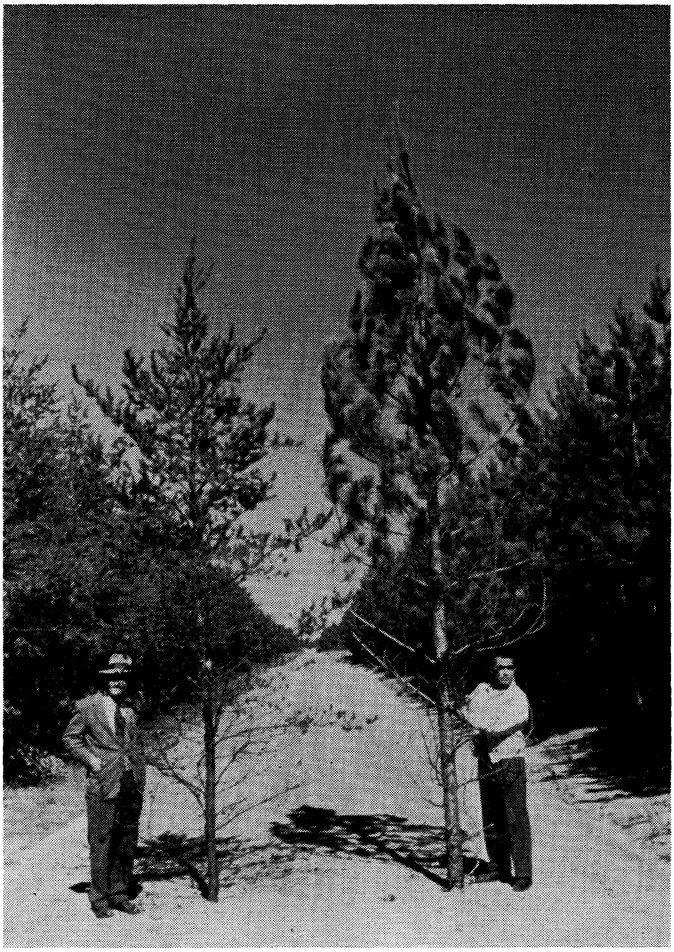

FIGURE 1. Trees of average height and DBH illustrating the relative performance of 17-year-old plantations of jack pine and red pine established the same day on Plainfield sand (Nepco Industrial Forest, Adams County, Wisconsin).

domly surveyed jack pine and red pine plantations (Wilde *et al.*, 1964a and 1964b). The results, given in Table 2, show that red pine plantations of all three site classes delivered a significantly higher volume than did jack pine plantations; according to the weighted average of all plantations, red pine produced 23 per cent more wood per year in comparison with jack pine.

An examination of the average fertility levels of soils supporting plantations of different site quality, given in Table 3, permits additional inferences.

TABLE 1. THE GROWTH OF SIMULTANEOUSLY ESTABLISHED JACK PINE AND RED PINE PLANTATIONS ON NON-PODZOLIC SANDY SOILS ENRICHED IN SILICATE MINERALS (RESULTS ON PER ACRE BASIS).

PLANTATION NO.*	AGE YRS.	JACK PINE					RED PINE				
		Ht. Ft.	DBH Ins.	No. of Stems	Basal Area Sq. Ft.	Vol. Cu. Ft.	Ht. Ft.	DBH Ins.	No. of Stems	Basal Area Sq. Ft.	Vol. Cu. Ft.
12, 13	16	16.5	2.6	1,600	62	307	16.9	2.9	1,580	70	351
173, 172	21	33.0	4.5	990	110	1,270	32.0	4.7	1,060	122	1,365
177, 176	20	24.0	3.6	830	60	461	27.0	4.5	800	85	734
181, 189	17	17.5	2.6	1,600	56	294	19.8	3.0	1,600	78	463
314, 315	34	38.5	5.2	960	134	1,909	44.7	5.9	940	179	2,960

*Legal description of plantations is given in Wilde, S. A., *et al.*, 1965, Technical Notes No. 90, Wisconsin College of Agriculture, Madison, Wis.

TABLE 2. RELATIVE PERFORMANCE OF JACK PINE AND RED PINE PLANTATIONS ON NON-PODZOLIC AND MILDLY PODZOLIZED COARSE SANDY SOILS NOT INFLUENCED BY GROUND WATER (RESULTS ON PER ACRE BASIS).

Tree Species	Age Yrs.	Height Ft.	DBH In.	No. of Trees	Basal Area Sq. Ft.	Volume Cu. Ft.	Ave. Annual Growth Cu. Ft.
Low Site Quality							
Jack pine.........	22	22.0	3.4	1,241	70	473	21.5
Red pine.........	23	21.3	4.0	1,282	101	688	29.9
Medium Site Quality							
Jack pine.........	24	30.5	4.1	1,177	107	1,106	46.1
Red pine.........	21	27.5	4.8	978	117	1,300	61.9
High Site Quality							
Jack pine.........	23	38.6	4.6	1,029	117	1,514	65.9
Red pine.........	20	32.9	5.1	1,054	136	1,960	98.0
Weighted Average of All Sites							
Jack pine.........	23.3	31.6	3.9	1,113	100	1,133	48.6
Red pine.........	21.7	27.8	4.6	1,052	112	1,377	63.5

The fertility of soils supporting red pine plantations of low site quality is definitely higher than that of jack pine plantations. This is undoubtedly because of the prevailing tendency to plant jack pine on soils depleted by wind erosion and previous farming. Therefore, the increase of the annual increment by 8 cu. feet per acre, shown by red pine, cannot be attributed to its inherent growth potential.

On the other hand, the fertility levels of soils supporting plantations of medium site quality reveal information of practical importance. The production of extra 16 cu. feet per acre per year, constituting nearly 35 per cent increase in the annual increment, was achieved by red pine on soils of a nearly similar average level of fertility in comparison with soils supporting jack pine plantations. These results indicate that misoriented tree planting may deprive the landowner of one-third of the volume of young timber; and it may inflict a still greater loss at the end of rotation.

Examination of the fertility of soils supporting plantations of high site quality further emphasizes the critical importance of the soil productive capacity in reforestation aiming at maximum re-

TABLE 3. AVERAGE FERTILITY LEVELS OF SOILS SUPPORTING JACK PINE AND RED PINE PLANTATIONS OF DIFFERENT SITE QUALITIES (AFTER WILDE *et al.*, 1964)

Site Quality	Tree Species	Annual Growth Cu. Ft./A.	Silt Plus Clay P. Ct.	Organic Matter P. Ct.	Total N P. Ct.	Avail. P Lbs./acre	Avail. K Lbs./acre	Exch. Ca me/100 g.	Exch. Mg me/100 g.
Low	Jack Pine	21.5	6.9	0.86	.037	9	45	0.64	0.17
	Red Pine	29.9	7.3	1.20	.048	18	65	0.76	0.17
Medium	Jack Pine	46.1	9.4	1.80	.074	27	67	1.33	0.26
	Red Pine	61.9	8.8	1.31	.059	27	75	0.84	0.24
High	Jack Pine	65.9	10.0	2.10	.090	31	76	1.26	0.24
	Red Pine	98.0	12.2	1.99	.086	37	121	1.41	0.33

turns. On soils of slightly higher fertility, red pine produced 32 cubic feet per year or 50% more than did jack pine. Moreover, the high rate of growth, yielding about one cord per year per acre, was obtained on soils whose fertility is not greatly superior to that of soils supporting jack pine plantations of medium site quality. The difference in the output of the two trees is enormous, constituting a debit of 52 cu. feet or a more than 100 per cent loss of the increment.

The observed superior growth of the red pine on non-podzolic coarse sandy soils is not necessarily valid on sandy loam soils, particularly those modified by a podzolization process or derived from quartzitic parent materials. Occasionally, jack pine on such soils was found to produce more than a 50% higher increment than the red pine. Planting jack pine on infertile soils could be justified only for the purpose of erosion control, soil amelioration, or isolation of parasites attacking other tree species.

Abstract

On coarse-textured soils enriched in silicate minerals, such as feldspar, mica and hornblende, red pine, *Pinus resinosa,* usually produces appreciably higher yield of timber than does jack pine, *Pinus banksiana.* This is especially true of soils in which prolonged cultivation or grazing has caused deterioration of root channels. The superior growth of red pine on non-podzolic coarse sandy soils is not necessarily valid on sandy loam soils, particularly those modified by podzolization process, or derived from quartzitic parent material. As shown by a survey of soils and growing stock, a disregard of the productive potential of soils and subsequent misoriented planting may lead to the loss of more than 50 per cent of the yield by either tree species.

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PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN NO. 55
COMPOSITAE IV—COMPOSITE FAMILY IV
(TRIBES HELENIEAE AND ANTHEMIDEAE)

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The Helenieae and Anthemideae are two of the ten tribes of the Compositae, the largest family both in the plant kingdom and in the flora of Wisconsin. The Helenieae, an artificial group segregated on the basis of the loss of the receptacular chaff, is represented by two native North American genera. The Anthemideae, a rather uniform tribe with most of the species native to the Old World, is represented in Wisconsin not only by many species that are introduced cultigens such as daisies and absinthe or weeds such as dogfennel and pineapple weed, but also by several important North American natives.

Previous portions of the family that have been treated in a preliminary fashion are the genera *Aster* (Shinners 1941), *Senecio* (Barkley 1963), *Solidago* (Salamun 1963), and the tribes Heliantheae (Melchert 1960), Eupatorieae, Veronieae, Cynareae, and Chicorieae (Johnson & Iltis 1963), and Inuleae (Beals & Peters 1966).

The present treatment of the Helenieae and Anthemideae of Wisconsin 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), Chicago Natural History Museum (F), Platteville State University, and the University of California (UC). Grateful acknowledgment is due to the curators of the above herbaria for the loan of their specimens.

Dots on the maps represent exact locations, triangles represent county records. Some records have been added from Thomas Hartley's manuscript "Flora of the Driftless Area" (1962), from Paul Sorensen's 1965 studies on the plants of Glacial Lake Wisconsin, and Duluth records from Lakela's Flora of Northeastern Minnesota (1965). The numbers in the map insets record flowering and fruit-

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ing dates in Wisconsin. Plants with vegetative growth only, in bud, or with dispersed fruits are not included. Nomenclature and order of tribes and genera follows that of Cronquist (1952). A key to the Wisconsin tribes and genera has been published (Johnson & Iltis 1963, pp. 257–262), the sequence and numbering of which is followed in the present study.

Special thanks are due to the first author's teacher, Dr. Florence Neely of Augustana College, Rock Island, Illinois, for an excellent introduction to botany, to Mr. Brian Marcks for much aid in field and herbarium, to Dr. Donald Ugent for advice in the preparation of diagrams, to Dr. John Moore, University of Minnesota, for his kindness in sending additional locations for map records, and to Mrs. Katharine Snell and Dr. John W. Thomson for various aids.

TRIBE II. HELENIEAE BENTH. & HOOK.

An artificial group (cf. Solbrig 1963) segregated on the basis of the naked receptacles. Bracts herbaceous, usually in one series. Styles truncate, branched as in the Helianthieae, the stigmatic lines running to the apex. Leaves alternate or opposite. Pappus of scales or chaff.

KEY TO GENERA

A. Leaves alternate; bracts free at base; pappus of long-awned scales; heads globose, conspicuously radiate, the rays yellow -- 18. HELENIUM.

AA. Leaves opposite; bracts united at base; pappus scales with numerous, long bristles; heads short-radiate; very rare adventive ---------------------------------- 18a. DYSSODIA.

18. HELENIUM L. SNEEZEWEED

Heads many-flowered, radiate, the *ray flowers yellow,* rather large and showy, pistillate (fertile) or neutral (sterile), cuneate, 3- to 5-cleft, pubescent without. Disks subspherical, the flowers perfect, 4- to 5-lobed, yellow or dark brown at maturity. *Involucral bracts reflexed at maturity,* in 2 or 3 series, the *outer longer than the inner. Receptacle naked, globose.* Pappus of 5–8, thin, 1-nerved, awned scales. Achenes 4- to 5-ribbed, the angles pubescent. Annual or perennial herbs with alternate, usually basally decurrent leaves covered with bitter, aromatic, resinous dots. Inflorescences few- to many-headed corymbs.

A Western Hemisphere genus of about 40 species, resembling sunflowers and blackeyed Susans *(Helianthus* and *Rudbeckia)* but differing in the globose disks and globose, naked receptacles. The resinous granules of *Helenium* give the plants a bitter taste, the milk from cows which have eaten it a bitter flavor, appear to poison livestock which have eaten quantities of it, and cause the sneezing reaction which gives it its common name (Rock 1957).

KEY TO SPECIES

A. Leaves lanceolate; stems winged by the decurrent leaf bases.
  B. Disk flowers yellow, 5-lobed; ray flowers pistillate; cauline leaves 1–3.5 cm wide; widespread throughout ---------- ----------------------------------1. *H. AUTUMNALE.*
  BB. Disk flowers dark brown, 4-lobed; ray flowers neutral; cauline leaves to 1 cm wide; very rare, in central Wisconsin ------------------------------2. *H. FLEXUOSUM.*
AA. Leaves filiform, less than 2 mm wide; stems not winged; disk yellow; very rare introduced weed -------3. *H. AMARUM.*

1. HELENIUM AUTUMNALE L. Sneezeweed. Map 1.

Perennial, subglabrous or puberulent herbs with basal offshoots from a stout rootstock. Flowering stems erect, 4–15 dm tall, conspicuously winged by the decurrent leaf bases. Rosette leaves 4–6 cm long, 5–8 mm wide, oblanceolate, entire to shallowly toothed; cauline leaves 3.5–15 cm long, 1–2(–4) cm wide, sessile-decurrent, lanceolate to elliptic, acuminate at apex and base, distantly serrulate, or rarely entire, sparsely pubescent and resinous-punctate. Heads few to many in paniculate corymbs; involucral bracts clasping the young head, reflexed at maturity; receptacles naked, conic-globose. Ray flowers 10–15, *pistillate,* bright yellow, 8–22 mm long; disk flowers perfect, *yellow, 5-lobed,* campanulate and narrowed to a tube just above the achene, 2–3 mm long. Achenes 1–1.5 mm long with 7–8 membranaceous, awned pappus scales. 2n=34 (Darlington 1955).

Abundant in all but northernmost Wisconsin, in sunny or shady moist areas such as river bottom floodplain forests, low open woods with alder, willow, elm, ash, red dogwood, silver maple, and yellow birch, on sand and gravel bars of rivers and lakeshores, meadows of *Carex, Scirpus,* and *Juncus,* and in low prairies, swales, or marshes with *Eupatorium perfoliatum, Bidens cernua, Aster, Solidago,* and *Prunella,* according to Curtis (1959) peaking in the wet prairies. Flowering from the second week in July to mid-October; fruiting from August through October.

Helenium autumnale var. *canaliculatum* (Lam.) T. & G., supposedly distinguished by its smaller size, narrow entire leaves, and strongly narrowed, often basally channeled ligules, if it occurs in Wisconsin at all, cannot be clearly segregated. The only linear-elliptic, entire-leaved extremes that do compare well with some

St. Lawrence estuary plants of var. *canaliculatum* are *J. J. Davis s.n.*, Spring Green, Sauk Co., and two collections in 1945 and 1955 by *H. C. Greene s.n.* from the calcareous Kenosha Prairie, Kenosha Co. Both of these may well be but xeromorphic forms, perhaps related to growth on calcareous substrates. Although Fernald lists two collections from La Crosse and St. Croix Counties (not seen), all our many collections from that region are clearly typical *H. autumnale.*

The Menomini Indians used the dried, nearly mature, pulverized heads of *H. autumnale* as a snuff to loosen head colds. The roots were used by the Meskwaki Indians for medicine, and a tea was made from the florets for catarrh of the stomach. In Indian languages the name for this plant means sneezing spasmodically *(aiatcianitikun)* or inhalant *(tcatcamosikan, pitcikomate)* (Smith 1923).

2. HELENIUM FLEXUOSUM Raf. Purplehead Sneezeweed. Map 2.
Helenium nudiflorum Nutt.

Perennial, puberulent or scaberulous herbs with basal offshoots from a compact rootstock. Stem erect, solitary, 4–8 dm tall, striate-sulcate, very prominently winged from the decurrent leaf bases. Rosette leaves oblanceolate, 4–5 cm long, and 1 cm wide, the cauline leaves linear-lanceolate to oblanceolate, 3–9 cm long, 0.5–1 cm wide, sessile-decurrent, entire to irregularly toothed, sparingly pilose, resin-dotted. Heads 7–12 or more in open paniculate corymbs; involucral bracts narrowly lanceolate, reflexed at maturity; receptacle naked, conic. Ray flowers 8–13, *neuter,* yellow, 1–2 cm long; *disk flowers dark reddish-brown, 4-lobed* (rarely 5), perfect, campanulate, 2–2.5 mm long. Achenes 1 mm long, with 5 membranaceous, awned pappus scales.

Centering in the southeastern United States (Rock 1957:139, map 3), abundant as far north as southern Illinois and Missouri in upland pine-oak woods, mesic-moist grass-sedge prairies and open places, spreading northward as a weed (Rock 1957), in Wisconsin known from but four collections, all since 1958, one from an open flood-plain forest, and three from open sandy or moist areas in former glacial lake beds, areas well-known for disjunct stations of Coastal Plain species. Adams Co.: Highway 21 about 3 mi east of highway 13, a sandy, peaty, low, sedge–shrub prairie with *Liatris pycnostachya, Aronia melanocarpa, Lycopodium innundatum, Cladium mariscoides, Spiraea tomentosa, Spiraea alba,* July 1962, *Iltis & Sorensen 3638.* (WIS). Jackson Co.: T22N; R3W; Sec. 4, rather moist sandy area bordering highway 54, July 24, 1958, *Hartley 4947* (WIS). Trempealeau Co.: Low moist bottomland woods on flood-plain terraces between Tank Creek and

Black River (T18N; R8W; sec. 33), with *Salix, Solidago, Aster, Eupatorium,* Sept. 5, 1958, *Iltis & Koeppen 11,947* (WIS). Waupaca Co.: Open sun, field with clay soil, Clintonville airport, Sept. 16, 1965, *Rill 1496* (WIS). Flowering from the end of July to mid-September; fruiting in September.

3. HELENIUM AMARUM (Raf.) Rock Map 2.
Helenium tenuifolium Nutt.

Distinguished easily from *H. autumnale* and *H. flexuosum* by its annual habit, linear-filiform leaves not exceeding 2 mm in width, and small yellow heads. A weedy southern species collected twice in Wisconsin, clearly adventive and non-persistent. Racine Co.: C. & N. W. right of way, sec. 14–15, Sept. 11, 1901, *Wadmond 1363½* (MIN). Sheboygan Co.: Sheboygan, waste place, Sept. 11, 1921, *Goessl s.n.* (WIS).

18a. DYSSODIA Cav.

4. DYSSODIA PAPPOSA (Vent.) Hitchc. Fetid Marigold. Map 2.

Ill-smelling, glabrous annual with slender taproot; stem 1–5 dm tall, single or freely branching. *Leaves opposite,* 1–4 cm long, 1–3 cm wide, pinnatifid into 1 mm wide, linear, toothed lobes, with few *large, pellucid orange glands* (these also on involucre). Heads few-flowered, paniculate; involucre 5–9 mm high, the outermost bracts green, free, linear, the inner oblanceolate, reddish brown, and *united at the base.* Ray flowers pistillate, 4 mm long, the very short (1 mm), green ligules scarcely exserted; disk flowers perfect, campanulate, 3 mm long. Achenes pubescent 3–4 mm long; pappus of numerous, 2–2.5 mm long bristles.

Native of more arid, western regions, adventive east to New England in disturbed, sandy or open habitats, collected once in Wisconsin in the sandy flats of the Wisconsin River, an area where other southern or western species occur (e. g. *Diodia teres, Leptoloma cognatum, Croton glandulosus* and *C. monanthogynus*). Iowa Co.: Triangle at junction of U. S. highway 14 and Wisc. 23, Sept. 18, 1965, *Murmanis s.n.* (WIS).

TRIBE III. ANTHEMIDEAE Cass.

Mostly aromatic herbs or subshrubs; bracts commonly dry-scarious, imbricate in several series. Receptacle naked, pubescent, or chaffy. Flowers white, yellow, or green, the outer pistillate or neuter. Style branches truncate, the anthers not tailed. Leaves alternate, often finely dissected. Pappus short or absent.

KEY TO GENERA

A. Receptacle chaffy, the heads radiate.
  B. Heads rather large, 1–4 cm wide, solitary and terminal on long peduncles; receptacle conic at maturity; achenes terete or angled .... 19. ANTHEMIS.
  BB. Heads small, 5 mm or less, densely corymbose; receptacle flat; achenes compressed .... 20. ACHILLEA.
AA. Receptacle naked or villous, the heads radiate or discoid.
  C. Inflorescence corymbose or heads terminal on long peduncles; ray flowers showy, sometimes obsolete, yellow or white.
    D. Receptacle flat or low-convex.
      E. Heads radiate (rarely discoid); pappus absent; achenes 5–10 ribbed ....21. CHRYSANTHEMUM
      EE. Heads discoid or short-radiate; pappus short-membranaceous; achenes 3–5 ribbed .... 22. TANACETUM
    DD. Receptacle conic at maturity; leaves pinnatisect .... 23. MATRICARIA
  CC. Inflorescence paniculate, racemose, or spike-like with inconspicuous (2–8 mm high), discoid heads; flowers green .... 24. ARTEMISIA.

19. ANTHEMIS L. CHAMOMILE, DOGFENNEL.

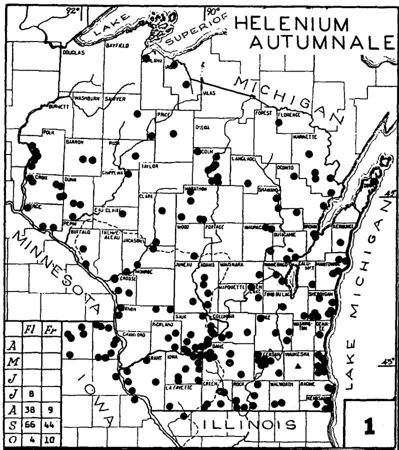
Heads few to many, solitary on long peduncles, radiate and resembling a small daisy. Rays ligulate, pistillate or neuter, white or yellow; disk flowers campanulate, perfect, yellow. *Receptacle with slender, scarious, prominent chaff.* Pappus a minute crown or lacking; achenes 4- to 5-ribbed, truncate. Aromatic, annual or perennial herbs with alternate, finely pinnatisect leaves and terminal heads. About 60 species, native to Europe, Asia, and Africa, ours weedy introductions.

KEY TO SPECIES

A. Ray flowers white; receptacle conic; involucre 2.5–5 mm high; achenes tuberculate (10x); very common, especially southern Wisconsin .... 1. *A. COTULA*.
AA. Ray flowers yellow; receptacle flat to shallowly convex; involucre 5–8 mm high; achenes smooth; rare adventive .... 2. *A. TINCTORIA*.

1. ANTHEMIS COTULA L. Dogfennel, Mayweed, Stinking Cotula. Map 3.

Ill-smelling or aromatic annual, 2–6 dm tall, simple or branching from a taproot, slightly tomentose when young. Leaves sessile, 2–6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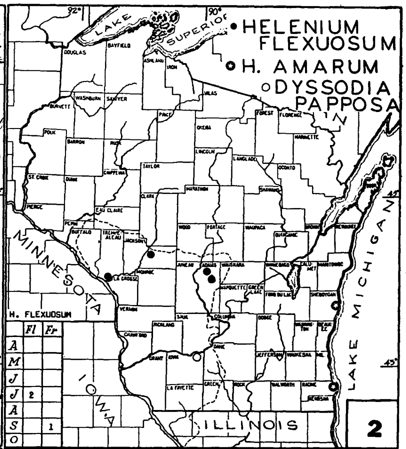
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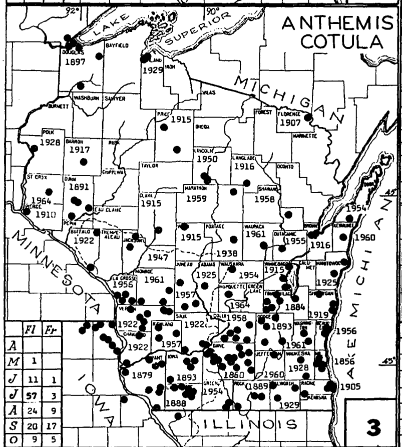
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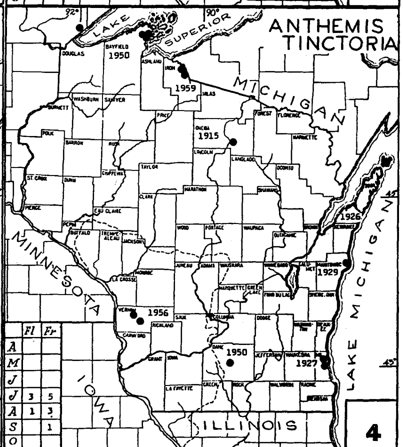
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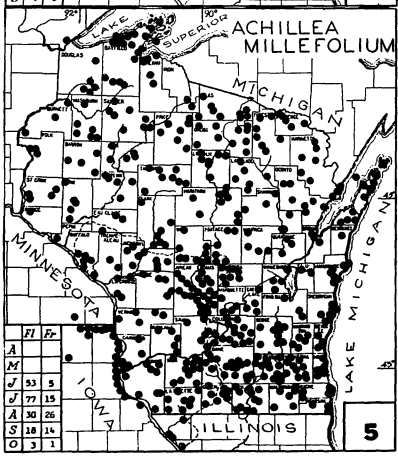
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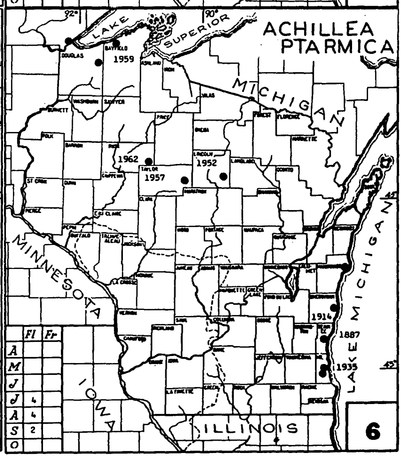
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cm long, 1–4 cm wide, delicately twice-pinnatifid into 0.3–0.5 mm wide segments. Heads few to many, radiate; involucre 2.5–5 mm high; bracts glabrate to tomentose. Receptacle conic at maturity, with linear-pointed chaff at the tip or covering most of the receptacle but *not subtending the outermost disk flowers. Rays 11–15, white, neuter* or pistillate and sterile, 8–11 mm long; disk flowers yellow, 3 mm long; achenes prominently tubercled, 1.5–2 mm long; pappus lacking. 2n=18 (Löve & Löve 1961).

Native of Eurasia, an abundant weed throughout S. Wisconsin, less so northward, in disturbed areas such as cultivated fields, hog pastures, railroad yards, roadsides, farmyards, lake shores, and bluffs. Flowering and fruiting from late May through mid-October.

The quite similar Eurasian *Anthemis arvensis* L., weedy in E. United States, but not yet known from Wisconsin, is distinguished by pleasant odor, fertile ray flowers, chaff subtending all disk flowers, and ribbed but smooth achenes. The similar, but rather rare *Matricaria chamomilla* L. (q.v.) has a smooth, chaffless receptacle and ribbed but etuberculate achenes.

2. ANTHEMIS TINCTORIA L. Golden Marguerite, Yellow Cotula. Map 4.

Aromatic, rhizomatous perennials, with 1–several stems 3–7 dm tall. *Leaves gray-green tomentose,* 4–6 cm long, 1–3 cm wide, twice-pinnatifid into 0.5–1 mm wide lobes. Heads solitary, radiate; involucre 5–8 mm high, the bracts tomentose. Receptacle flat to shallowly convex; chaff linear-lanceolate, persistent and very prominent (ca. 5 mm long), covering the receptacle. *Rays 16–41, bright yellow,* pistillate, 9–14 mm long; disk flowers dull-yellow, perfect, 3–4 mm long; achenes 2–2.5 mm long, ribbed; pappus rudimentary. 2n=18 (Darlington 1955).

Native of Europe and western Asia, often cultivated for its showy, all-yellow flowers, in Wisconsin a rare and sporadic escape in railroad yards, driveways, roadsides, lake shores and rubbish piles. The flowers yield a yellow dye (Clapham, et al. 1952). Flowering from July through early September; fruiting from July through September.

20. ACHILLEA L. YARROW, MILFOIL.

Heads many, small, densely corymbose, radiate, the 3–13 rays short, white or rarely pink, pistillate and fertile; disk flowers perfect, 10–75. Involucral bracts with dry, scarious margins, imbricate in 3–4 series. Receptacle chaffy, flat or conic. Achenes compressed, callous-margined; pappus absent. Aromatic perennial herbs with alternate, subentire to finely dissected leaves; about 75 species of the Northern Hemisphere, mostly in the Old World.

KEY TO SPECIES

A. Leaves finely dissected into linear segments; plant tomentose; ubiquitous throughout ....1. *A. MILLEFOLIUM*.

AA. Leaves undissected, serrulate; plant glabrate to subglabrous; rare adventive ....2. *A. PTARMICA*.

1a. ACHILLEA MILLEFOLIUM L. ssp. LANULOSA (Nutt.) Piper
Common Yarrow, Milfoil. Map 5.

Achillea lanulosa Nutt.

Achillea lanulosa f. *Peroutkyi* F. S. Seymour, Fl. Lincoln Co. Wis. 331. 1960 (Type: Rays pink, dry field, Rock Falls Township, Lincoln Co., Wisc. July 13, 1954, *Seymour 15,814* WIS.). Synonymous with f. *rubicunda* (Farw.) Farw.

Villous, strongly aromatic, rhizomatous perennial herbs, 2–8 dm tall. Leaves 1–2 times pinnatisect into slender, 0.2–1 mm wide, villous to glabrescent segments, the basal 13–34 cm long, 2–5 cm wide, long-petioled, the cauline 6–20 cm long, 1–3 cm wide, sessile. Corymbs flat-topped or rounded with many 3.5–6 mm high heads; bracts linear-lanceolate, with scarious margins; receptacle chaffy, conic at maturity. Flowers 18–28; rays 4–6, white (or pale pink in f. *RUBICUNDA* (Farw.) Farw.), 2–3 mm long; disk flowers 14–22, with a green tube and 5 white lobes, perfect, 2–2.5 mm long; achenes 2 mm long; pappus lacking or a small collar. $2n=36$ (Clausen, Keck, & Hiesey 1940; Ehrle 1958).

Ubiquitous throughout Wisconsin in a variety of sunny habitats, from disturbed areas such as sand bars of lakes or rivers, railroad yards, abandoned fields, roadsides, pastures, and juniper glades to prairies and open woods, an indicator of mesic prairies (68–69% presence, cf. Curtis 1955). Flowering from June through mid-October, the peak from mid-June through July; fruiting from July to mid-October.

The *Achillea millefolium* polyploid complex consists of a series of intergrading and morphologically often indistinguishable forms (cf. Cronquist 1955) separable mostly by chromosome number and pollen size correlated with distinctive geographic ranges. The widespread, evidently native North American *Achillea* is a tetraploid, with $2n=36$ and with smaller pollen (26–31 μ). Various studies suggest that nearly all Wisconsin specimens belong to this taxon, *A. m.* ssp. *lanulosa*.

1b. ACHILLEA MILLEFOLIUM L. ssp. MILLEFOLIUM, the European hexaploid ($2n=54$) with less dissected leaves, wider segments, smaller heads, less pubescence and larger pollen (31–33 μ), has been found by Mulligan and Bassett (cf. maps p. 76–77, 1959) and Lawrence (1947) to be sparingly introduced along the northeastern American coast but absent elsewhere. It is occasionally cultivated, especially in its deep pink form, and is represented by a few Wisconsin collections: Dane Co.: in garden, June 2, 1955, *E. J. Williams s.n.* (WIS). Rusk Co.: Ladysmith, July 30, 1915, *J. J. Davis s.n.* (WIS). It may be that some of the wild plants belong to this taxon, but this cannot be determined at this time.

2. ACHILLEA PTARMICA L. Sneezeweed. Map 6.

Glabrate, rhizomatous perennial herbs, 2–10 dm tall. *Leaves unlobed, linear-lanceolate, serrulate,* 3–7 cm long, 3–5 mm wide. Panicles corymbose, 2–40 headed, the heads 3–4 mm high; bracts lanceolate, keeled, the margin brown-scarious; receptacle slightly convex, chaffy. Rays usually 8–10, white, pistillate, 4–6 mm long, the disk flowers perfect, 2–3 mm long; achenes with 2–3 light colored, longitudinal ribs, 1.5–2 mm long; pappus lacking. 2n=18 (Löve & Löve 1961).

A Eurasian species, occasionally escaped from old gardens along roadsides, railroads, vacant lots, and near abandoned homes. Flowering and fruiting from July to September.

Most of the Wisconsin collections are of a horticultural variant with all flowers ligulate (f. *MULTIPLEX* (Reynier) Heimerl=f. *LIGULOSA* hort.=var. "The Pearl").

21. CHRYSANTHEMUM L. CHRYSANTHEMUM, OX-EYE DAISY.

Heads radiate (rarely discoid in *C. balsamita*), singly at the ends of long branches or corymbose. Rays numerous (rarely wanting), white (ours), pistillate and fertile; disk flowers perfect, 4- or 5-lobed, yellow, campanulate. Involucral bracts imbricate with dry scarious margins; receptacle naked, flat or convex. Pappus a short border or absent; achenes angular or subterete with 5–10 ribs. Annual or perennial herbs with alternate, entire, toothed, or dissected leaves. About 150 species, mainly in the Northern Hemisphere, chiefly in the Old World, many cultivated for their showy flowers.

KEY TO SPECIES

A. Heads with conspicuous white rays.
  B. Heads few, large, 4–6 cm in diam.; leaves toothed to lobed.
    C. Heads solitary on long, slender, naked peduncles; upper leaves strongly reduced or lacking; stems slender, 4–6

dm tall; abundant throughout ______________________ ______________________1. *C. LEUCANTHEMUM.*

CC. Heads few to many at end of robust, leafy, 1–2 m tall stems; peduncles 5–10 mm long; rare escape ________ ______________________2. *C. ULIGINOSUM.*

BB. Heads several to many, small, 12–22 mm in diam., corymbose; leaves pinnatisect; rare escape __________________ ______________________3. *C. PARTHENIUM.*

AA. Heads discoid or with minute, white rays, ca. 5 mm in diam.; leaves serrate; rare adventive __________4. *C. BALSAMITA.*

1. CHRYSANTHEMUM LEUCANTHEMUM L. Ox-Eye Daisy, Common Daisy, Marguerite. Map 7.

Rhizomatous, glabrous, perennial herbs, with one to several, 2–8 dm tall, erect stems. Leaves irregularly toothed to lobed, the basal spatulate-obovate, long-petioled, the cauline sessile, strongly reduced above. Heads solitary, 3–6 cm in diam., terminal on long peduncles; bracts imbricate, dark brown-margined. Rays (15) 20–40 per head, white and showy, 1–2(+) cm long, pistillate; disks 1–2 cm broad, the flowers perfect, yellow, 2–3 mm long; achenes 10-ribbed; pappus absent. 2n=36, 54 (Darlington 1955).

Native of Europe and western Asia, widely naturalized in cool temperate North America along roadsides, meadows, pastures, in abandoned fields, and other disturbed areas, in Wisconsin a common weed throughout but particularly abundant in north central Wisconsin (cf. map, Lindsey 1953), our plants generally referred to var. *PINNATIFIDUM* Lecoq. & Lamotte (with pinnatifid basal leaves, smaller heads), a variety of doubtful validity not differentiated here. Flowering from June to August (October); fruiting from July to October.

2. CHRYSANTHEMUM ULIGINOSUM Pers. Giant Daisy, High Daisy. Map 8.

Rhizomatous, glabrous, perennial herbs with erect, robust, 1–2 m tall stems, leafy to the top and in dense clones. Leaves sessile, lanceolate-serrate, 7–11 cm long, 1–2 cm wide. Heads few to many, large and showy. Involucral bracts lanceolate, the margin brown-hyaline. Rays about 20–22, white, pistillate; disks 15–20 mm broad, yellow, the lobes dark-tipped with age; achenes with short, membranaceous pappus. 2n=18 (Darlington 1955).

A native of southeastern Europe (Hungary, Balkans), often cultivated for its showy flowers, rarely escaped in moist, disturbed areas, collected but 4 times in Wisconsin: Dane Co.: Roadside south of Lake Waubesa, T6N, R10E, sec. 19, Sept. 1938, *Shinners s.n.* (WIS). Fond du Lac Co.: T15N, R17E, sec. 2, Sept. 24, 1960, *Wollitz s.n.* (WIS). Lincoln Co.: open pasture, T31N, R8E, sec. 12, Aug. 27, 1950, *Seymour & Peroutky 12,170* (WIS). Winnebago Co.: Neenah, filled marsh near Lake Winnebago shore, Sept. 23, 1965, *Harker s.n.* (WIS). Flowering and fruiting from August to October.

3. CHRYSANTHEMUM PARTHENIUM (L.) Bernh. Feverfew.
Matricaria parthenium L. Map 9.

Perennial, subglabrous to lightly pubescent herbs, one-to-several stemmed, 3–10 dm tall. *Leaves bipinnatisect into broadly obtuse segments*, the long-petioled lower 8–12 cm long, to 8 cm wide, the sessile upper smaller. Corymbs open, the many heads 12–22 mm in diam., whitish, radiate; involucre 3–4 mm high. Achenes 10-ribbed; pappus short-membranaceous. 2n=18 (Darlington 1955).

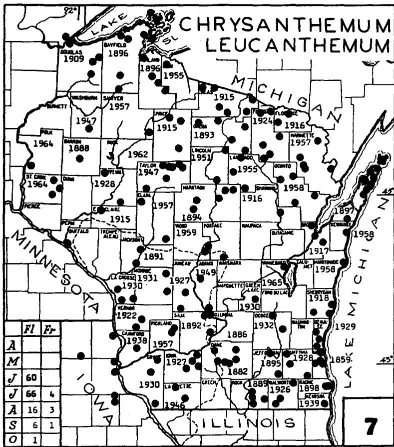
A European introduction, commonly grown in old gardens as an ornamental. An early, apparently oriental, introduction to Europe, known to Theophrastus and other ancients, and valued as a medicinal plant for its abortive properties, for promoting menstrual discharge, as well as for other ailments such as dropsy, fever, nerves and worms (Hegi 1929). A ruderal, occasionally escaped along roadsides and lake shores. Flowering and fruiting from June to August.

4. CHRYSANTHEMUM BALSAMITA L. forma TANACETOIDES Hayek
Costmary, Mint-Geranium. Map 10.

Rhizomatous, aromatic, perennial herbs, 3–12 dm tall. Leaves undissected, obovate-oblong, serrate, the juvenile silvery-pubescent, glabrous with age, the lower with 12–25 cm long blade and petiole of equal length, the upper oblong, smaller, sub-sessile. *Heads many, small, 5 mm broad, discoid,* clustered near branch tips. Involucre 3–5 mm high; *rays lacking* (minute and white in f. *BALSAMITA,* this not in Wisconsin); disk flowers yellow; achenes 10-nerved; pappus short, 2n=18, 54 (Darlington 1955).

Native of Asia Minor, Armenia and Persia, once often cultivated as a medicinal and for the sweet odor of its foliage, in Wisconsin an occasional garden escape along roadsides, lakeshores, and vacant lots. Flowering and fruiting from August to October.

CHRYSANTHEMUM CORONARIUM L., Map 9, the Garland or Crown Daisy, an annual with bipinnatisect leaves and yellow to white flowers, was once collected (from cultivation?) in Rock Co.: Aug. 28, 1889, *Skavlem s.n.* (WIS).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LEUCANTHEMUM
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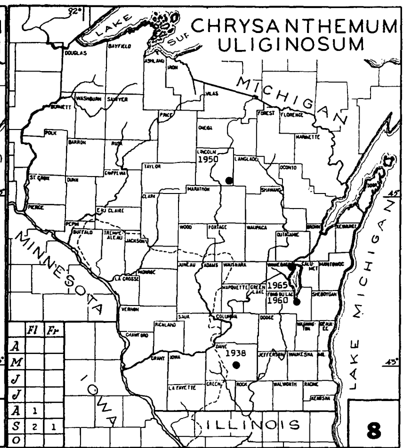
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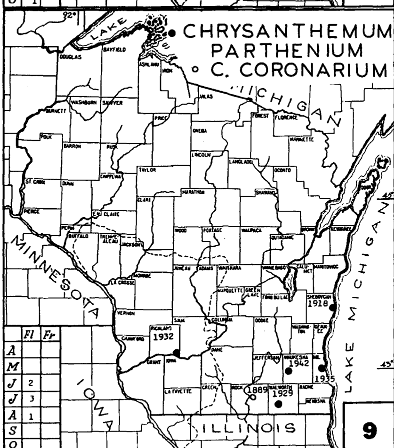
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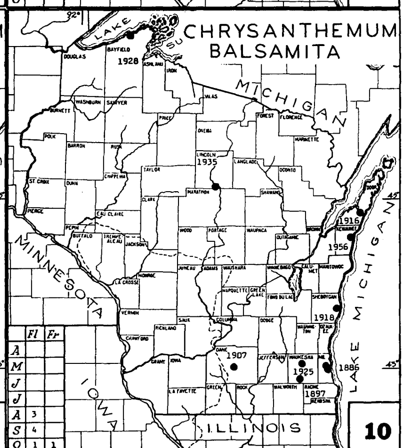
PARTHENIUM
∘ C. CORONARIUM
9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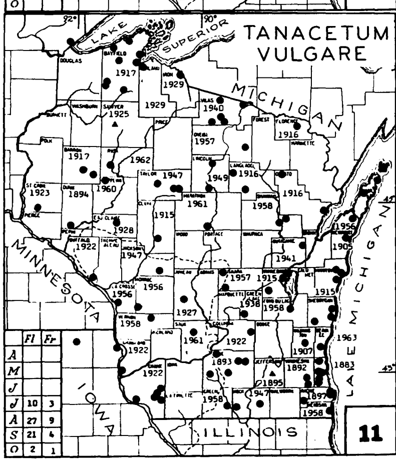
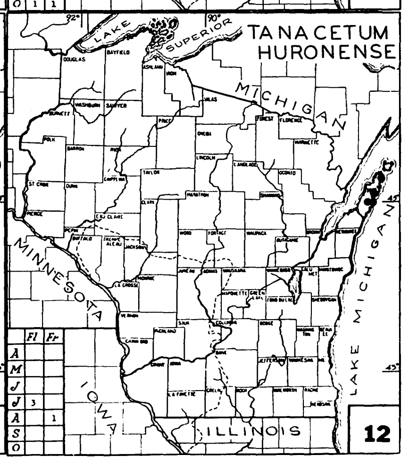
10


TANACETUM
VULGARE
11


TANACETUM
HURONENSE
12

22. TANACETUM L. TANSY.

Similar to *Chrysanthemum* (and often included in that genus), but differing in the often rather tight, flat corymbs, discoid or very short-radiate heads, short-membranaceous pappus, and 3–5 ribbed achenes. About 25 Northern Hemisphere species of mostly strongly aromatic, perennial herbs.

KEY TO SPECIES

A. Heads 25–100 or more in dense corymbs, 7–10 mm in diam., the ray flowers without ligules; leaves glabrate; plants in dense, many stemmed clumps; common introduced weed --1. *T. VULGARE.*

AA. Heads 3–17 in loose corymbs, 10–20 mm in diam., with 2–4 mm long, yellow ligules; leaves tomentose, stems solitary; rare on inner beaches of L. Michigan, Door Co. --2. *T. HURONENSE.*

1. TANACETUM VULGARE L. Common Tansy, Golden Buttons.
Chrysanthemum vulgare (L.) Bernh. Map 11.

Rhizomatous, glabrous, aromatic, perennial herbs with many stems in dense clumps, 4–10 (–14) dm tall. *Leaves twice-pinnatisect,* the ultimate segments sharply toothed (curled in the occasional f. *CRISPUM* (L.) Hayek), 8–18 cm long, 3–11 cm wide, sessile and clasping the stem. Corymbs dense, 5–12 cm wide, with *25–100 or more discoid, golden-yellow heads,* 7–10 mm in diam. Involucre 4–5 mm high; bracts imbricate with scarious margins; *receptacle flat.* Heads heterogamous; flowers fertile, resinous-granular; rays inconspicuous, pistillate, 3-lobed; disk flowers perfect, 5-lobed; achenes 1.5 mm long, 5-ribbed; pappus lobes small, membranaceous. 2n=18 (Löve & Löve 1961).

A favorite European (?) ornamental and ancient medicinal plant (oil poisonous!), commonly cultivated, escaped in open or disturbed areas along roads, railroads, fences, pastures, sandy beaches of lake shores, and floodplains and banks of rivers. Flowering and fruiting from July to October.

2. TANACETUM HURONENSE Nutt. Map 12.
Chrysanthemum huronense (Nutt.) Hultén
Tanacetum bipinnatum ssp. *huronense* (Nutt.) Breitung, Amer. Midl. Nat. 58: 66. 1957.

Perennial herbs, from long, slender rhizomes; stems 1–3, erect, 3–5 dm tall. Leaves deeply twice or thrice pinnatisect, ± tomentose, the ultimate segments mucronulate; *basal rosette leaves very large,* 23–36 cm long, 3–9 cm wide; cauline leaves 10–23 cm long, 3–8 cm wide. Inflorescence open, *heads few,* 3–12(–22), *1–2 cm in diam.;* involucral bracts scarious-margined; *receptacle hemispheric.* Rays short, 2.5–4 mm long, yellow, pistillate; disk flowers yellow, perfect, 5-lobed, 2–3 mm long; achenes 2–3.5 mm long, ribbed, truncate; pappus lobes membranaceous.

Central Alaska to Hudson Bay and the northeastern United States (Maine), in Wisconsin rare but locally abundant on Lake Michigan shores in Door County, in ecologically open habitats such as calcareous stony beaches, dry peaty and turfy limestone barrens, interdunal swales, and on dunes, especially the outer Great Lakes dunes with *Ammophila breviligulata, Agropyron psammophilum, Solidago (houghtonii?), Cirsium pitcherii, Prunus pumila, Salix syrticola,* and other Great Lakes specialities. In Wisconsin very rare: Door Co.: Baileys Harbor, July 21, 1940, *Goessl s.n.* (WIS). Jacksonport, Aug. 3, 4, 1929, *J. J. Davis s.n.* (WIS); Jacksonport, Lake Michigan beach, July 15, 1940, *Shinners & Sieker 2208* (MIL). Newport, July 3, 1905, *Milwaukee Public Museum Expedition s.n.* (MIL). Flowering and fruiting from July to September.

Tanacetum huronense var. *huronense* has recently been mapped by Guire and Voss (1963), who accepted its endemism and distinctness from the three other varieties described by Fernald (1935). However, in the *Flora of Alaska,* Hultén (1950) comments that the Alaskan populations contain *all* of Fernald's varieties! Although in general Great Lakes collections are more robust and have more heads than those from the East, one of Fernald's main characters, that of head number [high (6–30) in var. *huronense,* and low (1–6) in the other varieties], does not hold. Several Michigan collections have as few as 3 or 4 heads [e.g. *Ehlers 1061* (WIS), *Gates 13,995* (UC), *Iltis 14,843 & 14,850* (WIS)], yet are simply few-headed extremes of var. *huronense* populations (cf. Fig. 1), and are nearly indistinguishable from such collections as *Fernald 69* (Aroostook Co., Maine, UC), *Collins & Williams s.n.* (St. John River, Maine, UC), or *Fowler s.n.* [Restigouche, Bass River, N.B. (WIS)], of var. *johanense* Fern. On the other hand, the northernmost Hudson Bay collections and those from Newfoundland, with 1–3 heads and but 1–2 dm tall, appear to be depauperate plants strongly resembling Alaskan collections of *T. bipinnatum.* These findings agree well with those of Fernald (1923) which are more realistic than his later conclusions (1935, 1950).

It seems likely that Alaska is the area of glacial survival and the center of dispersal of this species. Here it is most abundant as well as morphologically most diverse, perhaps due to hybridization with *T. bipinnatum.* Furthermore, unless one accepts Fernald's "Nunataks", this is the only region where the species occurs in un-

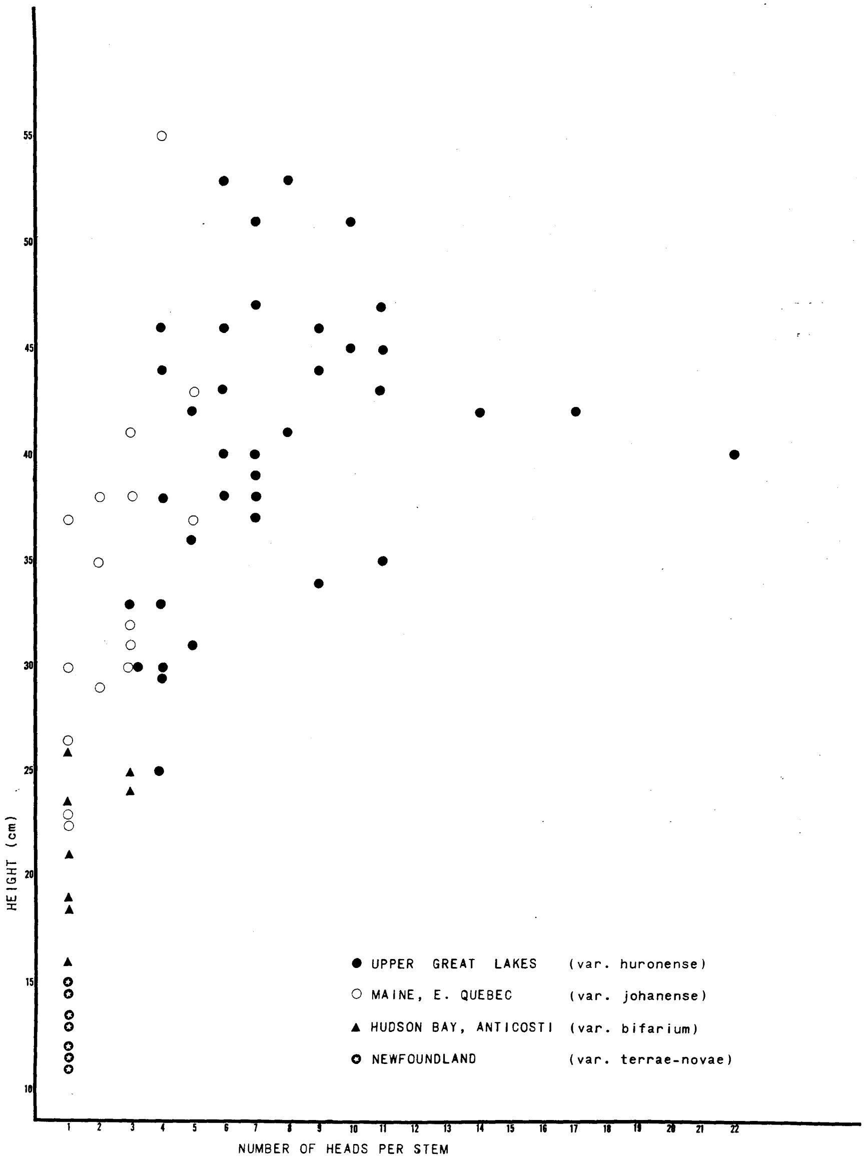
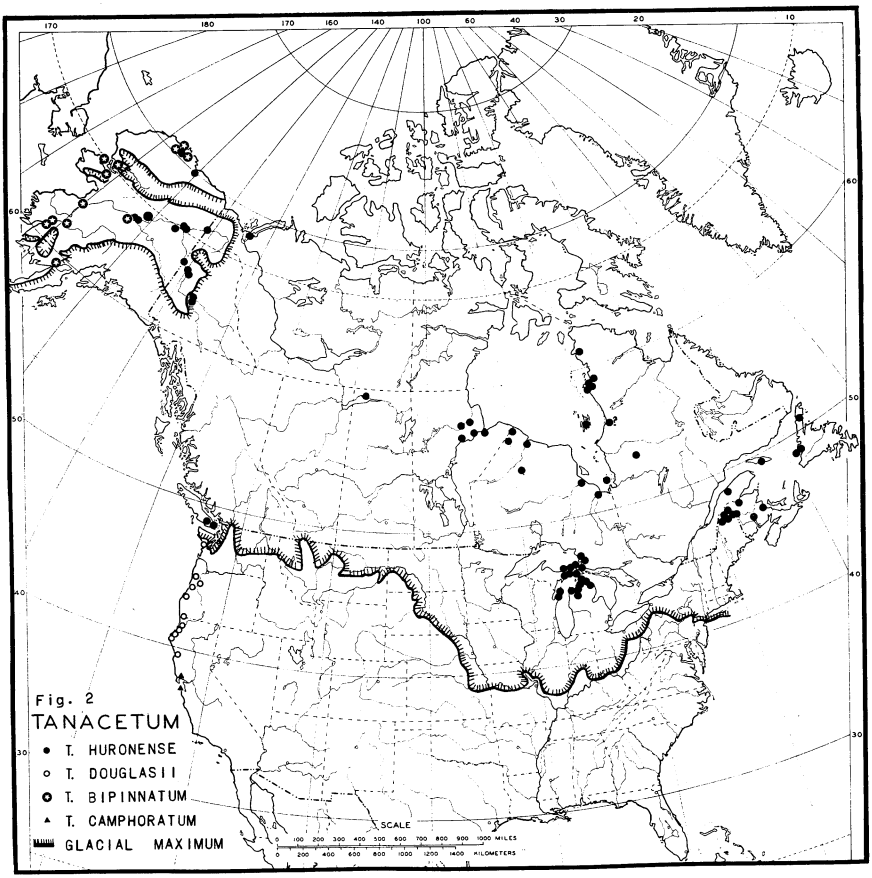


FIGURE 1. Comparison of number of heads per stem with height of specimens of *Tanacetum huronense* from four geographical areas in North America.



glaciated territory (cf. Fig. 2). One can postulate that the modern Eastern North American local populations are either the result of sporadic post-glacial long-range dispersal to "open", often calcareous habitats and/or the scattered residues of once broader distributions which now survive only in special open habitats such as dunes or gravel flats which are low in competition. Since only a few plants became established at any one place, to subsequently give rise to larger populations (either sexually or asexually), only a fraction of the diversity of the original Alaskan population would thus be represented. If to this lack of genetic variability one adds effects of inbreeding, as well as local selection and direct phenotypic responses to climatic factors, it is not surprising to find local populations differing in minutiae. A similar situation has been discussed in *Gentianopsis* (Iltis 1965).

23. MATRICARIA L. WILD CHAMOMILE.

Heads radiate with pistillate, fertile and white rays, or heads discoid and rays absent *(M. matricarioides)*; disk flowers perfect, fertile, campanulate, yellow or greenish, 4–5 lobed. Involucral bracts 2–3 seriate, slightly imbricate, scarious-margined. Receptacle naked, hemispheric or conic. Pappus a membranaceous crown, or absent. Achenes generally ribbed or wing-margined. Annual or perennial herbs with alternate, finely pinnately-dissected leaves, and few to many terminal heads. About 40 Northern Hemisphere and South African species, ours introduced weeds.

KEY TO SPECIES

A. Ray flowers none; disk flowers greenish, 4-lobed; heads short-stalked; achenes marked by elongated red-brown oil glands; very common throughout ________1. *M. MATRICARIOIDES.*

AA. Ray flowers white; disk flowers yellow, 5-lobed; heads long-stalked.

B. Receptacle conic at maturity; achenes ribbed, smooth, unmarked; involucre 2–3 mm high; rare, but see also *Anthemis cotula* ______________________2. *M. CHAMOMILLA.*

BB. Receptacle hemispheric at maturity; achenes prominently ribbed, transversely rugulose or tuberculate with apical oil glands; involucre 3.5–6 mm high; rare on Lake Superior shores ________________________3. *M. MARITIMA.*

1. MATRICARIA MATRICARIOIDES (Less.) Porter Pineapple Weed.
Matricaria suaveolens L. Map 14.

Glabrate annual with strong aromatic pineapple odor; stems one to several, erect, 4–50 cm tall. Leaves finely twice-pinnatifid into 0.5 mm wide linear segments, sessile, 2.5–9 cm long, 1–2.5 cm wide. Heads short-stalked, *discoid* and *conical.* Involucre 3–5.5 mm high; bracts 24–32, with red-brown midrib and broad scarious margins; *receptacle naked, hollow. Ray flowers lacking. Disk flowers 4-lobed,* yellow-green, 1–1.5 mm long; achenes 1–1.5 mm long, ribbed with *2 longitudinal, slender red-brown oil glands;* pappus rudimentary. 2n=18 (Löve & Löve 1961).

Native probably of NE Asia (Clapham, et al. 1952; Baker 1962), recently (1850's) occurring as a weed in Europe and North America, in Wisconsin the earliest collections from the northernmost counties (1915), not collected in Milwaukee until 1939 or in Madison until 1942, ubiquitous in farmyards, fields, along roadsides, industrial areas, and in cities along walks, streets, public grounds, and waste areas. Flowering from May through mid-September; fruiting from June through September.

2. MATRICARIA CHAMOMILLA L. Chamomile. Map 13.

Aromatic, glabrous annual; stems erect, slender, 2–4 dm tall. Leaves sessile, 1–2 cm wide, 2–6 cm long, twice-pinnatifid into linear-filiform segments 0.5 mm wide. Heads few, 5–12, radiate, resembling a small daisy; *receptacle naked, sharply conic at maturity,* hollow; involucre 2–3 mm high; bracts with brown midrib, *light scarious margins.* Ray flowers pistillate, white, 13–20, 5–7 mm long; disk flowers yellow, *5-lobed,* 1–1.5 mm long; achenes smooth, ribs not prominate, 1 mm long. 2n=18 (Löve & Löve 1961).

Native of southern and eastern Europe to west Asia, infrequent in Wisconsin in disturbed habitats, waste places in towns and water fronts. Flowering and fruiting from May to July. It has been known since 1588 that a blue oil can be distilled from the plant (Karsten 1946).

The Wisconsin plants are all erect, ± corymbose, few-headed, and much more uniform than European collections. The species strongly resembles *Anthemis cotula* (q.v.).

3. MATRICARIA MARITIMA L. ssp. INODORA (L.) Clapham. Map 15.
Matricaria inodora L.
Matricaria maritima var. *agrestis* (Knaf.) Wilmott.

Annual, 3–7 dm tall, erect, glabrous-glabrate. Leaves sessile, 2–5 cm long, 1–3 cm wide, twice pinnatifid into 0.5 mm wide, linear-filiform segments. Heads radiate, few to many; involucre 3–6 mm high; bracts with brown, scarious margins. Ray flowers white, 12–20, pistillate, 1–2 cm long; disk flowers yellow, 1–2 mm long; achenes with *2–3 wide ribs, 2 red-brown oil glands near the top, transversely rugulose,* 1–2.5 mm long; pappus rudimentary. Flowering from July through October; fruiting in September and October.

A Eurasian species, collected only near Herbster, Bayfield County on Lake Superior. Bark Point, lake shore and open fields, Sept. 6, 1959, *Iltis 15,515* (WIS). Bark Point, roadside, July 10, 1938, *Fassett 20,030* (WIS).

A plant cited by the collector as the above (Lakela 1965: 387), but more resembling *MATRICARIA MARITIMA* var. *MARITIMA* with short height (3 dm) and fewer, larger heads borne on long, sturdy peduncles, was collected once near Duluth, Minnesota: in bare soil of roadcut, Duluth Heights, Duluth, Oct. 18, 1947, *Lakela 7403* (WIS).

24. ARTEMISIA L. WORMWOOD, SAGE, SAGEBRUSH.

Annual, biennial, or perennial aromatic herbs or small subshrubs with erect to decumbent stems. Leaves alternate, entire to deeply pinnatifid or pinnatisect, pubescent to glabrous. Inflorescence a spike-like, racemose, or profusely branched panicle of small and inconspicuous, discoid heads. Receptacle naked or covered by hairs. Bracts imbricate in several series, the inner with scarious margins. Flowers resinous-granular, 1–3 mm long; rays not ligulate, 5-lobed, pistillate with bifid styles; disk flowers perfect, sterile or fertile, 5-lobed with bifid, truncate-erose styles (simple in *A. caudata*). Seeds minute, ca. 1 mm long; pappus lacking.

About 200 species, over half in the USSR, distributed mainly in cool or arid regions of the Northern Hemisphere, several species dominant shrubs in prairies, plains, and deserts, cultivated for foliage plants and, because of their aromatic, volatile oils and bitter substances, for use in tonics, antihelminthics, and liqueurs.

Key to Species

A. Receptacle hairy; leaves white-silky canescent; plants perennial and somewhat woody at base.

B. Leaves short, 1–2 cm, the segments filiform, 0.5–1 mm wide; flowering stems ascending, to 5 dm tall, the vegetative stems forming mats; inflorescence a narrow panicle; very local on Mississippi River bluffs from Pierce Co. to Trempealeau Co., rarely weedy elsewhere _1. *A. FRIGIDA.*

BB. Leaves 5–15 cm long, the segments 2–3 mm wide; flowering stems erect, to 9 dm tall; inflorescence a leafy panicle; sporadic adventive ________________2. *A. ABSINTHIUM.*

AA. Receptacle naked; leaves tomentose to glabrous; plants annual. biennial, or perennial.

C. Disk flowers sterile, the achenes abortive; adult plants usually glabrous.

D. First year lower leaves forming a basal rosette; leaves tomentose-glabrate; involucre 2–3.5 mm high; taprooted biennial; common in sandy areas ____________ ________________________________3. *A. CAUDATA.*

DD. Lower leaves not in a rosette; involucre 2 mm high; robust glabrous herbs from a rootstock; very rare and sporadic ________________4. *A. DRACUNCULOIDES.*

CC. Disk flowers fertile.

E. Leaves glabrous-glabrate, 2–3 times pinnatisect or pinnatifid.

F. Annual or biennial herbs; involucre 1–2 mm high; bracts glabrous.

G. Inflorescence a dense racemose panicle with many spike-like branches from the leaf axils; heads erect; common weed ____5. *A. BIENNIS.*

GG. Inflorescence a broad terminal panicle with nodding heads; rare annual weed -- 6. *A. ANNUA*.

FF. Perennial shrub; involucre 2–2.5 mm high; bracts canescent or tomentose; rarely escaped cultigen ------------------------------ 7. *A. ABROTANUM*.

EE. Leaves tomentose at least on one surface, simple or dissected.

H. Leaves unlobed and linear-lanceolate, the margins regularly serrate to entire in the inflorescence, densely white-tomentose beneath, bright green-glabrous above; moist deep-soil prairies -- 8. *A. SERRATA*.

HH. Leaves deeply lobed or cut, or entire with the margins irregularly toothed.

I. Leaves delicately divided, the segments filiform, gray-green pubescent; rarely escaped cultigen ------------------------------- 9. *A. PONTICA*.

II. Leaf segments broader or leaves entire.

J. Leaves green-glabrate above, white-tomentose beneath, coarsely lobed; rare weed, eastern Wisconsin --------------- 10. *A. VULGARIS*.

JJ. Leaves pubescent on both surfaces.

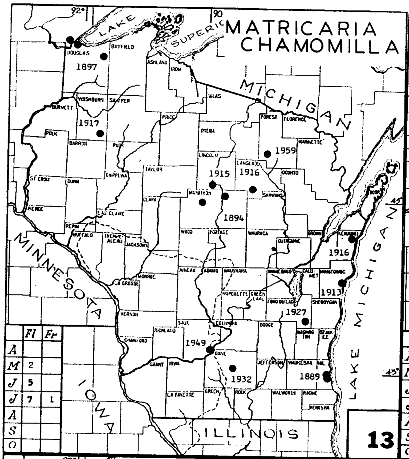
K. Involucre 2–4 mm high; leaves entire or irregularly toothed, densely white-tomentose beneath, tomentose to glabrate above; common prairie species -------------------------- 11. *A. LUDOVICIANA*.

KK. Involucre 5–8 mm high; leaves obtusely lobed, densely creamy white wooly; rarely escaped on L. Michigan or L. Superior ------------------ 12. *A. STELLERIANA*.

1. ARTEMISIA FRIGIDA Willd. Prairie Sagewort. Map 16.

Mat-forming, gray-green tomentose perennial, decumbently branched and ± woody at base, the several flowering stems 3–5 dm tall, erect-ascending. *Leaves 1–2 cm long, finely dissected into linear segments.* Panicles 17–28 cm long, narrow with ascending branches; heads many, 2–3 mm high; *receptacle long-villous;* bracts ca. 15. Flowers 26–34, fertile; rays 7–9; disk flowers 19–25; achenes 1 mm long. 2n=18 (Kawatani & Ohno 1964).

A western Great Plains and Rocky Mountains grassland species, ranging from central Alaska to New Mexico, in Wisconsin only along the Mississippi River in Pierce, Pepin and Trempealeau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ILLINOIS
LAKE MICHIGAN
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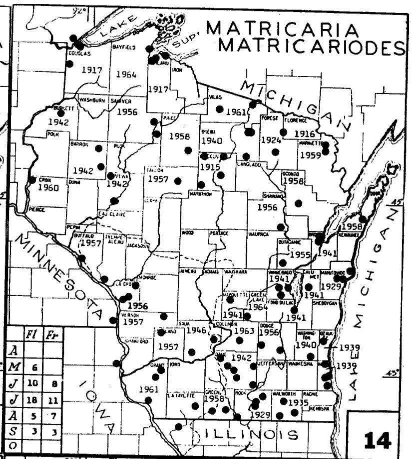
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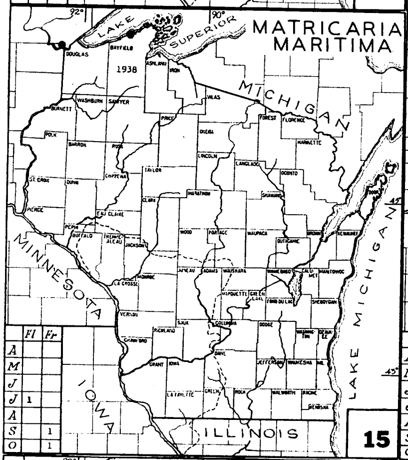
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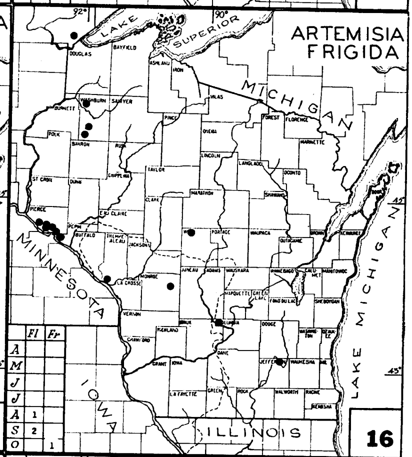
LAKE MICHIGAN
15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ILLINOIS
LAKE MICHIGAN
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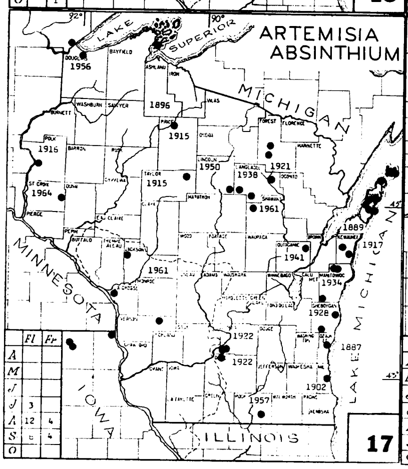
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IOWA
ILLINOIS
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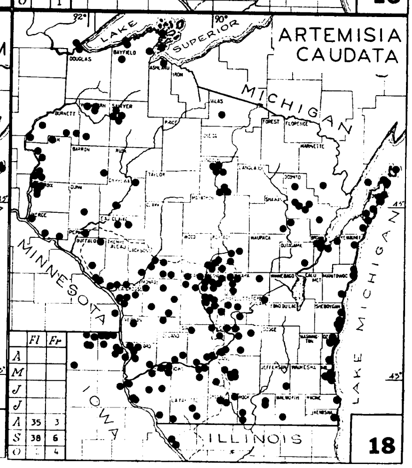
17


ARTEMISIA CAUDATA
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
18

counties on exposed limestone (dolomite) bluffs, talus slopes, and Mississippi River sand terraces (rarely adventive elsewhere in disturbed areas such as on railroads and road cuts). Flowering in August and September; fruiting in October.

These Mississippi and St. Croix River bluffs and adjoining sand terraces appear to be among the most xeric habitats in Wisconsin. Sloping steeply southwestward, they receive the maximum amount of sunlight and accumulate little soil because of high winds and extreme water run-off. In this environment water and nutrients are limited (Curtis 1959), and only a few plants can survive. Some fairly widespread dry-prairie species that are otherwise rare or restricted in Wisconsin occur here, including *Besseya bullii* (Salamun 1951), *Castilleja sessiliflora* (Salamum 1951), *Psoralea esculenta* (Fassett 1939), *Anemone patens* var. *wolfgangiana* (Fassett 1947), *Liatris cylindracea* (Johnson & Iltis 1963), *Bouteloua hirsuta, B. curtipendula* (Fassett 1951), *Artemisia caudata, Aster oblongifolius,* and *A. ptarmicoides.*

In addition a number of otherwise widespread Great Plains species have highly localized Wisconsin distributions very similar to that of *A. frigida,* and like that species reach their easternmost limits here. These include such Wisconsin rarities as *Psoralea argophylla, Astragalus caryocarpus,* and *Petalostemon villosum* (Fassett 1939). *Anemone caroliniana* (Almon 1930), *Liatris punctata* (Johnson & Iltis 1963), *Bouteloua gracilis,* and *Muhlenbergia cuspidata* (Fassett 1951), and *Erigeron glabellus.*

2. ARTEMISIA ABSINTHIUM L. Absinthe, Sagewort. Map 17.

Aromatic, rhizomatous, basally suffrutescent, perennial herbs, 6–9 dm tall. *Leaves white-silky canescent,* esp. when young, 6–15 cm long, 2–8 cm wide, long-petioled (4–13 cm), the upper sessile, divided to entire, the lower 2–3 times pinnatifid-pinnatisect, the lobes 2–4 mm wide. Panicles leafy, 17–50 cm long, to 30 cm wide, the branches rather strict-ascending. Heads many, rather large (3–4 mm), nodding; involucre 2–3 mm high; bracts 13–18; *receptacle covered with villous hairs.* Flowers 45–80, fertile; rays 10–21, the disk flowers 35–58; achenes 1 mm long. 2n=18 (Löve & Löve 1961).

Native of temperate, dry regions from central Asia to southwestern Europe, an ancient, prehistoric medicinal and magical herb, at present still grown for use as a tonic, antihelminthic (hence "wormwood"), local anaesthetic, and in the preparation of the liqueurs Vermouth and Absinthe, in Wisconsin in disturbed, esp. calcareous areas along roads, in pastured fields, and waste places in cities. Flowering from end of July to September; fruiting in August and September.

3. ARTEMISIA CAUDATA Michx. Field Sagewort, Wormwood. Map 18.

Biennial or occasionally short-lived perennials with a ± woody taproot; pubescence very variable, often gray-tomentose when young, usually glabrate throughout when mature. Stems 1–5, erect-ascending, 6–10(–16) dm tall, reddish-violet tinged. *First year rosette leaves* 10–20 cm long, 6–12 cm wide, long petioled (4–8 cm), *2–3 times pinnatifid into 1(–2) mm wide segments;* cauline leaves sessile, with axillary branchlet "fascicles", the lower 7–10 cm long, 2–6 cm wide, smaller, less divided above. *Panicles leafy,* 23–60 cm long, 2.5–22 cm wide, ascending-branched, with many greenish heads. Involucre 2–4 mm high; bracts 12–16, glabrous, green with a red-brown midrib, scarious margins; receptacle naked. Flowers 21–41; *rays fertile,* 11–21, ca. 1 mm long *disk flowers sterile,* the style simple (not bifid) 10–20, 1.5–2 mm long; achenes 1 mm long. 2n=18 (Kawatani & Ohno 1964).

A variable North American native of wide distribution, most common in the eastern and central United States and Canada, ranging westward to the Pacific coast, in Wisconsin very common in dry and sandy prairies (81–87% presence, Curtis 1959), sensitive to competition and often found in ecologically open habitats such as dry high-lime prairies, dry sand prairies (with *Stipa spartea, Delphinium virescens, Arabis lyrata, Oenothera rhombipetala*), sandstone and limestone cliffs, inner beaches and dunes on Lake Michigan, sandbars of rivers, and in jack oak–jack pine barrens, often weedy in disturbed areas along roadsides or sandy railroads, overgrazed or abandoned sandy fields, and waste areas of cities. Flowering from mid-August through September; fruiting to early October.

The smaller, somewhat similar, subarctic *Artemisia canadensis* Michx. (=*A. borealis* Pallas), is cited for Wisconsin by Fernald (1950), evidently on the basis of some depauperate specimens of *A. caudata.*

4. ARTEMISIA DRACUNCULOIDES Pursh. Dragon Sagewort, Estragon, Tarragon. Map 19.

Artemisia dracunculus L. of authors, not the Eurasian taxon.
Artemisia glauca Pallas, ex. Willd.

Glabrous, rhizomatous, robust perennials, 5–14 dm tall from a woody caudex. Leaves dark green, often turning black, sessile, (2) 4–7 cm long, *simple or 3-parted* into narrowly-linear, 1–2 mm wide, unbranched segments, the upper simple. *Panicles leafy, diffuse,* the slender branches often drooping, 3–6 dm long, to 2.5

dm wide; involucres 2–2.5 mm high; bracts 11–16, glabrous; receptacle naked. Flowers 19–32; *rays fertile,* 10–16; *disk flowers sterile,* 9–16, 1.5 mm long; achenes 1 mm long.

In Wisconsin sporadic, in sandy soils, on dry, sandy prairie bluffs, and along roads and railroads, similar to *A. caudata* (q.v.) but quite uncommon. Flowering and fruiting from August to October.

A complex group native to the western and midwestern U. S. in sandy or grassy habitats, probably consisting of several taxa poorly understood, apparently divisible into two major types: one, ranging from Oklahoma–Colorado to Montana–Alberta, and west to California, characterized by fewer, broader leaves, and erectly branched panicles; and the other, ranging from Nebraska–Missouri to Minnesota–Iowa and Wisconsin, characterized by numerous, slender leaves, and diffuse panicles with drooping branches. With both nomenclature and taxonomy confused, it is not possible to determine here proper species limits or names.

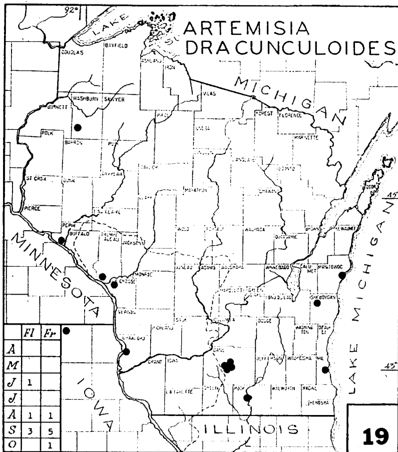
5. ARTEMISIA BIENNIS Willd. Biennial Sagewort. Map 20.

Biennial (or annual?) glabrate-glabrous herbs, 3–7 dm tall, unbranched above, or with short, dense, lateral inflorescence branches below, these often to the base. Leaves sessile, the lower 5–15 cm long, 2–7 cm wide, deeply once- less often twice-pinnatifid, the few sharp-toothed lobes 20–40 mm long, 1–5 mm wide, the reduced upper leaves once-pinnatifid. *Panicles dense, spike-like or racemose,* often axillary, usually exceeded by leaves. Heads small, erect, short-peduncled or sessile, 1–2 mm high; bracts 11–16; receptacle naked. Flowers 37–45, fertile; rays 17–22, the disk flowers 20–23; achenes 1 mm long.

Presumably native to western North America, widely distributed as a weed eastward, in Wisconsin on gravelly, sometimes muddy lake shores and river banks, often weedy in waste areas in cities, farmyards, gardens, railroads, and especially roadsides, one of the relatively few native American weeds in this area. Flowering and fruiting from very late August into November, peaking in mid-September.

6. ARTEMISIA ANNUA L. Annual Sagewort. Map 21.

Glabrous, 3–7 dm tall annuals. Leaves finely 1–3 times pinnatisect into 1 mm wide segments, the lower 3–10 cm long, 3–9 cm wide, petioled, the upper sessile, smaller. Panicles leafy, 10–50 cm long, 3–24 cm broad, very diffuse, with many minute heads. Involucre 1.5–2 mm high; bracts 8–18; receptacle naked. Flowers 10–29; rays 5–9, the disk flowers 5–20; achenes 1 mm long. $2n=18$ (Löve & Löve 1961).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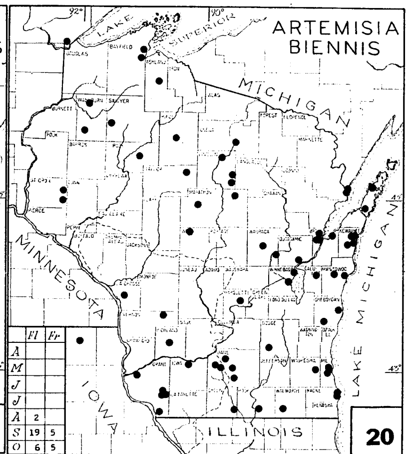
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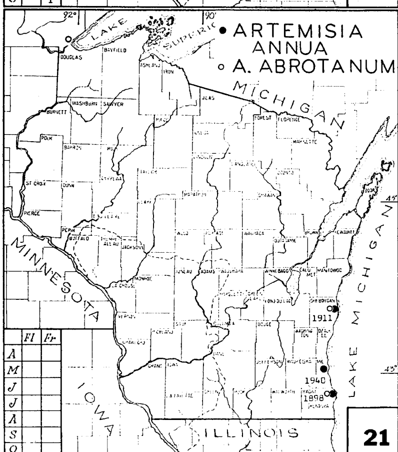
• ARTEMISIA
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∘ A. ABROTANUM
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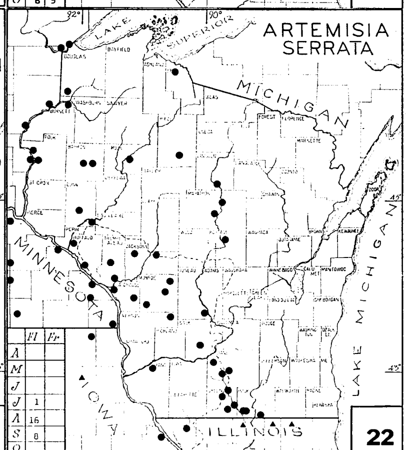
LAKE MICHIGAN
21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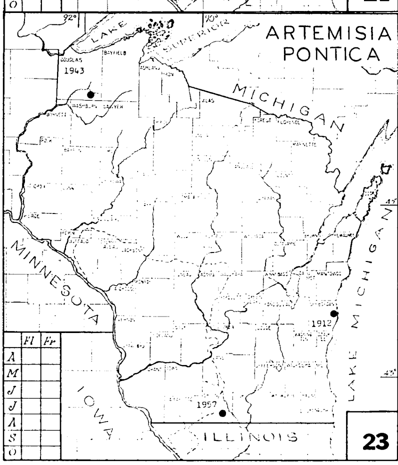
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1943
1912
1957
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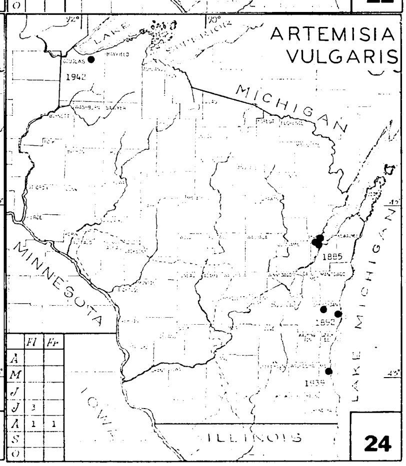
ILLINOIS
LAKE MICHIGAN
23


ARTEMISIA
VULGARIS
1942
1885
1939
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
24

A temperate Asiatic and southeastern European (Balkans) weed, sparingly naturalized in eastern North America in waste places and old fields, known from only 3 Wisconsin collections. Milwaukee Co.: Milwaukee, Sept. 2, 1940, *Shinners 3358* (WIS). Racine Co.: Racine, Aug. 6, 1898, *Wadmond s.n.* (MIN). Sheboygan Co.: Sheboygan, waste place in city, Aug. 1911, *Goessl s.n.* (WIS). Flowering and fruiting in August and September.

7. ARTEMISIA ABROTANUM L. Garden Sagebrush, Southernwood. Map 21.

Strongly aromatic, 5–10 dm tall sub-shrub, with the leaves finely divided into linear-filiform segments, these glabrous above, hairy below. Panicles leafy, 15–40 cm long, the many, small heads drooping, 2–2.5 mm high; bracts 8–18; receptacle naked. Flowers 15–35, all fertile. 2n=18 (Löve & Löve 1961).

Native of southeastern Europe and temperate Asia (apparently a race of *A. paniculata* Lam.) known only in cultivation or as a rare escape (cf. Hegi, 1929, 6^{II}: 635), in Wisconsin uncollected for over 60 years. Racine Co.: Racine, garden, ± 1860, *Hale s.n.* (WIS). Sheboygan Co.: Sheboygan, roadside, Sept. 9, 1903, *Goessl s.n.* (WIS). Lakela (1965) cites a collection from Duluth.

8. ARTEMISIA SERRATA Nutt. Genera of North American Plants 2: 142, 1818. (Lectotype: "Near the Prairie du Chien, on the banks of the Mississippi, in open alluvial soils" *Nuttall s.n.*, in PH.) Saw-leaf Mugwort. Map 22.

Erect, rhizomatous, robust, perennial herbs, 6–15 dm or more tall. *Leaves linear-elliptic, white pubescent beneath, dark green and glabrous above,* the lower 7–16 cm long, 1–2.5 cm wide, *regularly serrate,* the upper smaller, less regularly serrate to entire. Panicles leafy, 14–50 cm long, 2.5–18 cm wide; heads nodding, short-peduncled, 3 mm high; bracts 9–15; receptacle naked. Flowers 14–25, fertile, the rays 5–10, the disks 9–15; achenes 1 mm long. 2n=36 (Keck 1946).

A localized prairie species of the upper Mississippi River Valley (cf. fig. 3) occurring in rich moist soils along rivers and streams, wet prairies and ditches, low wet meadows, and moist sandy alluvial soils. Flowering and fruiting in August and September.

Although Nuttall's original description of *A. serrata* gives its location as "near the Prairie du Chien, on the banks of the Mississippi, ... also on the banks of the Missouri", the range of the species does not extend to the Missouri River; therefore, the Wisconsin collection is here designated as the lectotype.

THE PHYTOGEOGRAPHY OF ARTEMISIA SERRATA AND ITS SIGNIFICANCE.

Because the flora of glaciated lands (except for Arctic or coniferous forest species that might have lived *on top of* the ice) must be derived from unglaciated areas, because species or floras do not migrate readily except into "open" habitats without much competition, and because glaciation, especially that of the Wisconsin ice advance, occurred only very recently, we can profitably use the modern distribution of a species as shown on a detailed range map to pin-point the probable area of its glacial survival and possible routes of subsequent migration into once-glaciated territory. This approach has great utility for understanding the histories of individual species and whole floras, as well as for pinpointing glacial "refugia" (Hultén, 1937) or more appropriately "survivia" (Iltis, 1965). The resultant composite geographic patterns tend to center at one end of the survival areas, from whence they radiate, depending on the tolerance of the species, in ever-increasing "progressive equiformal areas" (Hultén, 1937), these especially beautifully shown by the Appalachian species in the upper Middle West.

It is a fact of the very greatest interest that, with the rarest exceptions, *all species present in glaciated territory of Eastern or Central North America have at least one small part of their range outside the glacial maximum,* this then the area where we may assume they survived glaciation.

Exceptions to this rule include first of all species which have evolved *since* the last glacial period, such as the many dune and strand taxa of the glacial lakes (Guire and Voss, 1963; Johnson and Iltis, 1963) a few of which are rather distinct (e.g. *Cirsium pitcheri* (Torr.) T. & G.; cf. Johnson and Iltis, 1963) but most of which are better treated as microspecies or geographic subspecies (e.g. *Tanacetum huronensis* Nutt.; cf. p. 200–203; *Iris cristata* Ait. ssp. *lacustris* (Nutt.) Iltis; cf. Mason and Iltis, 1965). Several Midwestern bog or cliff species with western affinities, if distinct at all, belong here as well (Iltis, 1965), such as *Dodecatheon amethystinum* (Fassett) Fassett and *Aconitum noveboracense* A. Gray (=*A. columbianum* Nutt.).

Secondly, there are a number of species of hybrid derivation, such as *Cyperus houghtonii* Torr. (Marcks MS.), *Penstemon wisconsinensis* Pennell (Crosswhite MS.) and *Quercus ellipsoidalis* E. J. Hill, these evidently also being post-glacial in origin.

Thirdly, there are a number of species or varieties in such large and actively evolving genera as *Bidens* or *Solidago,* or in apomictic genera as *Rubus* or *Crataegus,* which again we must assume to be post-glacial in origin. These three groups listed so far are particularly interesting for the evolutionist since in many cases they represent recent and often rapid morphological evolution that can be dated rather accurately by the retreat of the Wisconsin ice sheet.

Fourthly, there are a small number of highly distinct species without North American relatives, which we may assume that because of their microspermous seed were able to migrate here by stratospheric transport (jet streams?). Such rarities, with their known or probable region of origin in parentheses, include the fabulous and now extinct *Thismia americana* Pfeiffer (Burmaniaceae—Tasmania?) once collected in a wet prairie near Chicago, *Cypripedium arietinum* R. Br. (Orchidaceae—China), *Pedicularis furbishiae* S. Wats. of northern New England (Scrophulariaceae—Himalayas?) and a fern of E. Asiatic affinity (W. H. Wagner, personal communication).

Fifth and last are a small number of distinct to very distinct taxa whose geographic origins and histories are harder to explain. All these taxa, significantly we think, are associated with prairie habitats, and are mapped here (Fig. 3).

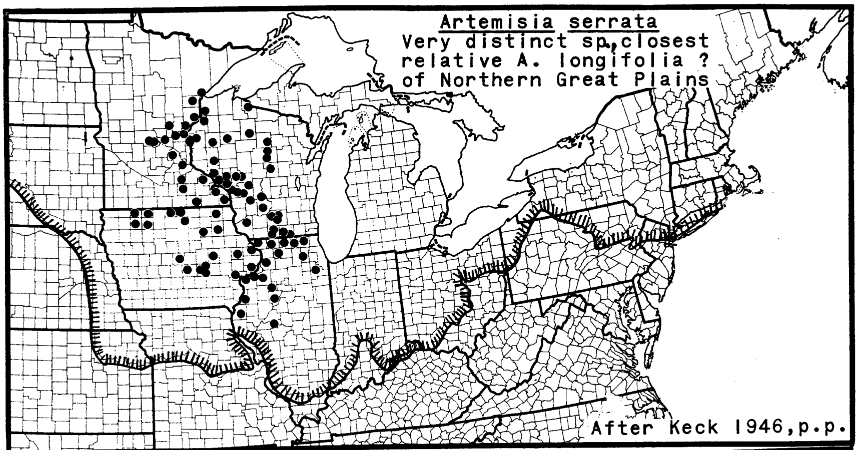
Of these, the most distinct is the monotypic genus *Napaea,* which does grow in unglaciated parts of Ohio, but there apparently as a recent weedy introduction (Iltis, 1963). It is a polyploid (Iltis and Kawano, 1964) with a relationship, if very distant, to *Sidalcea malachroides* (Hook & Arn.) A. Gray of California.

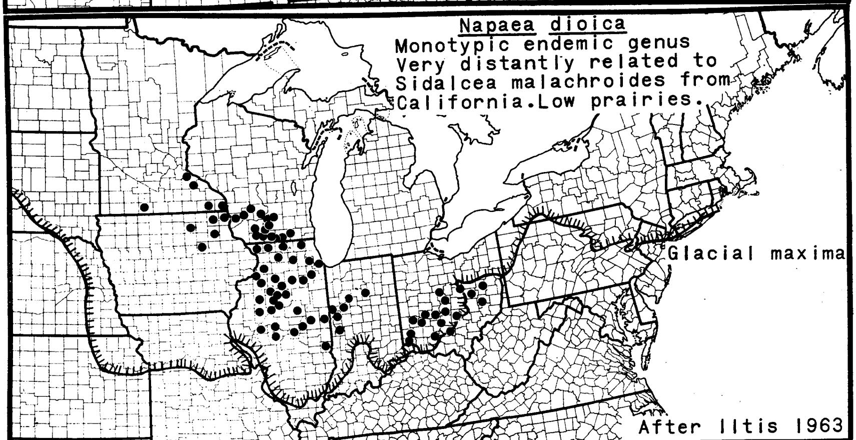
Artemisia serrata Nutt., a very distinct polyploid species (n = 18), appears closest to the diploid *A. longifolia* Nutt. (n = 9) of the northern Great Plains (Keck, 1946).

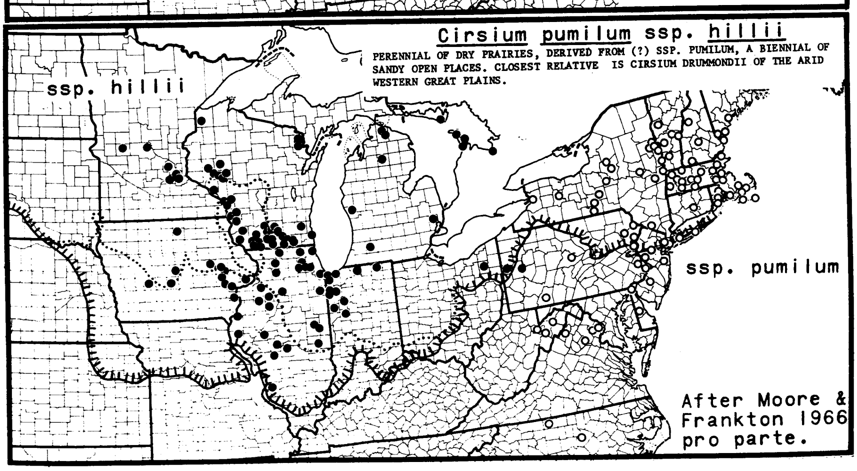
Besseya bullii has its rather close congeneric relatives in the Western mountains. Pennell (1935) suggests it may be of post-Wisconsin origin since all stations south of the Wisconsin maximum are on recent outwash plains.

Cirsium hillii (Canby) Fern. (*C. pumilum* (Nutt.) Spreng. ssp. *hillii* (Canby) Moore & Frankton), a perennial, appears to be derived from the biennial *C. pumilum* (Nutt.) Spreng. of the Eastern United States, this or both in turn from *C. drummondii* Torr. & Gray of the arid western Great Plains.

Excepting the enigmatic *Erythronium propullans* A. Gray from near Minneapolis, *the only good "Linnean" species that occur wholly within glaciated territory are the few prairie species listed above.* Iltis (1963) originally suggested that *Napaea dioica* survived the Pleistocene glaciations together with the tall grass prairie in the Oklahoma–Kansas–Ozark region from where, post-glacially, the species vanished to migrate north into glaciated lands with the tall grass prairie. However, in view of the fact that the other taxa of diverse geographic relationships listed above all share this restriction to glaciated prairie lands, as well as their occurrence in


Artemisia serrata
Very distinct sp, closest
relative A. longifolia ?
of Northern Great Plains
After Keck 1946, p.p.


Napaea dioica
Monotypic endemic genus
Very distantly related to
Sidalcea malachroides from
California. Low prairies.
Glacial maxima
After Iltis 1963


Cirsium pumilum ssp. hillii
PERENNIAL OF DRY PRAIRIES, DERIVED FROM (?) SSP. PUMILUM, A BIENNIAL OF
SANDY OPEN PLACES. CLOSEST RELATIVE IS CIRSIUM DRUMMONDII OF THE ARID
WESTERN GREAT PLAINS.
ssp. hillii
ssp. pumilum
After Moore &
Frankton 1966
pro parte.

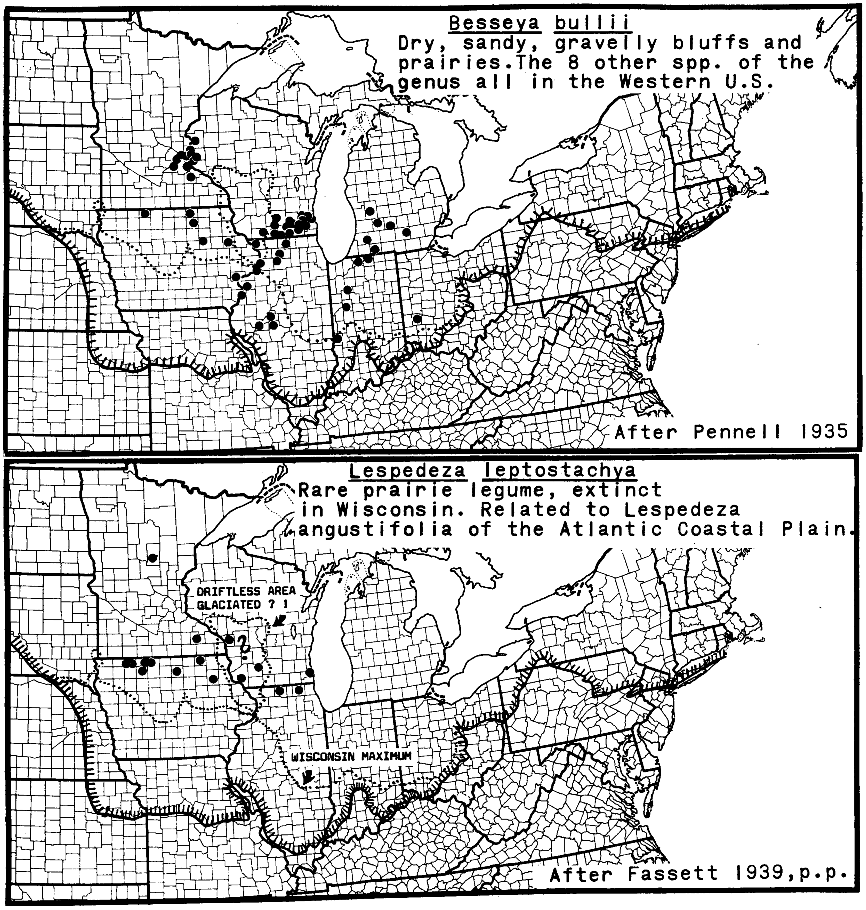


FIGURE 3. Five species whose ranges are restricted to deepsoil prairies in glaciated regions of the Middle West. The Ohio records of *Napaea dioica* in unglaciated territory appear to be introductions since they come from disturbed areas.

lands *both* glaciated and unglaciated by the *Wisconsin* glaciation, we may suggest a more specific hypothesis; namely that these species

a) originally became established in the prairie in the open habitats following the retreat of the Illinois glacier, a time sufficiently distant for considerable speciation, b) that subsequently they evolved into new taxa there, and c) that they survived the Wisconsin glaciation in the Illinois–Iowa prairies as well, which must have existed there then as they do now. The very distinct *Napaea,* of course, probably had an older history as previously outlined.

It is suggestive that one other, but not as sharply distinct a taxon, the rare *Lespedeza leptostachya* Engelm., is restricted to glaciated lands but only of the Wisconsin glaciation (as already pointed out by Fassett (1939)). Yet this restriction and its close relationship to the southern Atlantic Coastal plain *L. angustifolia* (Pursh.) Ell. (cf. Clewell, 1966) suggests that its introduction into the prairie vegetation was recent (post-Wisconsin), hence its morphological evolution is very slight (For a contrary opinion using the "Driftless Area" as a refugium, see Fernald, 1925). The significance of these speculations to the phytogeographic history of the region is obvious. They suggest, contrary to believers in marked periglacial climatic depressions and broad coniferous belts south of the ice, that the prairie in fact did occur and survive in the Illinois area at the height of the last ice advance and that the climate then was not too different from what it is now, views that agree well with those in the many publications of E. L. Braun and one of us (cf. Iltis, 1965; Mason and Iltis 1965), based on other and varied evidence.*

Artemisia serrata, like *Napaea dioica* with which it may grow (e.g. Dane Co. trunk PB, along a railroad near Verona; cf. photo in Iltis 1963), is thus phytogeographically clearly a most unusual species, one of a select group of prairie plants which originated in the area of Illinoian glaciation and which increased their ranges into the area of Wisconsin glaciation sometime between the retreat of that ice and the present. Its present survival in a few wet railroad rights-of-way, prairies which are now in ever-increasing danger of needless and thoughtless herbicide spraying for "weeds", is precarious. Its habitats, the remnants of low prairies, are in desperate need of protection and preservation.

9. ARTEMISIA PONTICA L. Roman Wormwood. Map 23.

Gray-green tomentose, rhizomatous perennials, 3–10 dm tall. *Leaves twice-pinnatisect into fine, linear, rather short segments,* the lower 1–3 cm long, petioled. Panicles 10–25 cm long, 2–4 cm wide, the *heads nodding, 2–3 mm* high; bracts 12–18; receptacle naked.

* Substantiation for prairies in the "Wisconsin"-glaciated Midwest immediately following glacial retreat comes from pollen analyses of W. S. Benninghof (The Prairie Peninsula as a filter barrier to Postglacial plant migration. *Proc. Indiana Acad. Sci. 1936.* 72: 116–124. 1964). Abundant grass pollen in the earliest Late-glacial Spruce–Fir zone deposits of Indiana and Ohio, and the relatively very late appearance of Hemlock and beech pollen is taken as evidence in support of earliest Late-glacial invasion by grassland elements; i.e. that the "Prairie Peninsula" became established in wake of glacial retreat, early enough to prevent its crossing by Beech and Hemlock. In view of the several endemic animals (K. P. Schmidt) and the endemic plants listed above, we may trace the Prairie Peninsula or part of it just one step further back in time; namely that prairie, is a pre-ice feature, which, growing during the Wisconsin maximum next to the ice in Illinois and Iowa, simply moved eastward following ice retreat. We may then also assume that the climatic pattern then was not too different from what it is now.

Flowers 35–60, fertile, the rays 10–15(–18), the disk flowers 25–45. 2n=18 (Suzuka 1952; Kawatani and Ohno 1964).

Native mostly of southeastern Europe and western Asia in arid grasslands, in America cultivated as a border plant for the grayish-white foliage, in Wisconsin escaped but not established in waste places in cities and roadsides: Douglas Co.: Brule River, sandy roadside T45N, R11W, S4, July 2, 1943. *Thomson, 5270* (WIS). Green Co.: Juda, roadside, Sept. 29, 1957, *Fell 57–1357* (WIS). Sheboygan Co.: roadside in Sheboygan, July 1912, *Goessl s.n.* (WIS).

10. ARTEMISIA VULGARIS L. Sagewort, Mugwort. Map 24.

Rhizomatous, 9–13 dm tall perennial herbs. *Leaves white-tomentose beneath, dark-green glabrous above, the lower 2–3 times pinnatifid-pinnatisect,* 5–11 cm long, 2–7 cm wide, the *lobes rather broad, acute.* Panicles leafy, 25–60 cm long, 3–22 cm wide, the heads short-peduncled, nodding, 3–4 mm high; bracts 12–16; receptacle naked. Flowers 22–26, fertile; achenes 1 mm long. 2n=16 (Löve & Löve 1961).

Native of Eurasia formerly cultivated as a medicinal, as a substitute for hops in making beer, as tea in England, and for its foliage, introduced in America and occasionally adventive in eastern Wisconsin in sandy or disturbed areas such as railroad yards or waste grounds in cities.

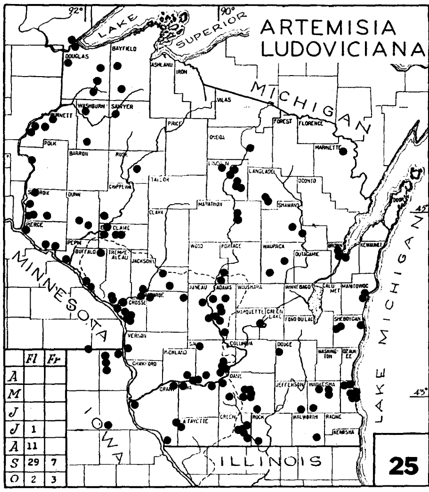
11. ARTEMISIA LUDOVICIANA Nutt. ssp. LUDOVICIANA Western Mugwort, White Sage. May 25.

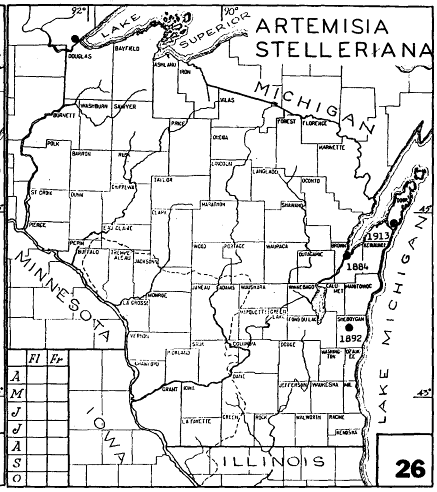
Artemisia gnaphalodes Nutt. Genera North American Plants 2: 143, 1818. (Type: "On dry savannahs about Green Bay, Lake Michigan, and on the banks of Fox River, and the Missouri" *Nuttall s.n.* (in PH?); cf. Keck 1946:441.)

Artemisia ludoviciana Nutt. var. *gnaphalodes* (Nutt.) Torr. et Gray.

Densely white-pubescent, rhizomatous, perennial herbs, 3–7(–12) dm tall, the stems unbranched (rarely branched above), often in *extensive loose clones.* Leaves densely white-tomentose beneath, tomentose to glabrate above, oblanceolate-ellipitic, 4–12 cm long, 0.5–2.5 cm wide, the lower often sharp-toothed, the upper reduced, linear-lanceolate, entire. Panicles rather leafy, 7–43 cm long, 1–13 cm wide, the heads many, 2.5–4 mm high; bracts 10–15; receptacle naked. Flowers 12–22, fertile; rays 6–9, the disk flowers 6–12; achenes 1 mm long. 2n=36 (Keck 1946).

Characteristic of Wisconsin prairies, especially dry-mesic (Curtis, 1959) and dry sand prairies, as well as deep-soil mesic, and even moist prairies, often somewhat weedy on railroads and





roadsides. Flowering and fruiting from (late July) mid-August through mid-October.

Widespread from Oregon to S. California, east to Indiana, with seven, often intergrading subspecies recognized by Keck (1946), in Wisconsin represented only by ssp. *ludoviciana,* here fairly uniform (although certain collections, especially in Green and Dane counties, with larger, more toothed leaves and tendencies for the upper surface to become glabrate, suggest introgression from *A. serrata,* a rarer species of moist prairies; cf. Keck l.c.).

12. ARTEMISIA STELLERIANA Besser Beach Sagewort, Dusty Miller Map 26.

Densely white-woolly, rhizomatous perennials with decumbent to ascending, 3–7 dm tall stems. Leaves sessile, 1–2 times pinnatifid, 3–9 cm long, 2–5 cm broad, the segments broad or rounded. *Panicles narrow, spike-like,* 9–30 cm long; *heads* ± *erect, large, 5–8 mm high;* receptacle naked. Flowers 28–39, fertile; achenes 2 mm long. $2n=18$ (Löve & Löve 1961).

Sand dune species native to N. Japan and N.E. Asia, widely cultivated for its attractive foliage, in Wisconsin rarely escaped but not established in sandy areas on Lake Michigan. Brown Co.: Green Bay, cult., June 26, 1884, *Schuette s.n.* (F). Door Co.: E. end of Sturgeon Bay Canal, in sand near lighthouse, June 1913, *Davis s.n.* (WIS). Sheboygan Co.: Elkhart, August 5, 1892, *Schuette s.n.* (F). The Duluth station is mapped from Lakela (1965). Flowering and fruiting in July and August.

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PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN NO. 56. *COMPOSITAE* V—COMPOSITE FAMILY V TRIBE INULEAE

(Antennaria, Gnaphalium, Anaphalis, and *Inula)*

Edward W. Beals and Ralph F. Peters
Herbarium, University of Wisconsin

The following notes and maps of these, among the taxonomically most difficult plants in Wisconsin, are based on collections in the Herbaria of the University of Wisconsin—Madison (WIS), University of Wisconsin—Milwaukee (UWM), University of Minnesota (MIN), and the Milwaukee Public Museum (MIL). We wish to thank the curators of these herbaria for loan of specimens, Olive Weber, Stephen Gilson, Frank Crosswhite, Harriet Peters, Katharine Snell and Carol Mickelson for aid in preparing the maps, and Dr. H. H. Iltis for his cooperation and encouragement during this study. Dr. Carroll Wood of the Gray Herbarium, Harvard University, has been kind enough to check one of the *Antennaria* types. Much of the herbarium work was supported by grants from the Wisconsin Alumni Research Foundation, as were many field trips on which *Antennaria* species have been collected. The field work of one of us (E. Beals) was supported by Fellowship No. GF-11,914, Division of General Medical Sciences, U. S. Public Health Service.

On the maps, dots indicate the specific location where a specimen was collected, triangles represent county records when the specific location is not known. The months of flowering and fruiting, as recorded on all the specimens observed, are shown in the lower left-hand corner of each map. The distribution of dots reflects not only the distribution of species but also the intensity of collecting. Southern Wisconsin, especially Dane and Sauk Counties, is much better represented than northern Wisconsin.

COMPOSITAE—TRIBE VI INULEAE

Anthers tailed at base; style-branches rounded or truncate, exappendiculate; leaves alternate; receptable naked or chaffy; heads small, the corollas all tubular, or, in the large yellow heads of *Inula,* the outer ligulate; plants more or less white-woolly; leaves alternate.

KEY TO GENERA

A. Plants slender 1–5(–10) dm tall, Heads 1 cm or less in diam., white or stramineous.

B. Cauline leaves few, strongly ascending, much smaller than those of the persistent basal rosette; stolons creeping or ascending; all plants dioecious ______38. *ANTENNARIA.*

BB. Cauline leaves many, about the same size as the basal leaves which soon wither; stolons absent.

C. Phyllaries pure white, with conspicuous, longitudinal creases creating the appearance of wrinkled tissue paper; plants dioecious, the fertile head often with a few perfect but sterile flowers in center; dry plants without a strong odor ____________________39. *ANAPHALIS.*

CC. Phyllaries grayish white, yellow, or brown, scarious, with very small longitudinal ridges but no conspicuous creases; heads perfect; dry plants with strong tobacco-like odor _______________________40. *GNAPHALIUM.*

AA. Plants very large and robust, 1–2 m tall. Heads very showy, the disk 3–5 cm in diam., yellow. Infrequently adventive with large woolly leaves ___________________________41. *INULA.*

38. ANTENNARIA L. Pussy Toes, Everlasting, Ladies Tobacco

(By Edward W. Beals)

Perennial woolly herbs with alternate and basal leaves, characterized by many-flowered heads of all tubular *dioecious flowers. Heads* often in congested inflorescences; involucral bracts imbricate in several series and often colored; receptacle flat or convex, not chaffy. *Pistillate flowers* with filiform corollas, bifid styles, and a row of capillary bristles united at the base. Achenes terete or flattened. *Staminate flowers* with broader, lobed corollas, undivided styles, caudate anthers, and thickened clavate or barbellate bristles. A common genus occurring throughout the north temperate and arctic zones and in southern South America, in Wisconsin among the earliest of all spring flowers.

The genus has been subject to many taxonomic interpretations. Linnaeus included two species of what we call *Antennaria* in the genus *Gnaphalium: G. dioica* of the Old World and *G. plantaginifolia* of Virginia. Brown (1818) transferred these to the genus *Antennaria.* Gray (1886) considered all *Antennaria* in eastern North America as one variable species, *A. plantaginifolia,* while Barton (1818) and Darlington (1853) segregated the narrower-leaved plants as *A. dioica,* which is also the species in Europe. Greene (1897) transferred the New World *A. dioica* to a new species, *A.*

neglecta. As workers continued to study *Antennaria,* it was divided into more and more species. The variability within the genus also led to the recognition of numerous varieties and forms. Identification has become a very difficult procedure. On the other hand, several workers (notably Cronquist, 1945, 1946) have tried to simplify this confusion by combining taxa. Today the two extreme views of this species complex are represented by Cronquist (in Gleason 1952) and Fernald (1950); the former recognizes two species whose range includes Wisconsin, and the latter, ten. Many individual plants in Wisconsin exhibit such great leaf variation that, using Fernald's treatment, different mature leaves of the same rosette may key out to different species!

The extreme variability and lack of well-defined taxonomic groups in *Antennaria* can be correlated with widespread polyploidy, apomixis, and very likely hybridization (Stebbins 1932a, 1932b). However, unlike other confused, apomictic taxa, such as *Rubus* and *Crataegus,* the original number of species contributing to the present *Antennaria* complex in Wisconsin is small—perhaps only two. Because of apomixis (the production of parthenogenetic seed), the traditional concept of a species—a population which has shared and will share genes freely—breaks down. To put species names on these plants becomes a matter of convenience—they are simply categories of plants with similar morphology and ecology. Such naming cannot imply a future mixing of genes within the named species—otherwise every apomictic plant would be called a new species. Nor does it imply a sharing of genes in the immediate past. It is quite probable that some apomictic "species," similar morphologically and ecologically, are derived from several independent occurrences of hybrdization and polyploidy.

The genus *Antennaria* in Wisconsin consists of a series of morphological gradients. It would be helpful to taxonomic analysis if the measurement of plants showed clustering along these gradients, but in most cases there is no such clustering. Even the universally accepted separation into narrow- and broad-leaved plants puts many herbarium specimens with intermediate leaves on a questionable border line. Morley (1958), in Minnesota, has made the most determined attempt to segregate these two groups.

It is important, therefore, to remember that species names in the genus *Antennaria* are convenient labels, and that there is nothing sacred or inviolable about where the lines are drawn between groups. For some work, finer lines may be drawn than for other work. In the following discussion, we have divided the genus about as finely as we dared for the purposes of describing the geographic distribution in Wisconsin. The categories we have chosen are usually distinguishable with adequate herbarium specimens (which should include mature rosette leaves, stalks with flowers or fruits, and well-developed stolons) or with live plants in the spring. These categories coincide somewhat with the traditional categories (Fernald 1950), but they include several modifications. There will always be borderline cases; however, with the realization that species names are a matter of convenience and not a matter of inviolable natural discretions, one can take less seriously the problem of labeling these borderline cases. This problem could be more intelligently approached if we discarded species names altogether and used some numerical system for identifying *Antennaria* plants along one or more taxonomic gradients.

Chromosomes of a number of plants were observed. The basal meristem of very young leaves provided the largest meristematic cells for observation. The leaves were treated with a solution of 8-hydroxyquinoline (.29 g/l) for about four hours. They were hydrolyzed without fixing with normal HCl at 60° for 10 minutes and then washed. The mitotic region was smeared in aceto-carmine. In diploid plants the chromosome count was 28. Because the chromosomes in polyploids were too aggregated to count, it was possible to distinguish only diploidy and polyploidy. Stebbins (1932a, 1932b) has previously counted chromosomes of various *Antennaria* species. Most of his polyploids, except for the tetraploid *A. neodioica,* were hexaploid (chromosome number 84).

The *Antennaria* complex in Wisconsin includes two basic diploid species, one broad-leaved, the other narrow-leaved, which are usually quite easily distinguishable from each other. In addition to these, there are various polyploids that cause confusion in two directions. First, some of these are hard to distinguish from their diploid ancestors. Second, among themselves there is every degree of gradation between the two diploid progenitors. The polyploids are all potentially apomictic, but several can apparently produce seed sexually as well.

Figure 1 shows 108 flowering specimens with corolla length (partially correlated with polyploidy) plotted against the width/length ratio of the rosette leaves (indicator of hybridization). Each species is represented in proportion to the total number of female specimens with flowers available, and specimens were selected at random from the herbarium folders to make these measurements.

It should be noted that the two diploid groups, *A. neglecta* and *A. plantaginifolia,* shown in Fig. 1 by solid black triangles and circles respectively, remain distinct from each other, but that both grade into the polyploid complex, especially *A. neglecta.* In Fig. 1, part of the apparent confusion in the polyploids is the result of using only one character for the abscissa. Different polyploid groups of *Antennaria* carry different characters which delineate

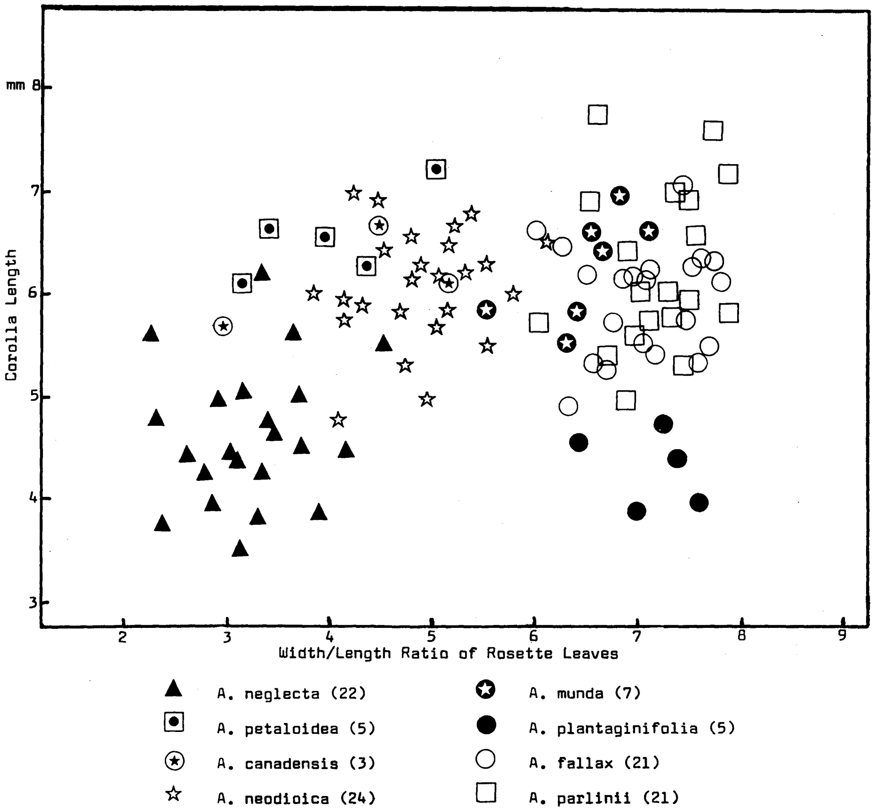


FIGURE 1. Distribution of two morphological characteristics of 198 randomly selected female *Antennaria* specimens.

"species" arbitrarily chosen on the practical bases of recognizability on herbarium specimens and of their relatively distinct and/or qualitative nature. They are described in the key below.

The detailed study of the ecology and life history of the genus in southern Wisconsin is reported elsewhere (Beals 1961). There is some differentiation of species on the basis of their ecology, but each species has rather broad ecological adaptability. *Antennaria* is found in many plant communities, most prominently in oak barrens, cedar glades, and dry-mesic prairies, but commonly also in dry prairies, mesic oak forests, pine barrens and oak openings, and in sand barrens, oak forests, pine forests, wet-mesic prairies, and lake sand dunes. Glabrous forms are more common in woodland than in the open, while tomentose forms are more common in open vegetation. *Antennaria* increases under grazing pressure and, to a lesser extent, with mowing. Factors which enable members of this genus to compete successfully in various plant communities include genetic diversity and polyploidy, drought resistance, wintergreen leaves, which can photosynthesize while other plants are dormant if temperature and sunlight are sufficient, and the secretion of an antibiotic into the soil which inhibits the growth of other species of plants.

Key To Species

A. Rosette leaves with 1–3 prominent veins, the lateral veins if present rarely prominent beyond broadest part of leaf.
  B. Stolons prostrate, lash-like.
    C. Cauline leaves with scarious appendages -- 1. *A. neglecta.*
    CC. Cauline leaves without scarious appendages -- 2. *A. petaloidea.*
  BB. Stolons short, ascending stiff.
    D. Upper cauline leaves with scarious appendages; leaves glabrous above ------------------- 3. *A. canadensis.*
    DD. Cauline leaves without scarious appendages; leaves glabrous to pubescent above ---------- 4. *A. neodioica.*
AA. Rosette leaves with 3–7 prominent veins, the two main lateral veins converging toward and nearly reaching the tip.
  E. Stolons prostrate, lash-like --------------- 5. *A. munda.*
  EE. Stolons short, ascending, stiff.
    F. Involucre 4–7 mm high, pistillate corolla 4–6 mm long; staminate corolla 3–4½ mm long; nodes on flowering stem 3–5 --------------------- 6. *A. plantaginifolia.*
    FF. Involucre 6–8 mm high, pistillate corolla 5–8 mm long; staminate corolla 4–5½ mm long; nodes on flowering stem 5–12.
      G. Rosette leaves tomentose above ------- 7. *A. fallax.*
      GG. Rosette leaves glabrous above; stem often purple-glandular ------------------------- 8. *A. parlinii.*

1. Antennaria neglecta Greene — Maps 1, 2.

Female: Rosette leaves narrow, usually 1-veined, cuneate, lanceolate, or spatulate, often subpetiolar, 15–50 mm long, 5–15 mm wide, sometimes becoming glabrous at maturity. Stolons spreading, long and flexuous, the terminal rosettes opening tardily; stolon leaves linear, 3–10 mm long. Flowering stems 4–30 cm high; cauline leaves usually 3–4, linear, 12–30 mm long, 1–2 mm wide, the upper with scarious appendage. Heads 1–7, in crowded inflorescences at anthesis, developing (in typical form) into racemes as flowers mature. Involucre 5–7 mm high; bracts white to purple, often with scarious tips. Corolla 4–6 mm long, regular or irregular; pappus 4–6 mm, achenes about 1 mm long.

Male: Similar, but heads remain crowded; involucre 4–6 mm long, the bracts white and petaloid, without scarious tips; flowering stems 2–13 cm tall.

This diploid species is much more common in southern than in northern Wisconsin, in pastures, sand and oak barrens, cedar glades, oak openings, pine barrens, dry pine woods, dry oak woods, and in all but the wet prairie types. The apparent absence of male plants in NE Wisconsin raises interesting questions about reproduction of this species.

Var. *campestris* may be differentiated by pistillate heads remaining crowded even when fruiting and by flowering stems generally much shorter. Corresponding male plants are probably indistinguishable from typical *A. neglecta.* The following may be of this Great Plains variety: Douglas Co.: Superior, May 16, 1927, *L. R. Wilson 2104* (WIS); Boylston, May 29, 1927, *L. R. Wilson 2087* (WIS). Jackson Co.: Black River Falls, June 11, 1947, *D. F. Grether 5140* (WIS).

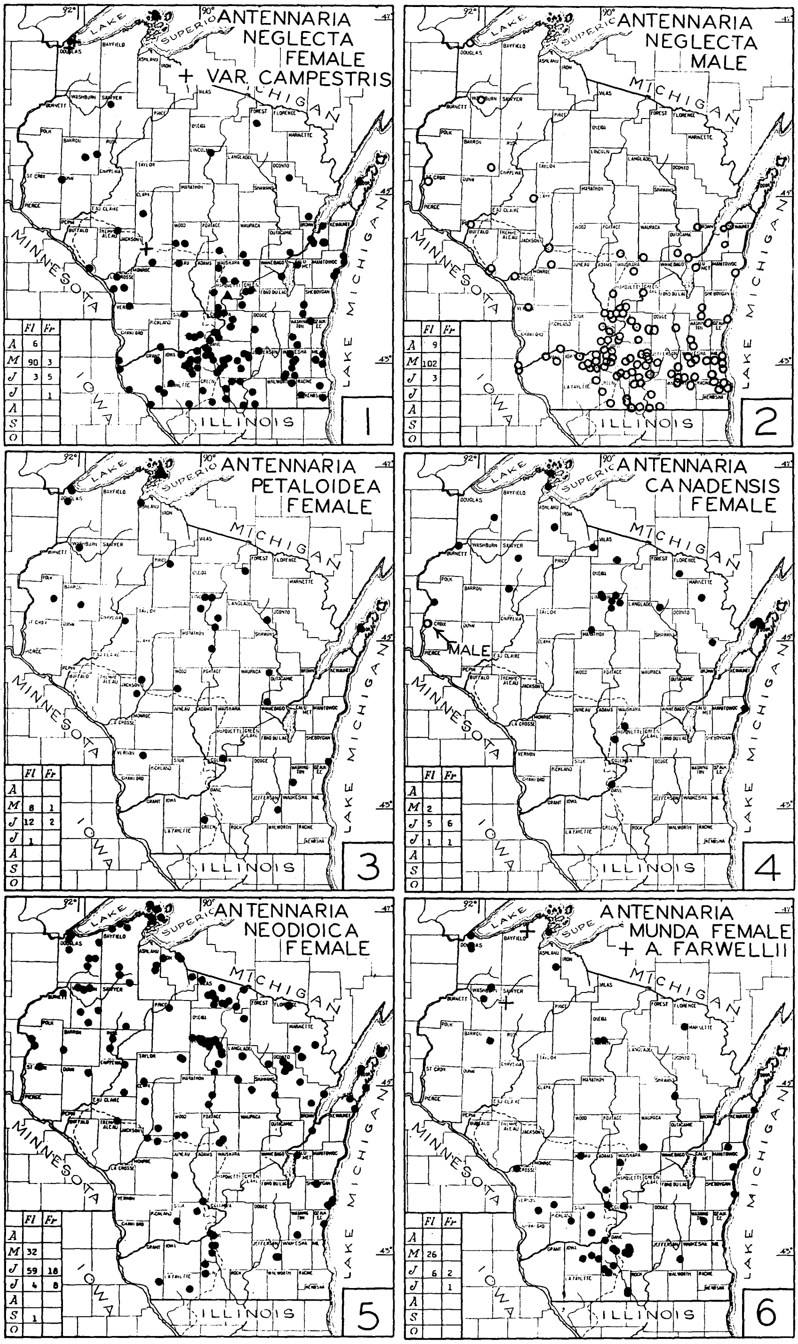
2. ANTENNARIA PETALOIDEA Fern. Map 3.

Female: Rosette leaves and stolons very similar to those of *A. neglecta.* Flowering stems 8–35 cm high; cauline leaves 5–8, linear, 8–25 mm long, 1–4 mm wide, without scarious tips. Head 1–10, crowded to loosely corymbose or racemose. Involucre 6–9 mm high; bracts green, brown, or purple, tips not scarious. Corolla 5–7.5 mm long, regular or irregular; pappus 5.5–7 mm, achenes 0.8–1.5 mm long.

This polyploid species, closely related to *A. neglecta,* though nowhere very common, is widely distributed over Wisconsin in prairies, pastures, and especially pine woodlands. Only female plants are known from Wisconsin.

3. ANTENNARIA CANADENSIS Greene Map 4.

Female: Rosette leaves somewhat narrow, usually 1-veined, oblanceolate to broadly obovate, short-petioled to sessile, 20–40 mm long, 5–20 mm broad, glabrous above. Stolons erect, short and stiff, the large terminal rosettes developing early; stolon leaves linear, 5–20 mm long, 1–3 mm broad. Flowering stems 5–30 cm high; cauline leaves 5–7, linear, 10–30 mm long, 1–2 mm broad, the upper with scarious appendages. Heads 3–12, in crowded to loose corymbs. Involucres 7.5–9 mm long; bracts brownish or greenish, sometimes with scarious tips. Corollas regular or irregular, 5–7.5 mm long; pappus 5–7 mm, achene 1–1.3 mm long.


ANTENNARIA NEGLECTA FEMALE
+ VAR. CAMPESTRIS
1
ANTENNARIA NEGLECTA MALE
2
ANTENNARIA PETALOIDEA FEMALE
3
ANTENNARIA CANADENSIS FEMALE
MALE
4
ANTENNARIA NEODIOICA FEMALE
5
ANTENNARIA MUNDA FEMALE
+ A. FARWELLII
6
LAKE SUPERIOR
MICHIGAN
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN

Male: Similar, except flowering stems shorter and involucral bracts broader, with white petaloid tips.

This rather infrequent polyploid, also similar to *A. neglecta,* is found predominantly in N. Wisconsin in pine barrens and woodlands, oak woodlands, and occasionally in dry prairies. The only male plant came from westernmost Wisconsin: St. Croix Co.: Pine Lake, open sandy shores, May 31, 1960, *Iltis 16,775* (WIS).

4. ANTENNARIA NEODIOICA Greene Map 5.

Female: Rosette leaves 1- to 3-veined (the lateral veins when present never approaching the blade tip), oblanceolate to obovate, 15–40 mm long, 5–20 mm broad, tomentose to glabrous above, with considerable variation in the same clone; petiole 4.5–8 mm long. Stolons erect, short, and stiff, with early-developing terminal rosettes; stolon leaves sessile, lanceolate, 6–25 mm long, 2–10 mm broad. Flowering stems 15–40 cm high; cauline leaves 7–10, linear to lanceolate, 12–30 mm long, 2–5 mm broad, without scarious appendages. Heads 3–15 in crowded to loose corymbs. Involucres 5.5–7.5 mm high; bracts green, purple, or brown, with scarious or white-petaloid tips. Corollas 4.5–7 mm, regular or irregular; pappus 4–7 mm, achenes 0.7–1.3 mm long.

A polyploid species, intermediate between the narrow- and broad-leaved species, common throughout Wisconsin, especially in the north, in dry to mesic prairies, oak and pine barrens or woodlands, cleared-woodland pastures and cedar glades. No male plants have been found in Wisconsin.

Stebbins (1935) postulated *A. neodioica* as derived from *A. virginica,* a diploid species of western Pennsylvania to western Virginia. This would imply either that *A. virginica* became extinct over a large area which would probably include Wisconsin, or that *A. neodioica* spread from a relatively small region of the Appalachians, where it originated, to southeastern Canada, all of the northeastern United States, and to the Midwest. Either way, a drastic difference in success between diploids and polyploids must be postulated. Wisconsin representatives of *A. neodioica* are as easily explained as allopolyploid derivatives of *A. neglecta* and *A. plantaginifolia,* since *A. neodioica* is intermediate in many characters between these two.

5. ANTENNARIA MUNDA Fern. Map 6.

Antennaria occidentalis Greene, of authors including Stebbins who named many of our specimens.

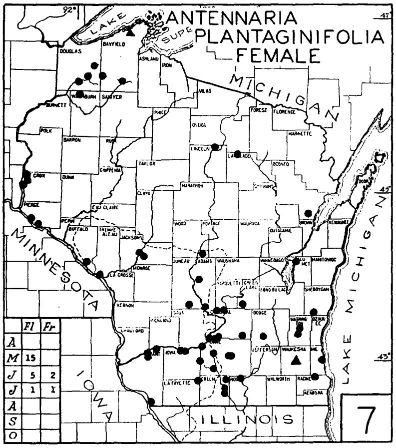
Female: Larger rosette leaves 3- to 5-veined, the lateral veins approaching the blade tip, broadly cuneate, spatulate, or obovate, 30–60 cm long, 10–30 cm wide, sparsely to densely tomentose above; tip of blade rounded or in forma FARWELLII subtruncate, sparsely to densely tomentose above; petiole 5–15 mm. Stolons decumbent and elongated, sometimes flexuous, the terminal rosettes developing early or late; stolon leaves linear, sessile to subpetiolate, 5–20 mm long. Flowering stems 10–45 cm high; cauline leaves 5–11, linear to oblanceolate, 15–30 cm long, 1–5 mm broad, without scarious tip. Heads 4–15, in a dense corymb. Involucre 6.5–9 mm high; bracts green, brown, purple, with white, subpetaloid or (occasionally) scarious tips. Corolla 5–7 mm long, regular or irregular; pappus 6–8 mm, achene 1–1.5 mm long.

This polyploid, most common in south-central Wisconsin and absent from the west-central part, is found mostly in prairies and pastures. Only female plants have been collected. Although its leaves would put it in the broad-leaved category, its stolons are more or less like those of *A. neglecta*. Fernald (1950) included under the name *A. munda* plants with either "short and assurgent or prolonged and decumbent" stolons, using the tapered base of the rosette leaf blade to characterize the species. Those with short and assurgent branches are hardly distinguishable from *A. fallax* in Wisconsin, while the distinction between short- and long-stoloned specimens is relatively clear. In light of this, I have placed part of Fernald's *A. munda* with my *A. fallax* and kept the rest as a separate species *A. munda*, according to Fernald's description (1936) of the type specimen.

Two specimens, both from northwestern Wisconsin, which key out to this species in the above key, would be called *A. farwellii* Greene according to Fernald (1950). They are distinguished from typical *A. munda* by the subtruncate leaf blades, but were tentatively called a form of *A. munda* (called *A. farwellii* on map 6) because of the tapering of the leaf blade and the spreading stolons. Since Greene's description of *A. farwellii* (1898) described the stolons as short and assurgent (which with reduction of rank would make it a form of *A. fallax*), it is difficult to know where these two specimens belong: Bayfield Co.: Siskowitt Lake, dry soil, 10 July 1938, Fassett 20015 (WIS). Sawyer Co.: Hayward, Lake Windigo, June–July 1943, E. M. Gilbert s.n. (WIS).

6. ANTENNARIA PLANTAGINIFOLIA (L.) Richards Maps 7, 8.

Female: Rosette leaves oblong, obovate to orbicular, 3- 7-veined, 25–60 mm long, 12–30 mm wide, canescent to glabrate above; petiole 10–30 mm long. Stolons short, ascending, the terminal rosettes opening early; stolon leaves linear to lanceolate, 15–25 mm long. Flowering stalks 10–30 cm high; cauline leaves 3–5, linear to lanceolate, 15–30 mm long, 3–10 mm wide, without scarious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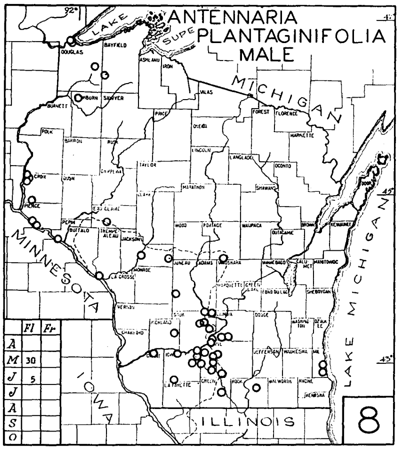
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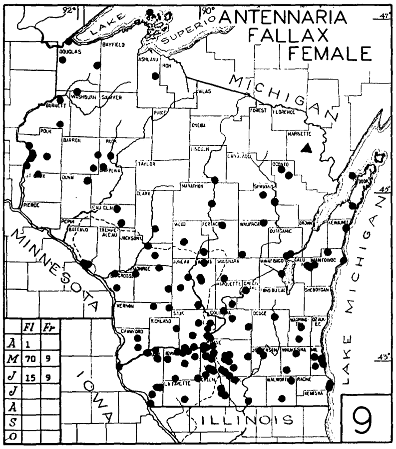
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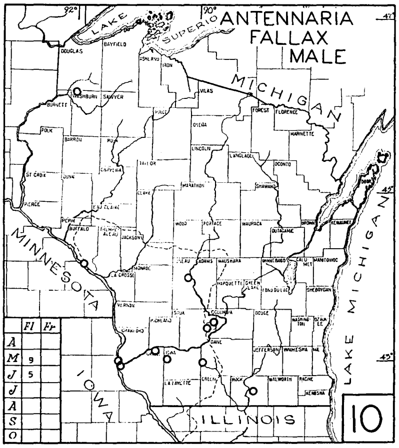
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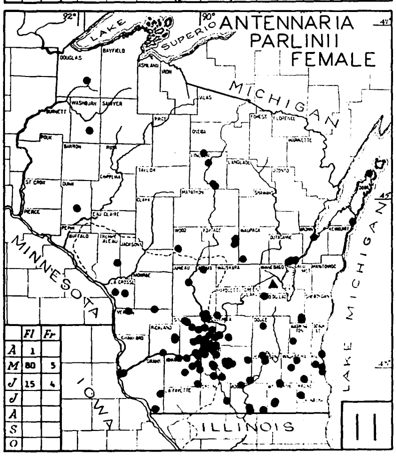
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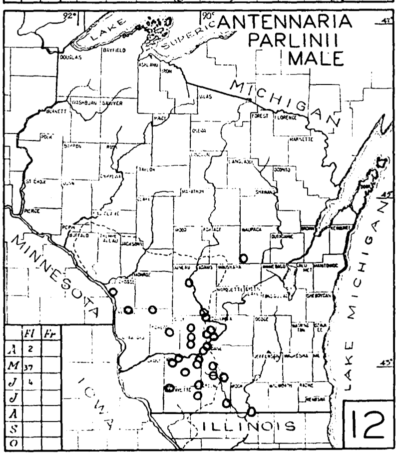
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appendages. Heads 4–20, in dense to loose corymbs. Involucres 4–7 mm high, often purple at base with white tips. Corollas 4–6 mm, usually irregular; pappus 5–5.5 mm, achenes 0.7–1.5 mm long.

Male: Similar to female but flowering stalks 3–20 cm long; involucral bracts broader and subpetaloid, and corollas 3–4.5 mm long.

This species, predominantly diploid and sexual with male and female plants occurring in about equal numbers, is most common in S. Wisconsin, following the Mississippi and St. Croix Rivers into the NW part of the state, and occurs in dry places such as oak openings, sand barrens, pastures, and dry prairies. Some herbarium specimens are on the borderlines between this and the next two species.

7. ANTENNARIA FALLAX Greene Maps 9, 10.

Female: Rosette leaves obovate to orbicular or often broadly quadrangular, 3- to 7-veined, 40–70 mm long, 15–40 mm wide, slightly to heavily tomentose above; petioles 9–35 mm long. Stolons short and ascending, the terminal rosettes developing early; stolon leaves linear to broadly lanceolate, 10–30 mm long. Flowering stalks 15–45 cm high; cauline leaves 5–12, linear to lanceolate, often crowded below, 18–45 mm long, 3–10 mm broad, without scarious appendages. Heads 5–22, in dense to loose corymbs. Involucres 6–8 mm high; bracts whitish, greenish, or purplish, sometimes scarious; corollas 5–7 mm, usually irregular but sometimes regular; pappus 6–8 mm, achenes 0.8–1.5 mm long.

Male: Similar but flowering stalks 5–25 cm high, involucral bracts broader, and corollas 4–5.5 mm long.

A polyploid species common throughout Wisconsin, except in the north-central region, the male plants rather uncommon and only near the rivers of the Mississippi Valley, especially the Wisconsin, in most dry to mesic prairies, oak openings, and in almost all previously grazed habitats, less common in ungrazed oak woods, infrequent in pine barrens, and rare in sand and oak barrens. Subglabrous specimens included here approach in character the following species.

8. ANTENNARIA PARLINII Fern. Maps 11, 12.

Female: Rosette leaves obovate to orbicular or often broadly quadrangular, 3- to 7-veined, 45–80 mm long, 20–55 mm wide, glabrous and bright green above; petiole 12–35 mm. Stolons short and ascending; terminal rosettes developing early; stolon leaves linear to lanceolate, 15–25 mm long. Flowering stalks 15–45 cm high, sometimes purple-glandular; cauline leaves 5–10, linear to lanceolate, often crowded below, 25–50 mm long, 5–12 mm broad, without scarious appendanges. Heads 5–18, usually in dense corymbs. Involucres 6–8 mm high; bracts whitish, greenish, or purplish. Corollas 5–8 mm, irregular or regular; pappus 6.5–8 mm, achenes 0.8–15 mm long.

Male: Similar but flowering stalks 3–30 cm high, involucral bracts broader, and corollas 4.5–5.5 mm long.

Common in the south, sparingly in the north, with male plants very common in parts of the "Driftless Area" and adjacent localities in SW Wisconsin but absent elsewhere, predominantly in both grazed and ungrazed oak woods, grazed dry prairies and other pastures, but rare in ungrazed prairies, sand and pine barrens. Although *A. parlinii* is closely related to *A. fallax,* the very characteristic glabrous upper leaf surface and occasional purple glands on the stem suggest that introgression may have occurred in the past with some unknown, now extinct species. (The glabrous- but narrow-leaved, asexual, northern *A. canadensis* is an unlikely candidate.)

39. ANAPHALIS DC. EVERLASTING

White-woolly herbs resembling *Gnaphalium* with many-flowered corymbose dioecious heads or with a few sterile hermaphrodite flowers in center of pistillate heads; flowers all tubular; receptacle flat or convex, not chaffy. Leaves alternate, entire, sessile. A small N. American and Asiatic genus, represented by a single species in Wisconsin, which is highly polymorphic and widespread from N. Asia to Eastern North America.

1. ANAPHALIS MARGARITACEA (L.) C. B. Clarke
Pearly Everlasting. Map 13.

Erect unbranched perennial herb, 2–9 dm tall. Leaves very variable, linear to linear-lanceolate, 5–11 cm long and 3–15 mm wide, tomentose below, glabrous to tomentose above. Stem tomentum gray-brown and spreading just below the heads, becoming appressed and usually white lower on the stem. Heads 4–7 mm high; *phyllaries papery, pure pearly white* with conspicuous longitudinal creases, imbricated in several rows. Pistillate flowers filiform with bifid style; corolla brown at the base, yellow higher up, with yellow-green, ascending lobes. Staminate flowers broader; corolla yellow-green with both base and apex brown, the brown corolla lobes recurved from the exserted anthers. Pistillate heads with a few perfect, but sterile flowers in center. Achenes brown, 0.4–0.8 mm long, conspicuously papillate under low power, terete or somewhat ridged.

Common throughout northern Wisconsin in open, often sandy places, most frequently on roadsides and lake shores, occasionally in open forests. Flowering in July and August; fruiting in August and September.

Fernald (1950) recognized four varieties, reflecting the tremendous variability the species shows throughout its range (and in Wisconsin) in leaf number, width, and indument. Without careful morpho-geographic analyses, however, which though at present lacking would be of great phytogeographic interest, these varieties cannot clearly be defined, and therefore recognized, in Wisconsin.

40. GNAPHALIUM L. CUDWEED, EVERLASTING, RABBITS TOBACCO

(By Ralph F. Peters)

Woolly slender herbs with many-flowered heads in corymbose or capitate inflorescences. All flowers tubular, mostly pistillate and very slender, a few central ones perfect and broader, the style bifid. Pistillate corollas white or yellow; perfect corollas green or yellow-brown with brown base and brown or yellow lobes. Pappus a single row of filiform white bristles. Phyllaries scarious, white or stramineous, in one to several rows. Receptacle flat, not chaffy. Achenes 0.4–0.8 mm long, light to dark brown, wrinkled and flattened at first, becoming terete and almost smooth as they mature. Leaves alternate, entire, sessile or decurrent. A widely distributed, large genus, especially in Andean South America and South Africa.

KEY TO SPECIES

A. Heads 2–3 mm high, in capitate leafy-bracted clusters; upper stems very densely white-floccose-tomentose, obvious to the naked eye; stems usually much branched, 1–2 dm tall ---1. *G. uliginosum.*

A. Heads 4–6 mm high, capitate or corymbose; upper stems with appressed, or nearly microscopic loose-spreading tomentum; stems erect, seldom branching except within a corymbose inflorescence, 1–10 dm tall.

B. Leaf bases decurrent; middle or lower stem with glandular-hirsute pubescence 0.2–0.5 (–1) mm long; leaves usually 10–15 times as long as wide, tapering gradually to an acute tip; achenes distinctly papillate under high magnification --2. *G. Macounii.*

B. Leaf bases not decurrent; middle or lower stem with glandular-hirsute pubescence less than 0.25 mm long or lacking; leaves usually only 7–10 times as long as wide, tapering more abruptly to the acute tip; achenes ridged but glabrous and not papillate --------------------------4. *G. obtusifolium.*

1. GNAPHALIUM ULIGINOSUM L. Low Cudweed. Map 14.

Low, usually much-branching or prostrate annuals, 4–20(–30) cm high. Leaves narrowly oblanceolate, tomentose on both upper and lower surfaces, 6–35 cm long. Upper stems with a very dense, long, white-floccose tomentum, becoming appressed-lanate below. Inflorescences densely capitate, usually several to a plant, each including 2–15 small heads, these 2–3 mm high and greatly overtopped by their subtending leafy bracts; phyllaries in 1 or 2 rows, barely imbricated, narrowly acuminate, 1–2 long, stramineous, pale brown or yellowish, often with green midribs; achenes papillate under high magnification.

Introduced from Europe, frequent in disturbed or sandy, usually damp and open places such as roadsides, lake shores, and pastures, sometimes on ledges of sandstone cliffs, mainly in northern Wisconsin and along the major rivers and Lake Michigan. Flowering from mid-June through September; fruiting from mid-July into November.

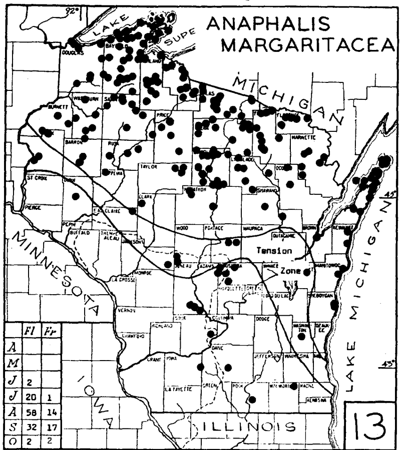
GNAPHALIUM PURPUREUM L. (Map 17), a common European weed resembling *G. uliginosum* but with erect unbranched stems, oblanceolate-spathulate leaves, and "spicate" inflorescences is represented by one undated *Goessl* collection from Sheboygan, very likely from his garden.

2. GNAPHALINM MACOUNII Greene Western Cudweed.
Gnaphalium decurrens Ives Map 15.

Erect biennial, 2–7 dm tall, unbranched except at the top. Leaves usually ascending rather sharply, linear lanceolate to linear oblanceolate, (7–)10–15(–20) times as long as wide, with relatively broad bases, decurrent onto the stem as wings, tapering gradually to an acute or acuminate tip; upper surface glandular, lower with an appressed tomentum. Upper stem with a short, loosely spreading to appressed-lanate tomentum, grayish brown to white; lower stem granular-hirsute. Inflorescence corymbose, generally not as widely branching as in *G. obtusifolium;* heads 20–100, 4–6 mm high; phyllaries light gray to yellow, 1–4 mm long, imbricated in 2–4 rows, the outer ones broader than the inner. Achene papillate under high magnification.

Common in northern Wisconsin in open places, and usually in dry, sandy soil such as beaches, fields, sand pits, roadsides, gravel banks, and edges of bogs and marshes. Flowering from late July to early September; fruiting from September to early October.

This western, Cordilleran species has apparently spread across the northern United States and southern Canada to New England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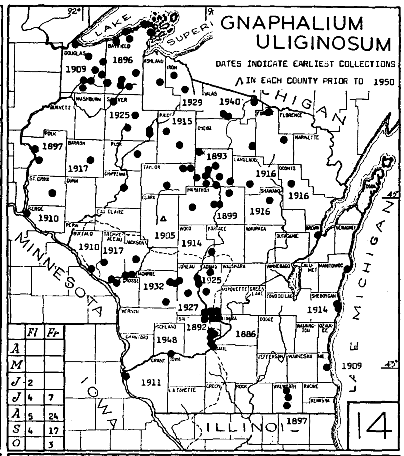
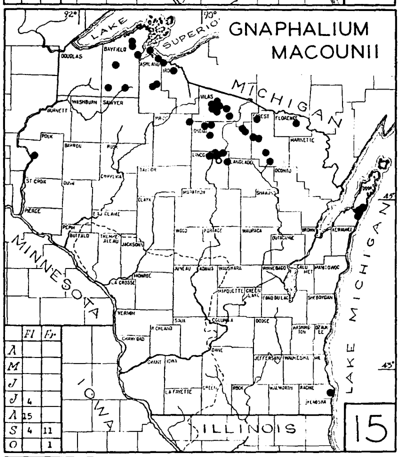
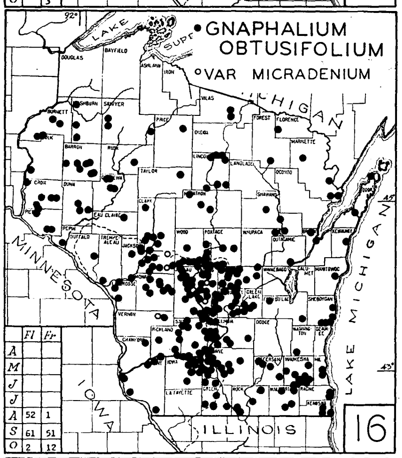
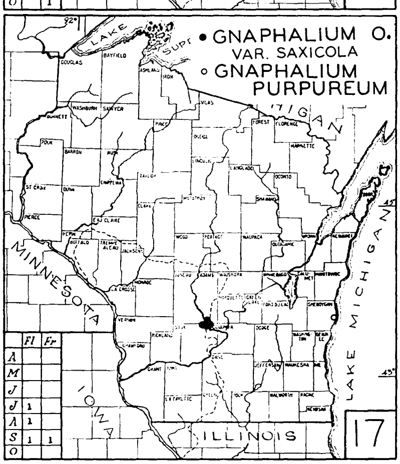
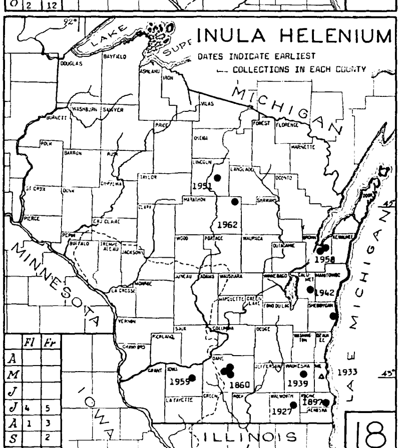
13


GNAPHALIUM
ULIGINOSUM
DATES INDICATE EARLIEST COLLECTIONS
Δ IN EACH COUNTY PRIOR TO 1950
MINNESOTA
IOWA
LAKE MICHIGAN
Fl Fr
A
M
J 2
J 4 7
A 5 24
S 4 17
O 3
14


GNAPHALIUM
MACOUNII
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J
J 4
A 15
S 4 11
O 1
15


• GNAPHALIUM
OBTUSIFOLIUM
° VAR MICRADENIUM
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J
J
A 52 1
S 61 51
O 2 12
16


• GNAPHALIUM O.
VAR. SAXICOLA
○ GNAPHALIUM
PURPUREUM
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J
J 1
A 1
S 1 1
O
17


INULA HELENIUM
DATES INDICATE EARLIEST
COLLECTIONS IN EACH COUNTY
1951
1962
1958
1942
1933
1959
1860
1939
1897
1927
MINNESOTA
IOWA
ILLINOIS
LAKE MICHIGAN
Fl Fr
A
M
J
J 4 5
A 1 3
S 2
O
18

and Nova Scotia since the Pleistocene. It tends to be weedy and most collections are recent, out of the past 30 years. The Racine Co. station is based on two old (ca. 1860) sheets of *Hale* (WIS).

3. GNAPHALIUM OBTUSIFOLIUM L. x G. MACOUNII Greene
hollow circle, Map 15.

A single collection, intermediate between the parents in that the leaves are but slightly decurrent and the achenes papillate suggest it to be a hybrid: Lincoln Co.: open field, T 35N, R 7E, Sect. 17, King, Sept. 11, 1951, *F. C. Seymour 13229* (WIS).

4. GNAPHALIUM OBTUSIFOLIUM L. Catfoot, Rabbit's Tobacco
Maps 16, 17.

A very variable taxon with one abundant and two very rare varieties in Wisconsin.

KEY TO VARIETIES

A. Stem with extensive lanate or loose-spreading, non-glandular tomentum.
  B. Phyllaries in 3–5 rows; stem closely appressed-lanate, occasionally with scattered, twisted flocks; 15 cm–1 m tall; common throughout all but northernmost Wisconsin ---4a. var. *obtusifolium*.
  B. Phyllaries in 1–3 rows; stem with loosely-spreading tomentum; weak-stemmed delicate herb 3–15 cm tall, very rare in Wisconsin Dells region ------------------4b. var. *saxicola*.
A. Stem glandular-hirsute with little or no tomentum ---4c. var. *micradenium*.

4a. GNAPHALIUM OBTUSIFOLIUM var. OBTUSIFOLIUM Map 16.

Erect biennial, 15 cm–1 m tall. Leaves lanceolate, ascending or spreading, (5–)7–10(–13) times as long as wide, glandular or scabrous above, appressed-tomentose below, tapering to a sessile but not decurrent base and rather abruptly to the acute tip. Stem with a white tomentum, usually closely appressed-lanate, but occasionally in scattered, twisted flocks reminiscent of the Greek origin of the generic name, meaning "locks of wool." Inflorescence corymbose, of 20–150 heads, these 4–6 mm high; phyllaries light gray or tan to yellow, 1–5 mm long, imbricated in 3–5 rows, the outer broader than the inner ones. Achenes wrinkled to ridged but glabrous.

Throughout Wisconsin except in the extreme north, very common in sandy soil of fields, roadsides, prairies, and occasionally in open, dry woods. Flowering from August to early October; fruiting in September and October.

4b. GNAPHALIUM OBTUSIFOLIUM var. SAXICOLA (Fassett) Crong.
Gnaphalium saxicola Fassett, Rhodora 33: 75. 1931.

[Type: Adams Co.: Sandstone ledges, Coldwater Canyon, Dells of the Wisconsin River, *Fassett, Uhler, & McLaughlin 9590* (WIS)]
Map 17.

Similar to var. *obtusifolium* but with very slender stems only 3–15 cm tall. Leaves usually oblanceolate, spreading, (3–) 4–9 times as long as wide, and frequently but sparsely tomentose beneath. Stems with a white, loosely spreading tomentum. Inflorescence with 1–15 heads; phyllaries much less imbricated, in 1–3 rows, usually all narrow.

Very rare on mesic to dry sandstone ledges in the Wisconsin Dells area. Flowering from late July to mid-September; fruiting in September and October.

At the type locality in Coldwater Canyon, Peters recently found it only on a single, south-facing ledge 5 m above the canyon floor. At this point the canyon is about 50 m wide and rather marshy. A black-top public path of the Dells Boat Company passes directly below this ledge about 150 m before it enters the very narrow Coldwater Canyon proper. The dry ledge is about 6 dm wide and 3 m long and is overhung by another ledge 1 m above it. In 1963, less than a dozen plants of var. *saxicola,* none taller than 6 cm were scattered along this sandy, barren ledge. It is possible that there are other colonies on similar, inaccessible ledges of the many sheer cliffs which in this region commonly rise from the nearby Wisconsin River.

The earliest collection of var. *saxicola* was made in 1866 [by an unknown collector (WIS)] at Congress Hall, now known as "Lost Canyon". Here in 1963, Peters found only two plants, a little taller than those of Coldwater Canyon, growing on a narrow ledge above a smooth, 15-foot rock wall located in the west branch of the canyon, at the turn-around for the horse-drawn wagons which carry visitors through the rocky gorge, currently a popular tourist attraction. Above the ledge, the cliff rises almost vertically for some distance, with no overhang. Here, as in Coldwater Canyon, there is no competition from other plants. This site is rather sunny and the only known habitat that is not heavily shaded. The fact that var. *saxicola* is just as depauperate here makes it extremely unlikely that it is merely a form of var. *obtusifolium* stunted by the absence of light, but rather that it is a cliff ecotype recently derived from var. *obtusifolium.*

A few specimens (all in WIS) have been collected which are intermediate to var. *obtusifolium,* especially in tomentum and/or height: Sauk Co.: "crags," Mirror Lake, shady coulee near Delton, 1891, *True s.n.*. Iowa Co.: north facing wooded bluff along Wisconsin River opposite Lone Rock, 1930, *Fassett 12549*. Sauk Co.: end of Lower Dells, Delton, 1949, *Fassett 28120*. Richland Co.: Boaz, 1959, *Wasuwat s.n.* These intermediates, coupled with the scarcity of specimens, make it advisable not to follow Fassett (1931), who considered it a separate species, but rather Cronquist (1946) who, on a 1944 annotation slip on the 1866 sheet (WIS), wrote, "In my opinion, *G. saxicola* Fassett constitutes a local variety of *G. obtusifolium,* with the *True* specimen being somewhat intermediate to the typical variety."

4c. GNAPHALIUM OBTUSIFOLIUM var. MICRADENIUM Weath. Map 16.

Very similar to var. *obtusifolium,* but somewhat smaller, with leaves only 1–5 mm wide. Stems with little or no tomentum, instead covered with a very short (less than 0.25 mm) long glandular-hirsute pubescence.

An eastern variety, represented in west-central Wisconsin by only four specimens (all in WIS): Adams Co.: oak–jack pine woods 10 mi NNE of Friendship, 1948 *Brown 334*. sandstone bluff, oak–pine woods, 7 miles SSW of Adams, 1948, *Brown 343*. Jackson Co.: black oak–sugar maple woods, north base of Bear Bluff, sandy soil, 1958, *Witt*. Vernon Co.: grazed bluff, Newman Valley, 1958, *Melchert & Witt s.n.* (together with a plant of the typical variety).

41. INULA

A large Old World genus of small to robust yellow-flowered herbs, with but one species escaped in Wisconsin.

1. INULA HELENIUM L. Elecampane. Map 18.

Robust herbs 1–2 m tall from a stout mucilaginous rootstock; basal leaves very large, on long petioles, the blades 4–5 dm long, ca. 2 dm wide, woolly beneath, scabrous above, the upper similar but reduced, sessile and cordate-clasping, ovate or ovate-lanceolate and long acuminate. Heads few, solitary at tip of 2–15 cm long stout peduncles, like a sunflower, massive, 2–3 cm tall, 3–5 cm in diam., the involucral bracts imbricate in several series, the outer foliaceous; rays pistillate, yellow, showy, 2–4 cm long, the disk fls. perfect. Pappus 7–10 mm long of brown-stramineous capillary bristles, the achenes slender, 3–6 mm long glabrous, 4-angled. Occasional escaped from cultivation and then often established in large colonies in old fields, pastures, fencerows, roadsides and near old gardens, rarely in open woods, flowering from mid-July to late August; fruiting into September.

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PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN NO. 57
POLEMONIACEAE—PHLOX FAMILY

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Donald A. Levin
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University of Illinois at Chicago Circle

Spring and early summer in Wisconsin are the principal seasons of flowering of the Polemoniaceae. Although the plants are often abundant, only three genera and seven species are found in Wisconsin, while the whole family comprises 18 genera and approximately 316 species (Grant 1959). Most of the genera are found in western North America, but a few are amphitropical with both North and South American representatives, and a few more are Eurasian, with none endemic to eastern North America.

The members of the family found in Wisconsin show conspicuous adaptive radiation. Some occur in riparian forests, others in upland forests, and still others in prairies and sand-hills or even in weed patches. Most species native to Wisconsin may occasionally be cultivated, with *Phlox paniculata* the common summer-flowering garden phlox. Additional aspects of the natural history of the family are well treated by Grant (1959), and Grant and Grant (1965).

POLEMONIACEAE A. L. DE JUSSIEU PHLOX FAMILY

Perennial or annual herbs; leaves opposite or alternate, simple or pinnately compound; flowers in terminal or axillary cymose clusters, diffuse or nearly head-like, perfect. Calyx of five wholly or partially united sepals, usually regular; sinuses between the lobes often membranous; corolla of five regular wholly or partially united petals, broadly campanulate or salverform, contorted in bud; stamens 5, epipetalous, alternate with corolla lobes; ovary superior, 3-celled, styles 1, or three partially united; stigmas 3, or 1, 3-lobed; fruit a loculicidally dehiscent capsule; seeds 1–several per locule, tending to become mucilaginous when wet.

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KEY TO GENERA

A. Leaves pinnately compound, leaflets 7–17; calyx becoming enlarged, chartaceous in fruit; corolla broadly campanulate, blue. ---------------------------------- 1. POLEMONIUM.

A. Leaves simple; calyx not conspicuously enlarged in fruit, frequently breaking through intercostal membranes; corolla salverform or narrowly trumpet-shaped.

B. Annual; calyx not breaking in fruit; corolla narrowly trumpet-shaped; inflorescence of tightly crowded inconspicuous flowers ------------------------ 2. COLLOMIA.

B. Perennial; calyx usually splitting along intercostal membranes as fruit matures; corolla salverform, conspicuous; inflorescence large, open. ------------------ 3. PHLOX.

1. POLEMONIUM L. JACOB'S-LADDER

Twenty-three species, mostly perennial herbs, primarily of western North America.

1. POLEMONIUM REPTANS L. Jacob's-Ladder, Greek Valerian. Map 1.

Perennial herb, 1–5 dm tall; leaves pinnately compound; leaflets 7–17, glabrous, villous or rarely glandular; inflorescence a loose few-flowered corymbose cyme; pedicels 4–8 mm long; calyx broadly herbaceous, accrescent in fruit, the lobes triangular, about equaling the tube; corolla broadly campanulate, deep blue to near-white, 8–16 mm long, lobed to mid-point; stamens equally inserted, slightly exceeded by length of corolla lobes; style barely exceeding stamens. 2N=18.

Widespread in eastern United States deciduous forest but lacking on the coastal plain, common in southern Wisconsin south of the floristic Tension Zone, in rich often moist hardwoods of sugar maple, basswood, elm and oak, northward in white pine-red maple, frequently in low meadows, marshes and even sphagnum bogs, on wooded bluffs of sandstone, rarely limestone, rarely in deep soil mesic prairies (e.g. at Juda, Green Co. cf. Bray, R. "Climax forest herbs in prairie," *Am. Midl. Nat.* 58: 437. 1957), sometimes along roadsides and railroad rights-of-way. Flowering from (late April) earliest May to the second week of June, fruiting from late May to August.

Wisconsin material of this taxon shows great variations in pubescence, e.g. density, trichome length, glandularity, which ranges from totally glabrous to densely pubescent with long-glandular trichomes on upper leaves, stems and inflorescences. Davidson (1950) conducted progeny tests on variable material presumably from Pennsylvania. At Berkeley, California, all of his plants were glabrous, which led him to conclude that such variation was unworthy of taxonomic recognition at any rank. Braun (1956) presented data demonstrating that a *Polemonium* localized in a few southern Ohio and northern Kentucky populations did indeed have sufficient integrity to warrant recognition as variety *villosum* E. L. Braun, which differed slightly in habit, leaf, and flower morphology. Braun demonstrated that the two varieties hybridize today where conditions are appropriate and postulated that variation such as that noted in Wisconsin could have resulted from post-Pleistocene contacts between var. *villosum* and var. *reptans*. Herbarium material from Wisconsin and field observations on Illinois plants suggest a high degree of recombination of the factors responsible for the determination of pubescence traits, and their extremes as well as their intermediates are evenly scattered throughout the range of the species in Wisconsin. Grant (1965) considers *P. reptans* an obligate outbreeder, the condition being enforced by protandry and self-incompatibility, with bumble-bees being the principal pollinators. This would tend to maintain the genetic diversity of a mongrelized population provided selective factors did not operate against recombinants.

The variation in Wisconsin seems not to include the extreme var. *villosum* types described by Braun, which show an association of several morphological and physiological characters with densely glandular pubescence. Accordingly, all specimens examined fall within *P. reptans* var. *reptans*.

2. COLLOMIA Nutt. Collomia.

Fourteen species, four perennials, 10 annuals, primarily of western North America.

1. COLLOMIA LINEARIS Nutt. Collomia. Map 2.

Annual herb 1–6 dm tall, subglabrous below, strongly glandular pubescent in inflorescence, unbranched or in vigorous specimens branched above, each branch terminating in a leafy-bracted head-like cluster of sessile flowers; leaves mostly alternate, simple, lanceolate to linear, narrowed to sessile base; calyx somewhat accrescent, to about 4 mm in fruit; corolla about 1 cm long, pale pink, bluish or white; *tube very slender; lobes very short*, ca. 1–3 mm long; stamens subequal, included; plants autogamous; seeds mucilaginous when wet, 1–3 per capsule. $2n=16$.

A Great Plains and western N. Am. mountain element, apparently native but rare in sands and gravels in Wisconsin; but this is difficult to prove, since it occurs mostly in "open habitats" along railroads, river and lake shores, sometimes in clearings in forest, and docks and waste places in cities. Flowering from late June through July (Oct.), fruiting from early July through August.

3. PHLOX L. Phlox, Wild Sweet-William.

Erect or spreading perennial herbs (subshrubs or annuals not in Wisconsin); leaves opposite, simple, entire, sessile, linear-lanceolate to ovate; flowers prominent, pinkish or rarely blue or white, in terminal, variously-shaped cymose clusters; calyx five-lobed, the lobes acute or aristate, herbaceous, the sinuses membranous, often rupturing as the 3-valved capsule enlarges; corolla showy, salverform, the lobes variously shaped, often with prominent eyemarkings; stamens unequally inserted in corolla tube; anthers usually included in tube; style elongate and exceeding the calyx lobes (rarely *exserted* from corolla) or shorter than calyx lobes; seeds not mucilaginous when wet. Sixty-six species North American, one Asiatic, all but three perennial.

Isolating Mechanisms in Phlox.

Geographical. The distribution of phlox in North America is bipartite, with all Wisconsin taxa belonging to the eastern 25% of the species. Within this group, certain taxa have greater affinity with the Appalachians, others with the Ozarks, while in some geographical affinity is obscure. The only Wisconsin phlox of apparent Appalachian origin is *P. glaberrima* subsp. *interior,* the westernmost lowland derivative of the Appalachian *P. glaberrima.* Ozarkian elements are *P. bifida, P. divaricata* subsp. *laphamii* and *P. pilosa* subsp. *fulgida.* The latter seems to have diverged directly from *P. pilosa* subsp. *ozarkana,* while *P. divaricata* subsp. *laphamii* is probably a hybrid derivative of *P. divaricata* subsp. *divaricata* and *P. pilosa* subsp. *ozarkana.* Of the remaining Wisconsin phloxes, the ancestry may not be readily traced. The few sporadic records for *P. paniculata* are probably escapes from cultivation. *Phlox divaricata* subsp. *laphamii* and *P. pilosa* subsp. *fulgida,* the only sympatric species, are ecologically isolated and no interspecific hybridization in Wisconsin has been seen.

Ecological. Ecological isolation is moderate to strong in all the phlox species in Wisconsin. In the Kenosha Prairie where *P. glaberrima* subsp. *interior* co-exists with *P. pilosa* subsp. *fulgida,* their requirements differ sufficiently so that populations of the two are usually contiguous rather than mixed, with wetter prairies occupied by *P. glaberrima.* Apparently *P. pilosa* subspecies are not isolated where they contact, but their generally separate ranges suggest that even they are ecologically differentiated. *Phlox paniculata* typically occurs in moist woodland (as an escape). Strongly sympatric in Wisconsin are *P. divaricata laphamii* of woodlands and *P. pilosa fulgida* of prairies, these virtually totally isolated ecologically.

Seasonal. The flowering periods of the respective species are shown on each map. Throughout the seasonal sequence overlapping occurs between species, but the flowering peaks are amply distinct. Even with slight overlap, ecological isolation or flower constancy of pollinators is usually sufficient to provide effective reinforcement of seasonal barriers. An interesting exception to typical seasonal isolation occurs in Kenosha County, where a late-flowering race of *P. pilosa* subsp. *pilosa* (*P. argillacea* Clute) overlaps for nearly three weeks the flowering period of *P. glaberrima* subsp. *interior*. In a similar population in northern Illinois where cross-pollination was documented, the pollen load carried interspecifically was very low and no hybrids were found. However, artificial hybrids have been produced, so that even the limited pollen transfer may have abiding significance.

Incompatibility. Controlled pollinations involving all Wisconsin *Phlox* taxa have demonstrated isolation by cross-incompatability. Seed-set failed whenever *P. bifida* was involved, and unilateral incompatability was encountered whenever pollen from short-styled species *(P. divaricata* and *P. pilosa)* was applied to long-styled species *(P. glaberrima* and *P. paniculata)*. Even when seed-set occurred, reduced numbers of seeds indicated varying degrees of incompatability. The weakest barriers were between the members of section *Protophlox, P. divaricata* and *P. pilosa,* while intersectional crosses always presented a strong or absolute barrier. Within Section *Phlox,* represented in Wisconsin by distantly related species, barriers were also strong or absolute. (Fig. 1, cf. p. 252).

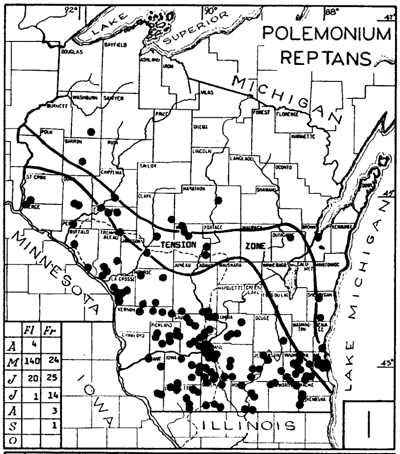
Key to Species

A. Style elongate, equaling or exceeding calyx lobes (Section *Phlox*) -- B.

B. Plants erect, unbranched from base, leaves linear-lanceolate to ovate, corolla lobes rounded or apiculate -- C.

C. Leaves elliptic-lanceolate to ovate, veins very prominent and areolate on abaxial surface, corolla-tube pubescent, anthers and pollen cream-white ------ 1. *P. paniculata.*

CC. Leaves linear-lanceolate or slightly broader, veins obscure, corolla tube glabrous, anthers and pollen orange --------------------2. *P. glaberrima* subsp. *interior.*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TENSION ZONE
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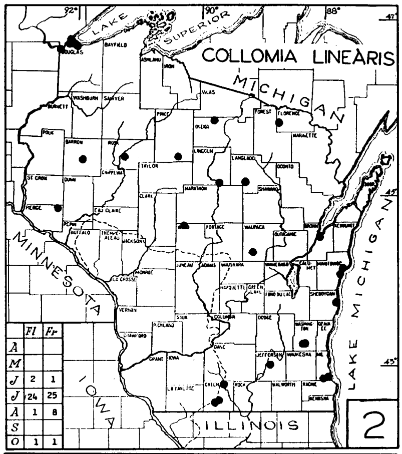
A 3
S 1
O
1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O 1 1
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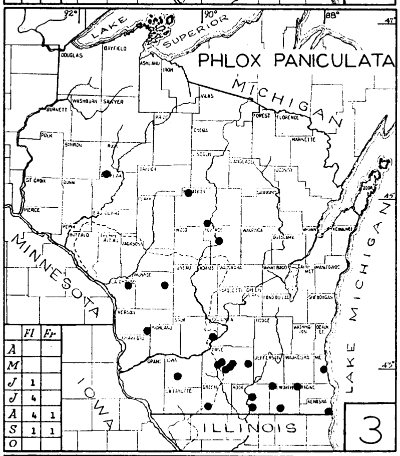
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MICHIGAN
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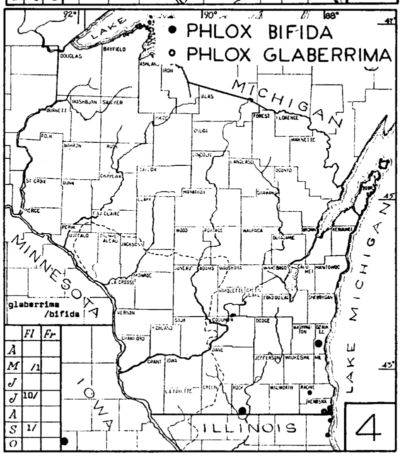
• PHLOX BIFIDA
∘ PHLOX GLABERRIMA
LAKE SUPERIOR
MICHIGAN
MINNESOTA
glaberrima /bifida
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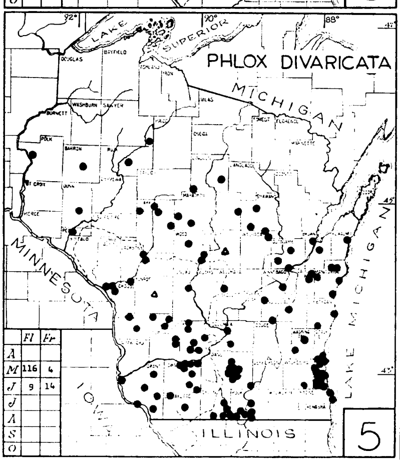
PHLOX DIVARICATA
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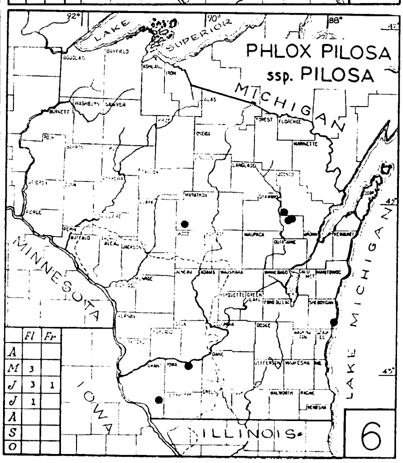
PHLOX PILOSA ssp. PILOSA
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MINNESOTA
IOWA
ILLINOIS
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BB. Plants spreading, branched throughout, corolla lobes conspicuously bifid, notched 3–5 mm _3. *P. bifida* subsp. *bifida.*

AA. Style short, included deeply within calyx (Section *Protophlox* Wherry)

D. Sterile basal branches conspicuous, their leaves broadly elliptic, subevergreen, leaves of fertile branches herbaceous, acutish with somewhat cordate bases; flowers mostly tending toward blue, corolla-tube glabrous, sepals acute. _________________________4. *P. divaricata* subsp. *laphamii.*

DD. Sterile basal branches absent or inconspicuous, all leaves linear to linear-lanceolate, flowers usually some shade of pink, usually with conspicuous eye-markings, corolla-tube pubescent, sepals with aristate tips _________5. *P. pilosa.*

1. PHLOX PANICULATA L. Summer Phlox. Map 3.

Perennial herb, 10–20 dm tall, from short rhizome; stem glabrous to pubescent, green or streaked with red; leaves sessile or short-petioled, lanceolate to ovate or elliptic, strongly areolate-veiny on abaxial surface, glabrous or pubescent; inflorescence a large cluster of smaller cymes; calyx lobes short-aristate, intercostal membranes often folded; corolla tube elongate, pubescent, petals mostly dark-pink; style elongate, usually exserted along with one or two cream-white anthers. $2n=14$.[2]

Widespread in the eastern U. S. north of the Coastal Plain to Chicago and northern Missouri, escaped in southern Wisconsin on wooded roadsides and ditches, grazed woods, railroad tracks and old cemeteries, in the East Wilderness Scientific Area of Wyalusing State Park appearing native in the midst of flood plain forest, but this close to the "Immigrant Trail" and hence, too, adventive (sub *Iltis 20,575*). Flowering from late July into October. This is probably the most extensively cultivated of all phloxes, and often the unaltered wild plants are grown in perennial summer gardens. Escapes from cultivation are common within and without its range, the precise area of native distribution therefore not likely to be determined.

2. PHLOX GLABERRIMA L. subsp. INTERIOR Wherry Smooth Phlox. Map 4.

Perennial glabrous erect herb, 3–8 dm tall, from short rhizome; stems green; leaves linear-lanceolate to lanceolate, 5–10 cm long, broadening upward; inflorescence a nearly flat-topped cluster of

[2] Chromosome morphology of eastern North American *Phlox* has been reported in detail by Smith and Levin (1967).

cymes; calyx lobes subulate, the intercostal membranes flat; corolla glabrous, brilliant rose-pink; style elongate; anthers orange. 2n=14.

A subspecies of the interior low plateaus from Arkansas to northwestern Ohio, in Wisconsin only from the low prairies along Lake Michigan in Kenosha (Chiwaukee Prairie and Carroll Beach south of Kenosha) and Racine County [wet meadows, 4 mi. E of Rochester, July 21, 1843, *I. A. Lapham s.n.* (WIS)] and adjoining Beach, Illinois, together with *Allium cernuum, Thalictrum revolutum, Liatris spicata, Fimbristylis drummondii,* and other species restricted in Wisconsin to this area, once common on low prairies in Illinois and Indiana, the typical subspecies southern Appalachian. Flowering from latest June through July.

3. PHLOX BIFIDA Beck subsp. BIFIDA Ten-point Phlox. Map 4.

Perennial, low, mat-forming herb, 1–2 dm tall, the base persistent; leaves 6–10 per shoot, linear to linear-lanceolate, 1–2 cm long, glabrous to slightly glandular near the few-flowered inflorescence; pedicels 15–30 mm long, glandular; calyx lobes subulate, the membranes mostly flat; corolla lobes deeply bifid (notched) for 4 mm, light blue or white, the eye-markings prominent; style 1 cm long, slightly exceeding calyx lobes. 2n=14.

An Ozarkian (there somewhat calcophilic) species, in southern Wisconsin at very edge of range and very rare [Ozaukee Co.: Cedar Creek, no date, *C. T. Tracy s.n.* (WIS). Rock Co.: sandy woods, SW¼, Sec. 33, T. 1N, R. 11E, ca. 6 mi. W of Beloit, May 12, 1946 (full flower), *E. W. & G. B. Fell 46253* (WIS)], the second collection probably native, the species much cultivated together with the deep purple-red *P. subulata,* the Moss Phlox, which it resembles and to which it is closely related, and their hybrids.

4. PHLOX DIVARICATA L. subsp. LAPHAMII (Wood) Wherry

Phlox divaricata β? *laphamii* Wood, Class Book of Botany ed. 2: 439. 1848 (Lectotype: Milwaukee, Wisconsin, *Lapham s.n.,* WIS!).

Blue Phlox, Wild Sweet-William. Map 5.

Perennial herb, 2–5 dm tall; decumbent sterile stems subevergreen, often rooting at the nodes; erect stems bearing a moderately compact cymose inflorescence; leaves on sterile shoots somewhat elliptic, those of the fertile branches cordate-based, lanceolate, sessile, pubescence glandular, 25–50 x 10–20 mm; calyx lobes subulate, the membranes mostly flat; corolla usually bluish-purple, violet, or white (in FORMA ALBIFLORA Farw.), the corolla lobes truncate, rounded, or apiculate; style 1.5–3.0 mm long, included. 2n=14.

Widespread in the central U. S. to southern Georgia and eastern Texas and centering on the Ozarks (hence somewhat calcophilic), in Wisconsin locally very abundant south of the Tension Zone, especially in damp flood plain forests (e.g. Avon bottoms, Green Co., where in early spring the whole forest floor is tinged blue), rich mesophytic hillsides of sugar maple, beech, and basswood, sometimes on sandstone bluffs, much cultivated in wild flower gardens. Flowering from earliest May to early June.

This *Phlox* is well-defined in Wisconsin. In Illinois, Indiana and Kentucky, variation in stature, leaf size and shape, development of sterile basal branches, and most conspicuously, degree of petal notching, are prominent. Wherry (1955) hypothesized that postglacially the two subspecies migrated, *P. d.* ssp. *divaricata* from the Appalachians, and *P. d.* ssp. *laphamii* from the Ozarks, to overlap and hybridize in an area roughly corresponding to the Illinois–Indiana state line, where maximum variability occurs. Levin (1966) postulates that *P. divaricata* subsp. *laphamii* arose in Ozarkia through hybridization between *P. divaricata* and *P. pilosa* ssp. *ozarkana* Wherry. The *P. pilosa* genes gave *P. divaricata* the morphological attributes of *P. d.* ssp. *laphamii* and physiological attributes which assured success in the forest-prairie border region.

5. PHLOX PILOSA L. Downy Phlox, Prairie Phlox.

Perennial herb, 2–6 dm tall, from a subligneous base; stem usually pubescent; sterile shoots sparse, not rooting at nodes, not evergreen; leaves linear to linear-lanceolate, generally pubescent; inflorescence a rather compact cluster of cymes; calyx lobes aristate, membranes flat; corolla typically pink, usually with prominent eye-markings; tube pubescent; styles short, 1.5–3.0 mm, included within calyx.

One of the most variable species of *Phlox,* rather close to *P. divaricata,* with two subspecies in Wisconsin.

KEY TO SUBSPECIES

A. Plants glandular pubescent, at least in inflorescence; rare ------------------------------------- 5a. *P. pilosa* ssp. *pilosa*

AA. Plants with lustrous non-glandular pubescence; very common ----------------------------------- 5b. *P. pilosa* ssp. *fulgida.*

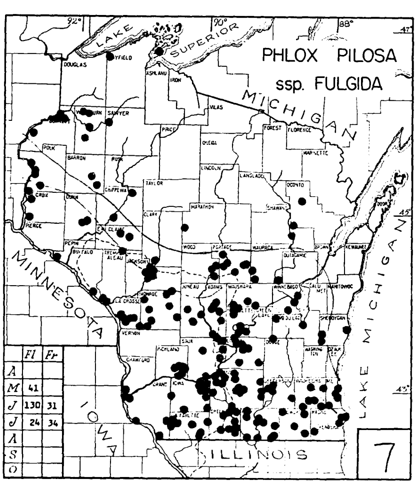
5a. *Phlox pilosa* L. ssp. *pilosa* Map 6.

Throughout the E. United States, occurring sympatrically with all subspecies except *P. p.* ssp. *riparia* in western Texas, the subspecies ecologically and morphologically defined, but often hybridizing in areas of sympatry, in general in dry forest, woodland borders, prairies, or areas of slight disturbance, in Wisconsin rare, reported from deciduous woods, wooded shady slopes, open sands with *Lupinus perennis*, limestone cliffs, or roadsides; differentiated from *P. pilosa* ssp. *fulgida* by glandular pubescence and more reflexed calyx lobes. 2n=14.

5b. *Phlox pilosa L.* ssp. *fulgida* Wherry — Map 7.

Strictly a prairie subspecies, widespread from Kansas to Manitoba and Indiana, not repopulating disturbed areas where prairie has been eliminated as does the preceding subspecies, in Wisconsin south of the Tension Zone (except in some sand areas), in a wide variety of prairie habitats from low damp to dry and calcareous "Goat Prairies", in open sandy oak-savannah with prairie flora, limestone bluffs, open oak woods, railroad right-of-way relic prairies, in recently burned jack pine stands; one of the showiest spring wild flowers, sometimes pollinated by day-flying clear-wing Sphingids. Flowering from mid-May to early (mid-) July, fruiting from late June to late July.

The fine, lustrous, non-glandular pubescence, which is the only feature differentiating this subspecies from ssp. *pilosa*, seems to be too insignificant on which to base a subspecies; furthermore, occasional non-glandular plants are found in other subspecies. However, because of eco-geographical differences associated with non-glandularity, recognition as a subspecies seems justified. The two Wisconsin subspecies of *P. pilosa* intergrade in a broad diagonal band across Illinois and some of this influence may be noted in southern Wisconsin. 2n=14.



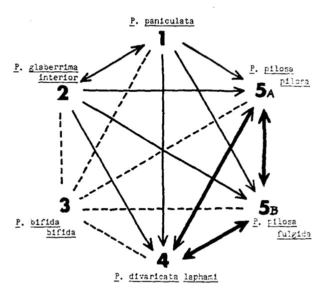


FIGURE 1

CROSSING RELATIONSHIPS OF WISCONSIN PHLOX.

ARROWS indicate direction in which cross was successful.
DOTTED LINE indicates absolute barrier to crossing.
SOLID THIN LINE indicates strong barrier to crossing.
HEAVY LINE indicates moderate barriers to crossing.

GILIA R. & P. is not included as part of the flora of Wisconsin, although one species, *G. multicaulis* Benth. (=*G. achilleaefolia* Benth.) was collected once in Two Rivers [Manitowoc Co.: no date. Coll. *E. Dapprich s.n.* (MIL), det. L. Constance 1963]. The species is native to the South Coast Range of California (Grant 1954) and has previously been reported as a garden escape in the eastern United States (Wherry 1936). *Ipomopsis rubra* of the southeastern United States was once collected [Adams Co.: Aug. 19, 1937. Coll. *J. W. Thomson s.n.* (WIS)], no doubt an adventive from a garden, for the species has a long record of escapes from cultivation in the midwestern states.

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PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN NO. 58
HYDROPHYLLACEAE—WATERLEAF FAMILY

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The distribution maps of species in Wisconsin were compiled from collections in the herbaria of the University of Wisconsin–Milwaukee (UWM), the University of Wisconsin (WIS), the University of Minnesota (MIN), and Milwaukee Public Museum (MIL), as well as some records in southwestern Wisconsin and adjoining states from the unpublished thesis of Hartley (1962). Numbers within the enclosures in the lower left-hand corner of each map represent the number of specimens that were flowering or fruiting in the respective months. Those which were flowering and fruiting simultaneously are included in both enclosures for that month. The habitats in Wisconsin are from data on the herbarium specimen labels.

Grateful acknowledgment is made to Professors Alvin L. Throne, Hugh H. Iltis, Gerald B. Ownbey, and Albert E. Fuller for the use of their herbarium facilities for this study; and to Professors Throne, Hugh H. Iltis and Peter J. Salamun for their assistance and advice in the preparation of this report. Assistance of Doris Bruch and Eunice Roe, the Research Committee of the University of Wisconsin on funds from the Wisconsin Alumni Research Foundation, and of the Federal Work Study Program are gratefully acknowledged.

HYDROPHYLLACEAE—WATERLEAF FAMILY

Annual, biennial, or perennial, more or less pubescent, succulent herbs. Leaves alternate, lobed or pinnate; flowers solitary or in scorpioid cymes, small to medium-sized, white to blue or purple, regular, perfect, hypogynous. Sepals 5, distinct or connate at base, persistent; corolla tubular to rotate, 5-lobed about to middle; stamens 5, inserted on corolla-tube, alternate, included or exserted; ovary entire, 1-locular, with 2 parietal, 1–4-ovuled placentae; style 1, cleft at summit. Capsules with 1–4 seeds.

KEY TO GENERA

A. Flowers in terminal cymes or axillary scorpioid cymes; leaves alternate.

B. Corolla lobes convolute in the bud; calyx sometimes with auriculate sinuses; blades of median stem leaves generally

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more than 8 cm long, deeply pinnate or palmate, basal leaves long-petioled; perennials or biennials ____1. *HYDROPHYLLUM.*

BB. Corolla lobes imbricated in the bud; calyx sinuses without auricles; blades of median stem leaves generally less than 8 cm long, pinnate–pinnatifid, basal leaves not distinctive; very rare adventive ____________________3. *PHACELIA.*

AA. Flowers solitary; leaves opposite below ________2. *ELLISIA.*

1. HYDROPHYLLUM L. WATERLEAF

Herbs with large, lobed or divided leaves and succulent stems; cymes terminal, one-sided, several- to many-flowered, repeatedly forked. Corolla campanulate; lobes erect or somewhat spreading; stamens slender, usually villous; ovary 1-locular, with 2 large dilated placentae; ovules few; style 1, slightly bifid. Capsule globose, pubescent. Small genus of 8 North American species.

KEY TO SPECIES

A. Perennial forming dense clones; principal cauline leaves deeply pinnately divided; calyx sinus naked; peduncle and pedicels subglabrous; fruiting inflorescences rather dense, to 8 cm across _______________________1. *H. VIRGINIANUM.*

AA. Biennial, with stems solitary; principal cauline leaves palmately divided to shallowly palmately lobed; calyx with reflexed appendages in sinuses; peduncles and pedicels pubescent, fruiting inflorescence very open, 10–20 cm across ________________________________2. *H. APPENDICULATUM.*

1. HYDROPHYLLUM VIRGINIANUM L. Virginia Waterleaf; John's Cabbage. Map 1.

Perennial from horizontal rhizome; stem 2–6 dm tall; stem, cymes, pedicels and sepals pubescent with appressed to ascending hairs up to 2 mm long; leaves pinnate almost to midvein, 5–7 lobed, broadly ovate or triangular, the terminal lobes and basal pair often with 2–3 additional lobes, acute or acuminate apices; cymes very dense. Sepals separate below the middle, narrowly linear, sparsely hirsute-ciliate; corolla white to purple, 7–10 mm long; stamens long-exserted. Seeds (1–)2. 2n=18 (Wilson 1960).

Widespread from the Appalachians and Ozarks to Canada, in Wisconsin common throughout except the northern tier of counties in mesic or damp, shady rich deciduous woods of maple-elm or beech, oak-basswood, or aspen-birch-red maple, in wooded pastures and bluffs, thickets, and on stream banks and river bottoms. Flowering from mid-May to early July; fruiting from late June to August.

2. HYDROPHYLLUM APPENDICULATUM Michx. Maple-leaved Waterleaf. Map 2.

Biennial from a thin taproot, with lateral fibrous roots; stem 2–6 dm tall, densely pubescent with both short, slender and spreading pilose hairs 2–3 mm long; upper cauline leaves shallowly palmately 5-lobed, truncate or cordate, the basal leaves pinnately 5–7 lobed (the lowest with additional 2 remote lobes); cymes loosely flowered. Sepals free nearly to base, lanceolate, densely hirsute, alternating with small reflexed appendages; corolla lavender to pink-purple, 9–14 mm long; stamens equalling or longer than corolla. Seeds 1. 2n=18 (Wilson 1960).

An Ozarkian element widespread in the central US, in southern Wisconsin in rich deciduous woods of beech–maple, on wooded oak hillsides, and in riverbottom forest. Flowering from late May to August, and fruiting from July through August.

2. ELLISIA L., ELLISIA

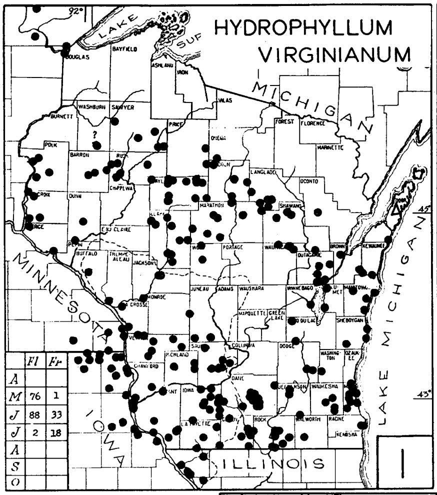
ELLISIA NYCTELEA L. Ellisia. Map 3.

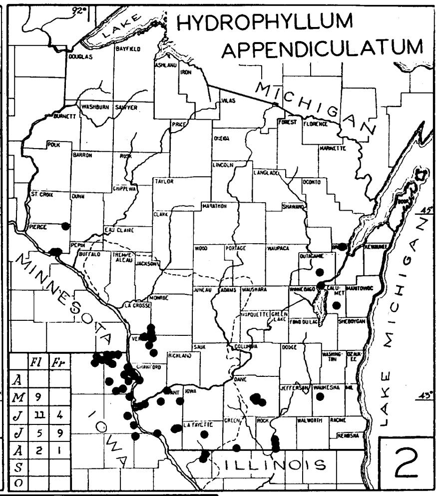
Slender somewhat succulent annual, 1.5–3 dm tall, usually branched from base; stems weak, glabrous or very sparsely hispidulous; leaf blade ovate-oblong, 4–6 cm long, pubescent, pinnately divided nearly to the mid-rib into 7–11 widely spreading, oblong lobes; flowers solitary; sepals triangular-lanceolate; corolla white, narrowly campanulate, 5–8 mm long, the lobes and the glabrous stamens shorter than the tube; ovary sub-globose, 1-locular but the 2 parietal placentae expanding and completely surrounding the 4 ovules. Capsule globose, much exceeeding the rotate accrescent calyx, about 1 cm in diam., 4-seeded; fruiting pedicels drooping, 2–3 cm long. 2n=20 (Wilson 1960).

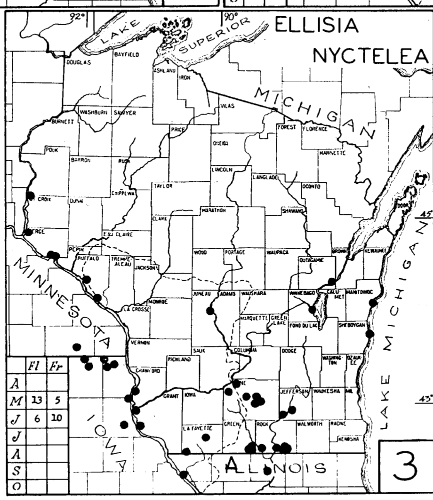
A monotypic genus of the prairies and plains from the Rocky Mountains to the Ozarks and Indiana, with an isolated population on the northern Atlantic slope, in Wisconsin somewhat weedy in moist locally disturbed habitats such as sandy areas along stream banks, eroding slopes to moist maple-basswood woods, chiefly in the main drainage areas of the Mississippi, Wisconsin, Sugar, Rock and Fox Rivers and the shore of Lake Michigan. Flowering from mid-May to early June; fruiting from late May through June.

3. PHACELIA Juss. Scorpion Weed, Phacelia

Annuals or biennials with alternate, lobed to pinnatifid leaves, flowers in dense strongly scorpoid cymes, of perhaps 100 species, none native of Wisconsin.







PHACELIA DISTANS Benth. (det. L. Constance 1963), a slender hispid annual with small pinnate-pinnatifid leaves, dense, pronouncedly scorpoid, paired cymes, 1 cm long flowers with exerted stamens, and an endemic of California, Nevada, and Arizona, has been collected once "along shore of Lake Superior near Herbster" [Bayfield Co.: July 15, 1951. H. A. Davis 9571 (MIL)], no doubt an accidental introduction.

PHACELIA FRANKLINII Gray, a 1–6 dm tall, usually unbranched sparsely pubescent biennial or annual with once pinnate or pinnatifid leaves, several scorpoid racemes, small blue to white flowers with hairy filaments, is a northwestern North American species from Alaska to Wyoming. Occurs commonly from Duluth eastward on the north shore of Lake Superior (cf. Lakela 1965, Gillett 1960, Fig. 4) and can be expected in Wisconsin on gravelly lake shores.

PHACELLA PURSHII Buckl., listed by both Fernald (1950) and Gleason (1952) for Wisconsin, ranges only as far north as central Illinois (Constance 1949).

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