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WALTER F. PETERSON

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NORMAN OLSON

50th President of the

WISCONSIN ACADEMY OF SCIENCE, ARTS AND LETTERS

THE AESTHETIC EDGE

Norman Olson, President 1970–71
May, 1971

Over the past several years I have developed a concern that the critical faculties of a great number of people have become impaired in the ability to understand and evaluate The Arts as they exist in our present culture. It is my sometimes worry that the Post-World War II period has seen the destruction in many, both artist and layman, of what may be termed the aesthetic edge—the artistic sensitivity that exists within a person. For, just as this aesthetic edge can be sharpened and fine-honed with proper study, self-discipline and training, it can be dulled and destroyed by constant exposure to the corroding effects of the vulgar, the false, and the inept in The Arts.

A problem for every man lies in recognizing those qualities of a piece of music, or a painting, or a play, or a poem, that make it a work of art or make it a fraud. For now, I will be content to define the problem and break it down into what to me are three of its major aspects. It will be your task to weigh my arguments with the indulgence that you would wish for if you were in my shoes. I will, for simplicity's sake, concentrate mainly on the art of painting.

It is a frustrating experience for many of us these days to visit an art gallery and discover that it is filled from ceiling to floor—and probably from wall to wall—with what is collectively called modern art. It is not unusual to travel the length of the gallery and find nothing whatever in it that produces a pleasurable response in us. We may sometimes recognize the object that the artist had in mind to create in paint or sculpture, but why he bothered to make it, or dared to show it, remains a mystery.

But do we dare reveal our inability to appreciate and respond to many creations of contemporary artists? Those who are skilled and schooled in such matters, or pretend to be, may scoff at us. They are proficient—we are deficient. They feel clever—we feel stupid. But why are we unable to appreciate so much of today's artistic production? I must warn you that I intend to explore the matter with the obvious bias of one who has lived in reverent appreciation of the rational in all of the arts. By "rational" I really mean the incorporation of the quality into the work of art that early Renaissance humanists called "right reason."

There is a vast field of scientific study aimed at analyzing human response in terms of psychological cause and effect. I do not reject the data pouring forth from this source, but merely acknowledge it in moving on to a more primitive body of data; i.e., the aesthetic theories, and critical observations, of some of the philosophers and artists whose reputations and writings have survived the test of time. For as André Malraux has pointed out in his brilliant book, *The Metamorphosis of the Gods,* just as the artist tries to immunize his creative work against time, "A work . . . becomes a work of art in virtue of being outside time."[1] And of course if this test of time applies to painting, it also pertains to endeavors of art in literature and other fields as well.

Plato in his Timaeus dialogue explains that, "God devised the gift of sight for us so that we might observe the movements which have been described by reason in the heavens and apply them to the motions of our own mind which are akin to them, so far as what is troubled can claim kinship with what is serene."[2] A bit farther along he observes that rhythm was given to us, "to help us in dealing with what is unmeasured and chaotic in the minds of most of us."[3]

Writer upon writer points out the common chords of rhythm, order and balance in all branches of the arts. Poetry, music, and the dance clearly depend upon these. So do sculpture and painting and when they are missing from a work by choice, chance, or the ineptness of the artist, the lack is conveyed inside us by our own powers of perception. Chaos in anything is disturbing, even frightening, and we tend to reject it when we see it on the canvas or in the plastic arts merely because it is contrary to our natural instincts.

How do we know that so much of modern art is without rhythm, order and balance? Is it there but we cannot comprehend through ignorance? Does the fault, dear Brutus, lie within ourselves? And one last question: what is abstract expressionism? The last question is necessary because that is the school or style arising from what Katherine Kuh describes as the break-up of traditional art forms.

Miss Kuh, in commenting upon the painting of Jackson Pollock says, "Very different in motivation from surrealism, abstract expressionism was not concerned with symbols of the unconscious, but with the artist's spontaneous feelings at the moment of painting. Abstract expressionism and especially Jackson Pollock were the final denial of all that Renaissance and Classical Art stood for."[4]

[1] André Malraux, *The Metamorphosis of the Gods,* p. 32.
[2] Plato, *Timaeus,* in E. F. Carritt, *Philosophies of Beauty,* p. 28.
[3] *Ibid,* p. 28.
[4] Katherine Kuh, *Break-Up: The core of modern art,* p. 105.

She added that Pollock ". . . created a new kind of fury to echo the fury within himself."[5] One can't help but wonder at the durability of such a great passion, and ponder whether the evidence of it via paintbrush on canvas is of interest as art or merely as a psychic efflux. In her comment on a painting by William DeKooning entitled "Excavation" Miss Kuh observes that the picture ". . . with its all-over pattern and warm loam-like color, has to do with the sensations of digging into the earth, and possibly into oneself."[6] After reading that, I had the impression that the author had reached very far into the realm of speculation.

The artist Frank Kline confesses, "I don't paint a given object—a figure or a table; I paint an organization that becomes a painting."[7] Miss Kuh in talking about a painting of Pierre Soulages that has no name, but only a date, explains, "For both artist and viewer, meaning relies on the gratification of rich pigment deftly manipulated. In other words, the paint itself becomes at once the *raison d'etre* and the image."[8] We have just been informed that for this painting at least, the medium is the message!

So, now we have one reason for our dilemma as viewers in not understanding a great many of the paintings that are included in exhibits today. The problem is that in abstract expressionism the artist often has nothing to convey to us. If we do think we have found a meaning, quite probably it is one evoked entirely within ourselves. Perhaps the artists, relying entirely upon the subjective creativity of the viewers for effect, are taking Oscar Wilde seriously in his statement that, "It is the spectator, and not life, that art really mirrors."[9]

Another kind of painting that confronts us these days is that which admittedly does contain the representation of a recognizable object. It may be the enlarged picture of a tin can, complete with label, or a character from a comic strip. The artist has used meticulous care—the rendition is perfect, and the reaction is that here is the work of someone who should get "A" in mechanical drawing, but who is woefully lacking in imagination.

The subject is prosaic; the message is that printed on the can's label or found innocently scrawled within the picture's confines. As Aristotle points out in the *poetics*, "The ludicrous is only one species of the ugly."[10]

Another painting hanging close by may be concerned with human anatomy. The chances are excellent that an entire figure will not

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[5] *Ibid.*
[6] *Ibid.* p. 103.
[7] *Ibid.* p. 101.
[8] *Ibid.* p. 102.
[9] Hesketh Pearson, *Oscar Wilde, His Life and Wit*, p. 132.
[10] Aristotle, *"Poetics,"* in Carritt, p. 32.

be there, however, but just a selected portion rendered with photographic precision. As counterpoint to pictures of this kind we find enormous plastic sculptured pieces placed strategically about the gallery. These are, seemingly, reconstructions of the entrails of fabulous monsters, or giant earthworms, or both. Yes, the organic element is definitely included in contemporary art.

Still another type of painting is that which depicts a subject that is sordid, mean or ugly. Satire with its sharp teeth has its place in art as witness the drawings of Hogarth, Grosz or Daumier. But when there is no purpose revealed in the picture except to move the viewer to feel disgust and perhaps admit that ugliness exists, what credit can we give to the piece as art?

The second aspect of the problem then, appears also to focus upon the artist. It is that the artist must utilize his genius within the framework of what is aesthetically acceptable and understandable to the sensitive viewer, and it is not a sufficient excuse on the part of artists or gallery directors to say that it is the viewers' limitations that make a painting misunderstood—or not understood at all. Tolstoy has commented upon this by observing, "To say that a work of art is good, but incomprehensible to the majority of men, is the same as saying of some kind of food that it is very good but that most people can't eat it."[11]

The third and last aspect of the problem, I feel, is that which concerns the taste—or aesthetic edge—of the gallery visitor. To consider this we must swing the mirror around until we see ourselves squarely in it. We have contended that there is good art and bad art; and that there are paintings and sculpture with a great message and some with a poor message; and very many with no message at all. But when we reach a conclusion as to the merits of a particular painting, that conclusion is the end result of our entire lifetime of conditioning. Thomas Hobbes who is emphatic in his philosophical observations and conclusions says in *Leviathan,* "Whatsoever is the object of any man's appetite or desire; that is it, which he for his part calleth *good:* and the object of his hate, and aversion evill, and of his contempt, *vile and inconsiderable.*"[12]

If Hobbes is right, and we see the evidence of this particular truth all around us, then we must realize that we can destroy our natural abilities to appreciate what is good and reject what is bad. The woodland Indian of Wisconsin Territory days, who could track game with uncanny skill because of his highly developed and unshattered sensitivity toward what he saw, heard, smelled, touched or tasted, is in great contrast to the Modern American who overeats three times a day and falls asleep at the symphony. We can-

[11] Lyov Nikolayevitch Tolstoy, "What is Art?" in Carritt, p. 192.
[12] Thomas Hobbes, *Leviathan,* quoted in E. F. Carritt, *Philosophies of Beauty,* p. 56.

not as a steady diet read books in the *Last Exit to Brooklyn* genre and then appreciate the delicate characterization in James' *The Wings of the Dove*. We cannot drown ourselves daily in rock music, and hope to experience the thrill that lurks for the responsive listener in a Brahms concerto. We cannot live and work surrounded by psychedelic posters without becoming color-numb.

Milton believed that for a man to become a great poet, he must rigidly follow rules of self-discipline and education. He must become in effect a priest in the purity of the conditioning he applies to his natural talents. That kind of life is, of course, beyond the reach or resolve of most of us. But we can resolve to avoid constant exposure to those things that would certainly dull our aesthetic edge.

What we do as individuals will not change the world of art. Painters and sculptors will continue to pour forth a never-ending line of questionable artifacts. And where these probable frauds would normally perish under the dead weight of their inherent lack of artistic merit, the directors of many art centers and some affluent collectors march forth in the role of *deus ex machina,* purchase the doomed pieces, and preserve them forever in our museums and galleries.

We must fight the good fight to defend and support the artists who produce honest art. To do this we have an obligation to know what is good in art and have faith in our knowledge. We may lose the battle to the frauds and their sponsors, but as Ajax said, "Oh Zeus . . . if so be that we must die, let us die in the light!"[13]

Lists of Works Consulted

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[13] Longinus, "On the Sublime," Carritt, p. 38.

THE NATURAL SCIENCE OF AN AMERICAN PIONEER: A CASE STUDY

Donald Zochert

How much did the common man of the frontier know about natural science? What grasp did he have of theoretical concepts? What evidence did he leave of scientific or philosophic speculation? The answers to these questions appear locked in an inarticulate past. Indeed, when students of science have turned their attention to the frontier it has generally been to trace the passage of great naturalists, or to demonstrate the growth of scientific interests in isolated academic contexts, or to detail the accomplishments of government-sponsored surveys. The nature and extent of popular scientific knowledge on the frontier have been all but ignored.

It may be argued that the common man rarely left a record of his mind at work, and that his intellectual stores must therefore remain inaccessible and uncounted. This, however, is to overlook the production on the frontier of a substantial literature—journals, letters, diaries—which has gone largely unexamined from the perspective of science. It is the purpose of this paper to examine from that perspective the journals of James Clyman (1792–1881), an early pioneer of Milwaukee and a man who spent his life on the successive edge of settlement.[1]

James Clyman is representative of the common man on the frontier in several respects. He had little or no formal education. He followed no specific trade, being by turn a farmer, a surveyor's assistant, a trapper, a storekeeper, a soldier, a miller, and ultimately the owner of a modest California ranch. His life, in common with others on the frontier, was restless and westering.[2] If he be considered atypical for having produced a journal, the thoughts and information he recorded give no evidence of having

[1] Clyman's journals have been published in Charles L. Camp, ed., *James Clyman, Frontiersman: The Adventures of a Trapper and Covered-Wagon Emigrant as Told in His Own Reminiscences and Diaries,* "definitive" edition (Portland, Ore., 1960). The present writer is preparing a biography of Clyman.

[2] Born in Virginia, east of the Blue Ridge, Clyman moved to Ohio at the age of sixteen. He left home for southern Indiana in 1818, spent the winter, and moved on to Illinois. From 1823 to 1827 he was engaged in the Rocky Mountain fur trade, ranging the Plains and Central Rockies north of Colorado. He settled at Danville, Ill., upon his return from the mountains, but in 1832, under the impetus of the Black Hawk War, resumed a wandering—and this time military—life, serving in the Illinois Volunteers, U.S. Mounted Rangers, and First U.S. Dragoons. Three years later he settled at Milwaukee.

been inspired by anything but the common experience of the frontier.

Clyman emigrated to Milwaukee in 1835 and made that frontier village his home until 1844. In the latter year, for what he said were reasons of health, he joined an emigrant train to Oregon. From Oregon, Clyman went to California in 1845 and the following year returned to Milwaukee; in 1848 he left Wisconsin to make his home in California.

During the early months of 1840 in Milwaukee, and through his entire western tour from 1844 to 1846, Clyman maintained a series of journals which indicate again that the conditions of the frontier, and more specifically of agrarian or even village life, imposed an intimacy with the natural world that is almost wholly dissipated today. Here, in the wildlife, the weather and the topography of the frontier must be the starting point for any survey of popular scientific knowledge. Clyman's journals contain a great number of elementary descriptions which derive from the directness of this experience.

His identification of trees and birds, for instance, suggests the energy with which the frontier environment acted upon the mind of the pioneer. Among trees he refers to the alder, aspen, birch, boxwood, cedar, cherry, cottonwood, dogwood, elder, elm, red fir, white fir, white balsam fir, hackberry, hazel, hemlock, hickory, manzanita, maple, sugar maple, black oak. white oak, red pine, spruce pine, white pine, yellow pine, redwood, sycamore, spruce, walnut, willow and yew. He identifies the following birds: the raven, mountain grouse, duck, pheasant, swan, teal, plover, heron, brant, shagg, mocking bird, goose, crane, blackbird, woodcock, fir grouse, quail, meadowlark, redbreasted woodpecker, sparrow, condor, buzzard, crow, hawk, pigeon, vulture, royal vulture, bald eagle, turkey buzzard and snipe. In addition, his journals contain references to fifty-one different kinds of plants and flowers, thirty-two species of mammals, twenty-one varieties of fruit, seven reptiles and insects, and four species of fish.[3]

None of these botanical or zoological references demonstrates a technical, systematic or theoretical understanding of the objects Clyman described; he does not suggest relationships between different plants or animals—other than to indicate the similarity between eastern and western species—nor does he draw analogies between plants and animals, as was common among popularizers of science. Despite the great naming and counting compulsion of the times, and perhaps because of the confusion generated by contending taxonomic systems, Clyman, like other laymen on the frontier practiced only the most rudimentary sort of classification,

[3] Camp, *passim.* Specific references are available from the present writer.

categorizing in such indistinct terms as "animal kingdom" or "plant kingdom" or "feathery tribe." This naming of the natural world forms the most elementary level of Clyman's knowledge of science.

Clyman's description of topographical features and meteorological phenomena, with one exception, likewise carries no indication of technical or theoretical competency. The exception is an observation made in September 1844, when Clyman, on his way to Oregon, noted that the emigrant trail had for several days been obscured by smoke from Indian fires. "The day verry Smoky," he wrote on September 26, "& I Begin to daubt Mr. Espys theory of produceeing rain by any phisical means as the whole country has been on fire for a month past & no rain yet."[4] The allusion is to a theory of James Pollard Espy, proposed in 1838 and given wide circulation in popular and scientific periodicals through 1843, that a rainfall of great duration would occur "if masses of timber . . . should be prepared and fired simultaneously every seven days in the summer, on the west of the United States, in a line of six or seven hundred miles long . . ."[5]

With his geological references, however, Clyman indicates a deeper and more sustained interest in the theoretical aspects of science. Many of his references, to be sure, remain simply descriptive. He notes the presence, for instance, of slate, sandstone, limestone, shell rock, granite, flint, pebble rock, basalt, chalk, obsidian, marble, slag and scoria, and attributes to them such qualities as "saturated," "vitreous," "decomposed," "indurated" and "porous." He identifies deposits of salt, lime, saleratus, coal, soda, potash, sulphur, lead, lye, mercury, gold, silver, iron and quartz.[6] But in several other observations he demonstrates a grasp of geological concepts and a recognition of classification.

In his 1840 diary at Milwaukee, Clyman summarizes the rock formations he had encountered in northeastern Wyoming seventeen years earlier: "I do not recolect that I saw any *primitive* rock in this place except some granite Boulders all the rock that I saw being *secondary* Lime rock although all the petrifactions and even pebble stone are verry hard and flinty and in fact all the rock formation in this region is Trasition [*transition*] and *secondary* . . ."[7] Clyman here followed an anglicized version of the system of classifying rock formations developed by the great Austrian mineralogist Abraham Gottlob Werner. Werner placed

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4 Camp, 107.

5 See James Pollard Espy, *The Philosophy of Storms* (Boston, 1841), 492–500. The passage quoted, however, is from W. E. Knowles Middleton, *A History of the Theories of Rain and Other Forms of Precipitation* (New York, 1966), 160.

6 Camp, *passim*. See Note 3.

7 *Ibid.*, 51–52. My italics.

rock formations in three classes—primitive, transition and floetz; his American followers substituted the more easily understood term "secondary" for the germanic "floetz."[8]

Clyman's periodic reference to the stratification of rocks also suggests a recognition of rock classification. The inclination of rock strata is a characteristic once thought to distinguish primitive from secondary rock formations.[9] Clyman's references include the terms strata, substrata, "regular stratification," "rocks without strata," as well as observations of the inclination of strata, e.g. "perpendicular strata."

Additional evidence of geological conceptualization can be found in Clyman's frequent allusions to the volcanic process; these include the terms volcanic eruption, volcanic mud, vitrification, convulsion, crater, globule and fusion. His description of a western valley as being bounded "by a range of Bald mountains shewing in a peculiar manner their volcanic origin by their standing in the form of wavse of the ocean" suggests a recognition of the molten nature of lava. On the same subject, Clyman attributes the turbidity of the Missouri River to airborne volcanic ash.[10]

The origin of erratic boulders or "lost rocks" posed a different sort of problem for scientist and layman alike. Benjamin Silliman, who had established a wide influence as professor at Yale College and editor of the *American Journal of Science,* pronounced it in 1821 "among the most interesting of geological occurances," and it continued to exercise a fascination for the next fifty years.[11] Considering the extent of his travels in the old Northwest Territory, Clyman could hardly avoid comment on the glacial drift.

> Every person that has ever passed through the western country [he wrote in his 1840 diary at Milwaukee] must have observed the Quanty of granite Boulders that lay scattered all over the vast extent of country . . . and which seem to grow larger and more plenty in allmost Regular progression as you traverse the Region northward . . . as none of this rock is found in regular strata it has been a matter of much speculation to know how they came situate whare they are as likewise whare they

[8] Werner's "primitive" rock formations were of chemical origin, "transition" were partly mechanical and partly chemical in origin, and "floetz" were formed chiefly by mechanical deposition. For the influence of Werner upon such American scientists as Benjamin Silliman, Amos Eaton and Thomas Cooper, see William Martin Smallwood and Mabel Sarah Coon Smallwood, *Natural History and the American Mind* (New York, 1941), 243–244, 267–268, 296.

[9] John Playfair, *Illustrations of the Huttonian Theory of the Earth* (1802; facsimile reprint, Urbana, Ill., 1956), 12. This view was being challenged in the late 1820s, however; see Charles Schuchert, "The Progress of Historical Geology in North America," in Edward Salisbury Dana, *et al., A Century of Science in America with Special Reference to the American Journal of Science, 1818–1918* (New Haven, 1918), 78.

[10] Camp, 221, 49.

[11] See Herbert E. Gregory, "Steps of Progress in the Interpretation of Land Forms," in Dana, *A Century of Science,* 131–139. Silliman's observation is quoted on p. 132. J. D. Dana, writing in 1871, concluded (p. 138) it "is still a mooted question in American geology whether the events of the Glacial era were due to *glaciers* or *icebergs.*"

> came from and as all Speculation on this head must be mere conjecture my oppinion is that [in a] remote period the whole of the Missisippi valy was covered with water at which time those rocks were brought from the base of the Rocky mountains in the ice and carried southward wore let loos as they progressed by the thaws and sunk whare they are now found[12]

Clyman's explanation of erratic boulders clearly involved both ice and water as agents of transportation, a popular and persistent stand which comfortably reconciled the Mosaic account of the Deluge with the new science of glaciology. More importantly, however, Clyman's discussion demonstrates a speculative, as well as observational, approach to science.

Popular science obviously could not be restricted to quantitatively describing the natural environment. The same impulse which led to the description of natural objects led as well to speculation concerning their origin and meaning. While scholastics calculated such imponderables as the depth of Hell,[13] more modest men were brought face to face with concepts and abstractions almost too great to bear. James Clyman, in a reflective mood at Milwaukee, grappled with no less an abstraction than the nature of infinity and the dimensions of the universe.

He begins by asserting that time and space are infinite, but this leads him rather quickly to a quandary:

> Two things Infinite Time and space Two things more appear to be attached to the above infinity (wiz) Matter and number matter appears to prevade the infinity of space and number attempts to define the Quantity of matter as well as to give bounds to Space—which continually Expands before matter and number—and all human speculation is here bounded in matter and number leaveing space at least allmost completely untouched. . .[14]

Infinity, Clyman is saying, defies measurement; therefore how can we define it? We are restrained from a definition of infinity by our dependence upon number. There is, however, another way to approach the problem. If one could find an instantaneous phenomenon—that is, one beyond measurement—then the universe might be inferred to be infinite. But if there are no phenomena except which can be measured, then the universe is ultimately finite—even if beyond our capacity to measure it.

> The velocity of light seems to be the greatest of all Known principals unless Electricity should be greater Some have thought that Electricity

[12] Camp, 49–50.

[13] 1,832,308,363 miles, as computed by Josiah Meigs. Dirk J. Struik, *Yankee Science in the Making,* new revised edition (New York, 1962), 463.

[14] James Clyman, MS. memorandum and diary, Everett D. Graff Collection, Newberry Library, Chicago. My transcription differs slightly from Camp's in spelling and punctuation, although notes will be to Camp. Camp, 49.

is insantaneous throughout all universal space I can hardly think this to be the fact but if it should it puts to rest the difficult Question of infinity of space For if any Known and palpable principle is instantaneous through eternal space then Eternal space may be infinite as to bounds and duration and mater may likewise be infinite as to Quanty and duration But on the contrary if no Known palpable or impalpable principle or matter can be found but what is limited by size or time then infinity means nothing more than such an imense mass of space matter or time as becomes immeasureable and incomprehensable to all means of comparison for instance

We may comprehend the globe we inhabit pretty fully and even the sollar System but a million of such systems becomes incomprehensible allthough even a million such Systems may fall verry short of the Quantity of matter in existence throughout the universal Kingdom

But notwithstanding the immense Quantity still Finity becomes a part of infinity and the globee being Finnite or mesureable so by comparison of one mesurable part or particle of infinite matter occupying a speck of space may we geathur some crude Idea of infinity itself allthough this Idea may ammount to nothing more than to say all things have thier Bounds and limits space has its bounds and time has its limmits mater occupies all space and time wears out all things[15]

What has Clyman accomplished thus far? He has begun by asserting time and space to be infinite, but has quickly found it difficult to define infinity. Then he has subtly changed the grounds of the problem, from a consideration of the nature of infinity to a consideration of whether the universe—space—is indeed infinite. To this question he provides two possible answers. One, the universe may be considered infinite if there exists an instantaneous phenomenon—the speed of light, for instance, or of electricity. Clearly he does not consider either of these to be instantaneous or beyond measurement. This leads him to the second possibility: that the universe can be finite even though "incomprehensible." Our perceptions, crude and limited, cannot finally settle the question, although by comprehending a part of the universe we might get a "crude Idea" of the whole. But to suggest, as Clyman does, that this crude idea would be "of infinity itself," and might mean no more than that all things have limits, appears to collapse the argument in a contradiction of terms. He must go back and once again try to find a definition of infinity:

Some seem to think that infinity means something than can never Even have a beginning nor an end and that if it were posible to move with the velocity of Light for millions and millions of years and even time without limit that you then have not more than set out But admit all this and say that after you have flown with the velocity of light for as many yares as there is particle of sand included in the whole Solar System even at that immense time and immense swiftness if you have advanced a Quarter of an inch comparatively you at once give imaginary Bounds

[15] *Ibid.*, 53–54.

> to space although it may not be posible to measure or comprehend but a verry small Quantity of Space or matter[16]

The definition of infinity as something without beginning or end carries no endorsement from Clyman; he uses it, in fact, as a device with which to reconsider the dimensions of the universe. I would suggest that Clyman was content with the position that infinity appears to be beyond definition, as he indicated at the beginning of the passage. As for the extent of the universe, he appears to rest on the assumption that the definition of a part in effect sets limits on the whole, even if the limits of the whole are beyond perception.

I have quoted these reflections on infinity and the universe at such length chiefly to illustrate the strength and quality of Clyman's thought. Crude, untrained, repetitious, without discipline—it nevertheless testifies to a forcing of the intellect, and to thoughts being carried forward and at least momentarily sustained, not on the basis of formal knowledge but purely on the speculative impulse.

James Clyman's interest in natural science found expression at three different levels—one of simple observation, another of classification, and a third of speculation or theory. In the fields of botany, zoology, geography, and to some extent meteorology and geology, he clearly operated at the most elementary, observational level, without attempt at classification or explanation. His concern with geological phenomena, however, frequently did extend to the level of classification; his reference to the classification of rock formations, and the terminology of stratification (implying classification) provide evidence of this. At the level of speculation and theory may be placed his refutation of Espy's theory of the artificial production of rainfall; his explanation of the turbidity of the Missouri River; the conceptualization which lay behind the terminology of vulcanism; and his reflections on the nature of infinity and the dimensions of the universe.

If there is a common element to these levels of scientific interest and capability, it is a willingness to confront and define the natural world. Even though the physical world may ultimately surpass man's ability to perceive or comprehend it, Clyman was intent upon preserving the possibility of limits—quite clearly a rational sentiment, and the expression of a *desire* to perceive and comprehend.

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[16] *Ibid.* From here, Clyman goes on to a brief exegesis of Genesis 1:1 in an effort to determine what limits are placed upon time and matter by the creation account. This passage is noteworthy in two respects: it represents Clyman's only appeal to authority—in this case biblical—and by referring to "the first revolution of the first globe of matter," he indicates an exposure to the nebular theory of the origin of the solar system.

The extent to which other men on the frontier shared this desire is beyond the province of a case study. It may be useful, however, to suggest some coeval expressions of scientific interest as clues to the commonality of Clyman's interest and competency.

Our knowledge of how frequently, and with what success, the common man engaged in metaphysical speculation is sharply limited by the infrequency with which such thought was transcribed; it is much easier, for instance, to make a journal of botanical and zoological notations than it is to wrestle with the devil of infinity—with pen in hand. We are fortunate, then, to have the reflections of Osborne Russell, a fur trapper who worked the Rocky Mountains a decade after James Clyman. Russell writes of being "almost lost in contemplation" while standing on a mountain peak: "In viewing scenes like this the imagination of one unskilled in Science wanders to the days of the Patriarchs and after numerous conjecturings returns without any final decision wonder is put to the test but having no proof for its argument a doubt still remains but supposition steps forward and taking the place of Knowledge in a few words solves the mysteries of ages Centuries and Eras . . ."[17] Here is the same pell-mell rush of thought, the same undisciplined cession to speculation that one finds in Clyman.

Clyman's description of topographical features was matched in similar language by many other frontier journalists, as was his interest in geological phenomena.[18]

What truly determined an inclination toward popular science seems to be related less to education and station in life than to a specific frontier experience. In Clyman's case, service in the state land surveys probably sharpened his awareness of many scientific objects,[19] and the presence in Milwaukee of Increase A. Lapham and other men of serious scientific interest must have provided

[17] Osborne Russell, *Journal of a Trapper,* Aubrey L. Haines, ed. (Lincoln, Neb., 1967), 63.

[18] Compare Clyman's topographical terms with those employed in the journals of Nicholas Carriger and James Mathers, in Dale Morgan, ed., *Overland in 1846: Diaries and Letters of the California–Oregon Trail* (Georgetown, Calif., 1963), 1:150–158, 225–236, and in the journal of the Mormon immigrant Appleton Milo Harmon, in Maybelle Harmon Anderson, ed., *Appleton Milo Harmon Goes West* (Berkeley, Calif., 1946). Harmon, who had no more education than Clyman, is much weaker in geology. However, Thomas J. Farnham, whose training was in law, reported during his western journey on alluvium, basalt, scoria, stratification and "regular" stratification, and "primary formations"; see his *Travels in the Great Western Prairies, the Anahuac and Rocky Mountains* (1843) reprinted in Reuben Gold Thwaites, ed., *Early Western Travels 1748–1846* (Cleveland, 1906), vols. 28–29.

[19] The formal instructions given to surveyors at this time required them to take notice of "all rivers, creeks, springs . . . the kinds of timber and undergrowth . . . all swamps, ponds, stone quarries, coal beds, peat or turf grounds, uncommon natural or artificial productions, such as mounds, precipices, caves . . . all rapids, cascades or falls of water . . . minerals, ores, fossils . . . the quality of the soil . . . the true situation of all mines, salt springs and mill seats . . ." Lowell O. Stewart, *Public Land Surveys: History, Instructions, Methods* (Ames, Iowa, 1935), 146.

some stimulus toward scientific thinking on the part of many laymen.[20] But as was suggested earlier, the natural science of James Clyman gives no evidence of having been generated by anything but the common experience and inspiration of the frontier.

This is not to say that events beyond the frontier did not on occasion stimulate thoughts about science. Clyman's comment on Espy, and those portions of his science in which he demonstrates an exposure to concepts of classification suggest the importance, for instance, of popular scientific literature.

The interest in popular science was fed more strongly by the very closeness of the natural world, and the familiarity it bred. As the "aesthetic contemplation of a perfected universe," it gained impetus from the desire to escape from provinciality, or from the crudeness of frontier life. Natural science itself—especially on a popular level—was still an accessible enterprise, as open to the dilettante as to the devotee.

As James Clyman demonstrated, one did not need formal training to pursue the pleasures of science. All that was needed—and they were there in abundance—was a rich and vital environment, and an aggressive, Whiggish spirit that sought to improve not only property but the mind.

NOTE

The author wishes to acknowledge the kindness of George H. Daniels, Department of History, Northwestern University, in criticizing an earlier draft of this article.

[20] Lapham witnesses Clyman's signature to a letter of attorney dated July 20, 1836. Camp, 301. There is no additional evidence of a relationship between them however.

THE EVOLUTION OF FACULTY GOVERNMENT OF THE UNIVERSITY OF WISCONSIN—MILWAUKEE*

Ted J. McLaughlin

Outsiders frequently are surprised to discover that life within an academic community is no more tranquil or stable than it is among citizens who live and work off campus. In a time of social unrest and revolt, internal campus confusion leads to public concern over the operation of state supported universities. No more pressing priority faces the state university than does the achievement of understanding of its structure and conduct. This paper is a response to the critical need for clarification of the historical development, contemporary status, and probable future of faculty government of The University of Wisconsin—Milwaukee (UWM).

Scope and Rationale of the Study

The Concept of University Academic Organization. Like all human enterprises, an institution of higher learning must operate under some rational system characterized by identifiable roles, predictable continuity, and group goals. Unlike a military unit with the "command" implications of concentrated authority or a business enterprise with the "management team" functions of authority, responsibility, and accountability, a university is organized as a polity. By traditional practice and by legal sanction, a state university operates under a faculty government, with varying degrees of democracy.

The jurisdiction and powers of a university faculty are seldom definitive, attempts at legal specificities notwithstanding. Does the faculty "control" or merely "participate in" decisions concerning the academic program? Such extreme disclaimers and claims are useless rhetorical exercises. Ultimately, ". . . an effective system of campus governance should be built on the concept of 'shared authority' between the faculty and the administration."[1] A democratic government depends on mutual checks and balances—especially a balance of authority ("effective influence")[2] among its major branches. At least in the ideal university academic or-

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* This paper was presented in condensed form at the Centennial Meeting of the Wisconsin Academy, October 3, 1970.

[1] American Association for Higher Education, *Faculty Participation in Academic Governance* (Washington, D. C., 1967), p. 1.

[2] *Faculty Participation,* p. 14.

ganization, the faculty *legislates* academic policy proposals, while the administration exercises the *executive* functions of review, approval, and implementation. Curiously, the *judicial* function of democratic governance appears to operate as a *de facto* rather than a *de jure* phenomenon in contemporary university practice.

Method, Data, and Limitations of the Study. This study reports the results of a descriptive evaluation of UWM faculty government as an effective instrument in the operation of the institution. The period covered begins with the initial academic year of 1956–57 and extends to the conclusion of the 1969–70 academic year. The writer has compared the theoretical assumptions underlying faculty government with the actual decision-making processes of the faculty. In arriving at the conclusions and predictions stated at the end of this report, the author has used two major categories of information. Archival records of faculty meeting agendas, minutes, documents, and reports provide the primary source basis for developmental assessment, in addition to statutory laws and other codified regulations. Critical observations of faculty meetings and practices constitute the other body of source material. Except as faculty-administrative relationships impinge directly on the subject of faculty governance, no attempt is made to study administration, *per se.* And although discrete faculties of the several colleges, schools, and departments are responsible for academic policy within their restricted jurisdictions, the operation of these subsidiary UWM units is outside the limits of this general study.

Historical and Legal Basis of UWM Faculty Government

In a landmark action, the 1955 special session of the Wisconsin Legislature created a Coordinating Committee (later Council) for Higher Education, directed the CCHE to merge the competing state college and university extension center in Milwaukee into a single institution of higher learning as an integral part of the University of Wisconsin under the governance of its Board of Regents, and placed administrative authority for the new institution in a Provost (later Chancellor) reporting directly to the President. For purposes of this study, however, the most significant legislative provision was that ". . . this unit of the university . . ." (shall have) ". . . the same degree of self-government by its own faculty as is vested in other units of the university."[3]

The political solution in Madison to the Milwaukee problem of educational consolidation was a pragmatic decision, as are most political acts. The Executive Committee of the "Committee of Thirty" (composed of representatives of the three institutions

[3] *Wisconsin Statutes,* 39.024 (3) (h).

involved in the merger) commented in its final report of implementation recommendations to the Board of Regents that the Legislature's language had been ". . . probably fortunately far from precise."[4] The Committee noted its difficult preoccupation in arriving at decisions regarding organization of UWM to emphasize autonomy while insuring the integrity of the total University of Wisconsin. Developments in succeeding years were to demonstrate continuing shifts in this delicate balance of academic government which the basic legislation and initial implementation had attempted. Changing powers, structure, and external relationships of the Milwaukee campus faculty seem to have been inevitable.

Because there was no other unit of the University which was comparable to the Milwaukee institution and because of the psychological and physical separation of the Milwaukee faculty from the rest of the University faculty in Madison, the implementation document suggested that the UWM faculty would have ". . . a smaller degree of participation in affairs considered by the total University faculty, and (2) a larger degree of self-government than ". . . existed in other units of the University."[5] Although notices of the Madison-based general faculty meetings were to be sent to Milwaukee faculty members,[6] it was clear that they were effectively disenfranchised. This was especially irksome to UWM faculty members in search of their own unique identity, in view of the Regents' definition:

> The faculty of the Milwaukee unit, operating within policies and standards governing the University as a whole, and its several units, shall hold meetings at regular intervals (1) to discuss matters which require action by the [general] University faculty and to make recommendations thereon; and (2) to take actions on matters which are within established University policy but which relate to the Milwaukee campus only.[7]

The Regents did make one concession to the Milwaukee institution's different character and tradition inherited from its state college predecessor institution: Faculty membership was extended to those holding the rank of instructor. (The general University faculty and its co-terminous Madison campus faculty excluded academic staff members below the rank of assistant professor.)[8]

Milwaukee faculty members anxious to assert their own self-governing identity may have overlooked a major result of the act of merger. As interpreted in an official opinion by the state attorney general, a three-way merger had been effected.[9] The two Milwaukee

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[4] *Summary Report of the Actions Leading to the Establishment of The University of Wisconsin—Milwaukee* (Madison, Wisconsin, 1957), p. 1.
[5] *Summary Report*, p. 57.
[6] *Summary Report*, p. 48.
[7] *Summary Report*, p. 29.
[8] *Laws and Regulations Governing the University of Wisconsin* (Madison, Wisconsin, 1951), 4.112.

institutions had become one with the University of Wisconsin. A university system had been created which would eventually operate as a federal academic government. Of greater immediate importance, Milwaukee faculty members had become instant heirs of a long and strong tradition of faculty authority over educational affairs. In over a century, University faculty members had achieved a remarkable degree of self-determination over courses, degree programs, and personnel matters subject to usually only nominal administrative and regent approval. By legislative enactment and bylaws of the Regents,[10] the immediate government of the University had become the province of the faculty.

The contemporary structure and scope of faculty authority in the University is a product of intensive self-examination around the turn of this century. University historians Merle Curti and Vernon Carstensen point out that in the waning years of the nineteenth century "The faculty was not only a legislative body but a judicial and, to some degree, an administrative agency as well."[11] Following a critical controversy in 1910 over the respective roles of the faculty and the Regents in educational policy decisions, the faculty adopted in 1916 a committee recommendation which ". . . went a long way toward solving the problem of maintaining democratic faculty control over educational policy and of relieving the teaching staff from routine matters"[12] of administrative implementation. In essence, the plan recognized the faculty's direct legislative interest in policy formation based on investigation and recommendations of a new faculty standing committee, called the University Committee. Under the new rationale, an Administrative Committee composed of the President, other University administrators and the Secretary of the Faculty would supervise the execution of routine matters. To complete the separation of powers in academic government, the plan classified other faculty authorized committees according to whether their chief functions were policy determining or administrative. The basic rationale of the 1916 faculty reorganization has continued to underlie the philosophy and practice of faculty government.

But if the new faculty government at UWM was an heir, it was also a parent of change. The merger of 1956 precipitated a series of academic government revisions in structure and relationships which affected the total University system, the Madison

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[9] Attorney General, *Wisconsin Statutes*, 39.024 (3) (h), cited in *West's Wisconsin Statutes Annotated* (St. Paul, Minnesota, 1966), Vol. 5 and in *Wisconsin Annotations* (Madison, Wisconsin, 1960).

[10] *Wisconsin Statutes*, 36.02 (1), 36.06 (1), and 36.12.

[11] Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History: 1848–1925* (Madison, Wisconsin, 1949), Vol. I, pp. 608–609.

[12] For a succinct account of this action, see Curti and Carstensen, Vol. II, pp. 105–107.

campus operation, and other units of the University. In a 1958 special report to the UWM faculty, its University Committee acknowledged successful operation of UWM self-governance within its legally required framework as an integral part of the total University. But the report called for a reaffirmation of the faculty's traditional prerogative to have charge of academic affairs and for appropriate safeguards to insure the faculty role in policy-making. At the same time, the University Committee insisted that ". . . faculty committees should reverse the trend toward greater concern with administrative detail and non-policy matters by insisting that these functions be carried out by administrative personnel,"[13] in keeping with the traditional role of the faculty of the University. Viewed as a major faculty committee statement on the future of the University of Wisconsin—Milwaukee, the 1958 report is perhaps surprising in its mild and scant mention of desirable modifications in academic government relationships within the University.

Despite the initial guarantee of faculty self-government, the operation of academic affairs at the Milwaukee campus for the first few years was essentially a branch or satellite activity of the Madison-based faculty. An elaborate system of inter-campus conference committees to coordinate curricular and personnel questions began to break down in complexity. Requirements for review and approval of Milwaukee campus faculty policy decisions became steadily more irksome. Finally in 1963, the UWM faculty set the stage for the University system-wide reform in academic government which has continued to the present. It adopted proposals which would (1) make the UWM faculty the final faculty approval body for curricular programs, (2) authorize the UWM faculty to inaugurate its own campus committees to review course proposals, (3) establish a discrete Madison campus faculty, (4) establish a University of Wisconsin faculty for consideration of general policy matters which affect all campuses of the University, and (5) recognize the UWM faculty as having final faculty jurisdiction over Milwaukee campus matters. Approval by the general University faculty and by the Board of Regents contributed to a comprehensive overhaul and codification of University rules.

Today, the *Laws and Regulations of the University of Wisconsin* provide for the academic government of a University federal system. General "constitutional" provisions relating to the whole University set forth basic statutory laws and Regent bylaws, describe the operation and jurisdiction of the system-wide University Faculty Assembly, state system-wide rules, and prescribe

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[13] *Special Report of the University Committee—Milwaukee on the Future of the University of Wisconsin—Milwaukee,* UWM Faculty Document 55, May 26, 1958.

a minimal legal framework for legislation by unit faculties, such as the UWM faculty. Legislation adopted by the UWM faculty, following approval by the Regents, is embodied in a set of chapters reserved for the Milwaukee campus government.

OPERATION OF FACULTY GOVERNMENT

Structural Elements of the Polity. The faculty government of The University of Wisconsin—Milwaukee operates as a deliberative body and as a cluster of subordinate committees. Meeting as a body, the faculty legislates academic policy decisions usually based on investigations conducted by subject matter committees. Beginning with the 1969–70 academic year, the faculty delegated its powers and jurisdiction to a representative senate, between meetings of the faculty. An examination of meeting practices of both bodies reveals to a large degree the identifiable roles, predictable continuity, and group goals of UWM faculty government.

Sessions of the Body: Faculty Meetings. The initial regulations governing UWM faculty meetings[14] were a brief adaptation of the existing rules of the parent University of Wisconsin faculty. With the preoccupation of integrating the two diverse faculties and academic programs into the University system, UWM faculty members apparently were satisfied with minimal and non-original rules of procedure in the early years of the institution. Succeeding years brought piecemeal changes, culminating in a codified exposition in 1967 and a major experimental revision of faculty government processes in 1969.[15]

According to current faculty adopted and regent approved legislation, the faculty meeting is parliamentary, democratic, systematic, and definitive. But in the light of empirical observation of recorded experience, the faculty meeting is sometimes licentious, authoritarian, anarchic, and indecisive. Viewed from the perspective of fourteen years, a meeting of the UWM faculty is remarkably similar to other public deliberative bodies. Like other legislative polities, the faculty places increasing faith in an increasing corpus of complex rules directed toward simplistic ends. To some extent, it shares the common communication mystique which assumes that Truth and Understanding are inevitable products of free and unlimited verbal confrontation. A summary look at faculty procedures implemented in practice illustrates its strengths and weaknesses.

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[14] *Proposed Regulations Governing University of Wisconsin—Milwaukee Faculty Meetings by University Committee—Milwaukee,* UWM Faculty Document 1, February 6, 1957.

[15] *The University Faculty—Milwaukee,* UWM Faculty Document 384 (revised), March 9, 1967 and *The University Faculty—Milwaukee and its Senate,* UWM Faculty Document 485 (revised), March 20, 1969.

From its first organizational meeting on September 14, 1956 through the last session of the 1969–70 academic year, the UWM faculty was convened as a body 123 times. Ninety nine of these sessions were regularly scheduled monthly meetings; twenty four were additional special meetings. (With the inauguration of the senate, the full faculty held only two prescribed regular meetings during 1969–70, with four additional special meetings.) Legal membership of the faculty exactly doubled during the fourteen years of this study: from 310 to 620. (In 1964–65, except for those who enjoyed "grandfather's rights," instructors were disenfranchised by system-wide rules and the net membership declined by eight from the previous year.)

Because the faculty convenes as a "town meeting" with no regular quorum requirement, attendance is affected by the urgency of issues, the intensity of feeling of special interest groups, or ceremonial obligations. The percentage of those attending ranged from 25% to 37% during the first year, and the range has not varied significantly in the succeeding thirteen years. The all time low of 7% was recorded at a meeting which debated important basic portions of the University code concerning personnel, UWM faculty government, and the system-wide University Faculty Assembly.[16] Two special meetings tied for the second low percentage of participating attendance: One adopted the UFA legislation, and the other passed a resolution in opposition to the Vietnam war.[17] The record high attendance figures were achieved at two special faculty meetings in response to emotional campus issues. Recruiting policies and attendant student protests concerning the Vietnam conflict brought out 69% of the faculty, plus 70 student visitors. At the height of campus disruption associated with the national student strike of May, 1970, 64% of the eligible faculty debated and passed a series of resolutions greeted by the jeers and cheers of an estimated 250 students in a standing room only auditorium. In neither of these two most highly attended faculty meetings in fourteen years were the stated consensus or adopted resolutions binding or effective on University policy and action.[18]

Although the official minutes of faculty meetings record only fragmentary or sporadic excerpts of meeting dialogue, veteran faculty meeting-goers conclude that a small number of members dominate discussion and debate. Categories of frequent vocal participants include spokesmen for the "safe" positions of the faculty "establishment," apologists for militantly activist causes of a

[16] *Minutes,* Regular Meeting of the UWM Faculty, March 9, 1967.
[17] *Minutes,* Special Meeting of the UWM Faculty, March 21, 1967 and *Minutes,* Special Meeting of the UWM Faculty, November 14, 1969.
[18] *Minutes,* Special Meeting of the UWM Faculty, November 27, 1967 and *Minutes,* Special Meeting of the UWM Faculty, May 14, 1970.

para-educational nature, self-appointed defenders of real and imagined "oppressed" minorities of faculty opinion, and chronic participants indulging a need for public recognition. Explanations for non-attendance and non-participation by the overwhelming silent majority probably range from passive apathy to active disgust. Regardless of motivations, faculty meeting government obviously is a minority exercise.

Although faculty meeting attendance and participation are predictably unpredictable, the content of agenda items is relatively certain. Faculty rules provide that, except by unanimous consent, business at a faculty meeting is limited to written proposals in proper form which have been included in the prepared calendar (agenda) distributed in advance. The original mechanism designated the Administrative Committee to prepare the calendar, including only those matters under the jurisdiction of the faculty. Although that criterion is still implicit, a later codification dropped the stated requirement. The latest rule assigns the task of calendar preparation to a faculty committee elected by the senate. As a further indication of faculty preoccupation with democratic due process, regulations assure that any matter omitted from a calendar shall be included in the calendar of the next regular meeting by affirmative vote of those present.[19] Calendar regulations were intended to insure advance familiarity with issues, parliamentary efficiency, and protection of individual rights. But periodic complaints of arbitrary and capricious actions by the former Administrative Committee and the current Calendar Committee pose a continuing and unresolved question for the future of faculty government.

The problem of appropriateness of faculty meeting business is substantive as well as procedural. Controversy about access to faculty meeting deliberation is matched by controversy about the appropriateness of the issues themselves. The question is not merely academic; it is at once political and social. UWM faculty members are not merely state employees; they are also public officers. The transacted business of a faculty meeting is not merely University educational policy; it is also public policy. The provisions of the Wisconsin Anti-Secrecy Law, as interpreted by the attorney general, are applicable to meetings of the UWM faculty as to those of other public bodies concerned with the transaction of governmental business.[20]

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[19] Chapter 31, The University Faculty—Milwaukee and its Senate, *Laws and Regulations of the University of Wisconsin.* 31.04 (4) (c).

[20] Attorney General Bronson C. La Follette, letter to University of Wisconsin President Fred Harvey Harrington, December 23, 1968.

A review of the calendars and minutes of the meetings of the UWM faculty during its early years shows only rare recourse to special meetings devoted to issues of dubious or uncertain faculty jurisdiction. Until 1959–60, the faculty deviated from its preoccupation with academic programs only once; it passed a resolution to the Regents protesting the inauguration of fee parking facilities on campus and claiming "faculty control" of University affairs as a traditional right.[21] Only two of the five special meetings of the 1959–60 academic year[22] involved strongly controversial matters, and both concerned academic policy: ROTC and a discussion of the loyalty oath provisions of the National Defense Education Act. In general, through the first eleven years, the UWM faculty's handling of controversy was parliamentary, democratic, systematic, and definitive. Appropriate issues of scholarship, campus planning, grading systems, and related academic subjects were deliberated with little public notice. But in 1967–68 and ensuing years, a public mood of division and unrest was equally apparent on the campus and in meetings of the faculty. Public issues became University issues, and faculty controversies became public controversies.

However historians of the future may judge the conduct and results of faculty meetings of our recent past, the pragmatic conclusion of many faculty members from their limited perspective must have been that the general faculty meeting as an academic government device was tried and found to be wanting. Impatience with reliance on reasoned discourse, the raising of peripheral and emotional issues, or aborted attempts to inject such subjects into faculty deliberations often seemed to arise in frustration and to end in frustration. The crisis in faculty government perhaps was inevitable. The growth in numbers and complexity of the institution had increased the probability that the faculty meeting as a "system of communication"[23] would fail. George Reed Field's doctoral study had found that ". . . only slightly over 50% of the Milwaukee faculty members reported that they had substantial authority to participate in academic policy determinations" and that in other critical areas of institutional relationships Milwaukee faculty members had a greater degree of dissatisfaction than did their well established counterparts on the Madison campus.[24] UWM academic government also seemed to have become a classic

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[21] *Minutes,* Special Meeting of the UWM Faculty, December 3, 1958.

[22] *Minutes,* Special Meeting of the UWM Faculty, September 24, 1959 and *Minutes,* Special Meeting of the UWM Faculty, December 17, 1959.

[23] George Reed Field, *Satisfaction and Dissatisfaction of University of Wisconsin Faculty Members by Campus Location,* Ph. D. Thesis (University of Wisconsin, Madison, 1965), p. 11.

[24] Field, p. 128.

case of "executive–legislative conflict."[25] In this period of strife, the conflict was only partly the traditional campus administration–faculty clash over authority. In a larger sphere, the authority of the established faculty parliamentary system and leadership seemed to be as much in question as the authority of the administration. In the waning years of a decade in which most American college and university presidents reported increased faculty influence as the most important campus change,[26] the UWM faculty's perception of its role was confused and divided.

The testing and at least tentative resolution of the role of the faculty meeting in governance began in November of 1967. A special meeting of the faculty was called to consider a resolution attacking administrative policy on demonstrations by students against job recruiting agencies associated with the Vietnam conflict. In a ruling subsequently supported by the faculty Codification Committee,[27] the presiding officer ruled that the issue was limited to discussion without formal action. The angry response of proponents was the adoption of a resolution which distilled the essence of faculty division. In a regular meeting attended by 13% of the eligible members, the faculty directed that the Chancellor establish a student–faculty committee to inquire into matters of university autonomy, academic freedom, and decision-making. The "Committee of 32" was to be concerned specifically with the relationship of the University to critical public issues and political action on campus.[28] Without official sanction as a formal faculty committee,[29] the vague alliance of faculty members and students went about its investigation with no definite conclusion.

The underlying issues raised in the "Committee of 32" resolution erupted again in a special meeting in March of 1969. Approximately 18% of the faculty and an uncounted number of students listened to an emotional debate which ended with the adoption of three resolutions and adjournment fifty minutes after the regulation time. Again the faculty motions reaffirmed the "validity of the Wisconsin tradition of shared faculty power," called on the administration to consult with faculty committees prior to acting contrary to recommendations, and requested administrative and regent permission to enable the admission of black students who had been expelled from Wisconsin State University—Oshkosh fol-

[25] A. Clarke Hagensick, "A Propositional Inventory of Executive-Legislative Conflict," *Transactions of the Wisconsin Academy of Sciences, Arts and Letters,* Vol. LVI (1967–68), 81–92.

[26] Carnegie Commission on Higher Education, report quoted in New York Times News Service dispatch, *The Milwaukee Journal,* July 19, 1970, p. 4.

[27] *Minutes,* UWM Codification Committee, February 5, 1968.

[28] *Minutes,* Regular Meeting of the UWM Faculty, December 14, 1967.

[29] *Minutes,* UWM Codification Committee, January 23, 1968.

lowing a disturbance at that institution.[30] One week later, another special meeting adopted motions which would develop a degree-granting Center for Afro-American Culture. Counter-proposals, charges of "institutionalized racism,"[31] and a dramatic walkout of dissident faculty members and students were observed in silence by a majority of the faculty.

The minutes of the regular meeting of March 20, 1969 constitute an understated record of a peak of strong feeling which accompanied the almost continuous intrusion of faculty authority issues. The main scheduled business of the meeting was consideration of a recommendation of the Codification Committee for amendment of the charter chapter of UWM faculty government to provide for the creation of a faculty senate. Consideration of the proposal previously had been delayed at the last regular meeting by discussion of the Oshkosh students case. Before the senate proposal was referred finally to the full faculty (and subsequently approved by mail ballot), it was subjected to a barrage of substantive objections and extraneous verbal maneuvers. Interruptions included attempts to permit students to speak on a petition circulated earlier, challenges to rulings by the chair, frivolous amendments, a premature motion to adjourn, a call for a vote recount, and requests for parliamentary rulings.[32] The conduct and atmosphere of this and previous meetings probably contributed to final approval of the senate as a partial replacement for general faculty meetings.

The controversy over controversy continued into the final year covered by this study, in spite of and because of the creation of a faculty senate. In two regular and four special meetings, the faculty debated Indo-China resolutions, response to a student strike, sustained senate action on the academic year calendar, and prohibited the senate from amending provisions of the basic charter of faculty government.

Sessions of the Body: Senate Meetings. A summary of the steps leading to the creation of the UWM faculty senate[33] reveals a lengthy, deliberate, and democratic process in the achievement of faculty government goals. Because of political realities, the senate represented an evolution in faculty governance rather than an abrupt departure. The persuasive case rested on a compromise solution to schedule two regular meetings of the general faculty each year and to delegate interim legislation to the smaller repre-

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[30] *Minutes,* Special Meeting of the UWM Faculty, March 6, 1969.
[31] *Calendar* and *Minutes,* Special Meeting of the UWM Faculty, March 13, 1969.
[32] *Minutes,* Regular Meeting of the UWM Faculty, March 20, 1969.
[33] *Documents Leading to the Establishment of the Faculty Senate at the University of Wisconsin—Milwaukee,* undated compilation, Office of the Secretary of the Faculty, UWM.

sentative body. In response to faculty fears of loss of participatory rights, the power of review of senate actions was retained by the faculty, senate meetings were opened to non-voting participation by non-senators, the right to convene special meetings of the faculty was retained, and senators would be bound to conduct their sessions according to general faculty rules. Finally, the senate meeting mechanism was frankly proposed as experimental legislation, subject to future faculty review and modification. The limited experience of the first year of operation can only suggest some tentative characteristics.

With a quorum requirement of a majority of its membership of 47 and a roll call provision, the freshman year senate maintained an attendance ranging from a low of 68 to a high of 82 per cent. In another evidence of increasing concern with "pure" faculty governance, the senate elected its own president *pro tem* to preside in the absence of the Chancellor. Meetings generally adhered closely to established parliamentary rules and reasoned debate, after some initial uncertainty over jurisdiction and procedures. Reflecting in part its composition of faculty members of higher academic rank and greater seniority, however, the initial senate spent little time expressing doubt about its authority in academic policy determinations.[34] Legislative actions involved internal matters of faculty concern, except for the adoption of a motion providing for committee study of academic cooperation among the several University campus units in southeastern Wisconsin.[35] This action was taken despite the contrary advice of a visiting officer of the Milwaukee campus administration who asked for delay.

The Faculty Committee System. One of the first acts of the UWM faculty was to define a system of faculty committees. The process of definition has continued at an increasing pace through the period of this study. Certain general themes and trends are readily apparent; they include standardization of codified committee descriptions, consolidation of outmoded and overlapping committee functions, recognition of distinctive Milwaukee campus problems, procedures, and goals, emphasis on committee membership by election rather than by administrative appointment, fluctuating interest in providing for student involvement, and identification of committee authority, responsibility, and accountability. The basic charter of the UWM faculty declares that it ". . . may delegate functional authority and responsibility to committees . . .; however, such bodies . . . are accountable to the University Faculty—Milwaukee which retains final jurisdiction over all educational matters. . .".[36] A separate Milwaukee unit chapter of University

[34] Field, p. 128.
[35] *Minutes*, Regular Meeting of the UWM Faculty Senate, January 8, 1970.
[36] Chapter 31, 31.02 (4).

laws and regulations specifies provisions for the establishment and regulation of both standing (permanent) and special *(ad hoc)* faculty authorized committees.[37] This chapter also prescribes the membership and functions of the current roster of standing committees.

Committees exercise an important and sometimes confused role in academic government. Most business transacted in meetings of the faculty or its senate is based on informational reports of committee activities or specific recommendations to the faculty legislative body. But much committee activity is in separate implementation of faculty delegated duties. Although the Secretary of the Faculty is administratively responsible for mechanical details of the committee structure and operation, each committee reports directly to the faculty or its senate. Problems of interpretation of functions, conflicts of jurisdiction, charges of usurpation of powers, failures to carry out specific assigned responsibilities, and disagreements between committees are either ignored by neglect, resolved by private negotiation, or subjected to a faculty body vote. In the absence of any real judicial mechanism, there is no alternative to these options. For example, when a joint meeting of the University Committee and the Codification Committee failed to resolve the question of applicability of general committee regulations to the University Committee,[38] the issue was adjudicated by a vote of the senate.[39]

The existing committee structure is a product of a flurry of codification activity which began in 1966[40] and extended through the 1969–70 academic year. A significant part of this activity was due to the intervention of the University Board of Regents in requiring or requesting faculty legislation affecting or involving students. Faculty committees on student conduct were defined in accordance with regent instructions. In 1969, the Regents requested the various unit University Committees to investigate and to develop procedures for greater student involvement in broad educational matters. A subsequent survey by the UWM University and Codification Committees led to greatly increased student membership on a number of faculty standing committees.[41] Earlier efforts to provide for student representation in the committee element of faculty government were essentially ineffective, with the notable exception of the active Student Life and Interests Committee.

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37 Chapter 34, Milwaukee Campus Committees.

38 *Minutes,* Joint Special Meeting of the UWM Codification Committee and the University Committee—Milwaukee, September 18, 1969.

39 *Minutes,* Regular Meeting of the UWM Faculty Senate, October 9, 1969.

40 On December 5, 1966, the Secretary of the Faculty issued a memorandum informing the chairmen of all faculty committees that faculty legislation required a self-study report of functions and membership to the Codification Committee by February 1, 1967.

41 Action by the University Board of Regents, July 25, 1969.

"Meaningful participation in . . . university government is not guaranteed merely by the presence of students on committees, . . ."[42] but the experience of another state university system with unit campus governance suggests that "the development of increased student participation must . . . grow naturally. . .".[43] After fourteen years, the starting point for student participation in UWM academic government appeared to have been committed to committees.

Conclusions and Predictions

To describe the shape and nature of the past and present is difficult enough; to describe the precise pattern of the future is absurd. We do not know what conditions will affect The University of Wisconsin—Milwaukee in 1984—nor in 1983, for that matter. We cannot do more than enjoy the good-humored warning of McGeorge Bundy's prophetic report from an "Academic Utopia" of 1975 in a pseudo-retrospective look at our shortcomings of the 1960s.[44] But any future UWM faculty government will be derived from its past. Here, then, are some major conclusive assessments with their likely predictive corollaries.

1. The judicial functions of a democratic academic government are not being served as an identifiable activity or are being exercised on a sporadic and non-systematic basis. These normal judicial functions include: (a) determination of compliance with prescriptive and proscriptive rules, (b) interpretation of the meaning/intent of discrete rules and provisions, (c) reconciliation of apparent conflicts or inconsistencies among rules, and (d) judicial remedy for individual grievances in cases of illegal acts, usurpation of powers in the practice of faculty government or failures to act as required. This study suggests that judicial concerns will continue to be faced in something less than a comprehensive rationale.

2. The "doctrinal anti-administrative attitude"[45] as a faculty characteristic may be expected to persist in the muted form of an "arm-length" communicative relationship between faculty government representatives and members of the campus administration. This study suggests that traditional anti-administrative feeling is becoming more translated into anti-faculty establishment authority bias by individuals and groups of faculty members who are alienated from the silent majority which supports gradual change.

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[42] "Draft Statement on Student Participation in College and University Government," *American Association of University Professors Bulletin* (March 1970), 35.

[43] Executive Vice President John W. Oswald, University of California, letter to Professor Kirk R. Petshek, Chairman, UWM Codification Committee, March 23, 1970.

[44] McGeorge Bundy, "A Report from an Academic Utopia," *Harper's Magazine* (January 1962), 10–15.

[45] T. R. McConnell, "Faculty Interests in Value Change and Power Conflicts," *American Association of University Professors Bulletin* (September 1969), 346.

3. The modest but increasing trend to increasing exercise of legal power by administrative and regent levels to cope with immediate and potential campus problems may be expected to persist, "lacking faculty action"[46] of specific appropriateness and acceptable speed. The future may see a reversal of the traditional "faculty proposal—administration/regent disposal" process unless faculty anticipatory behavior involves more than the adoption of resolutions on public issues which spill over into campus controversy and disruption.

4. During the period covered by this study, UWM faculty government became increasingly codified into a systematic rationale of fixed and delegated authority. But the academic tradition of free and extensive dialogue is so strong that action oriented faculty government leaders and campus administrators will continue to find it difficult to heed Robert M. Hutchins' conclusion that "durable action" in university governance requires "patience."[47]

5. The structure and operation of UWM faculty government has changed gradually into its present form and practice. Confronted with the impact of persistent or recurring social disruption, it will continue to evolve. The major faculty goal of self-determination of institutional uniqueness through parliamentary democracy will continue to dominate its individual and collective behavior.

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[46] "The Harrington Resignation," *Wisconsin Alumnus* (June 1970), 9.

[47] Robert M. Hutchins, "The Administrator Reconsidered," reprinted in *Administrative Control and Executive Action*, edited by B. C. Lemke and James Don Edwards (Columbus, Ohio, 1961), p. 65.

THE EFFECT OF RESTAURANT SERVICES ON THE SURVIVAL RATE OF TOURIST-LODGING ESTABLISHMENTS IN WISCONSIN

L. G. Monthey and *R. A. Ricketts*

INTRODUCTION

The number of tourist–lodging (T–L) businesses in Wisconsin has been decreasing steadily since the mid-1950s, when the total was in excess of 8,000 establishments. However, the greatest decrease has occurred in the years since 1964, when the rate of decline accelerated to about 3% a year. As Figure I shows, every major region of the State lost T–L businesses between 1964 and 1968; and the total loss during the period was about 870.

Previous studies have shown that the largest declines during the Sixties were in the small, seasonal lodging businesses. On the other hand, year-round establishments—particularly of the motel or motor-hotel type—have gained both in numbers and size. Meanwhile, the State's total capacity in bedroom units (B.U.) has remained near 80,000 for at least 10 years.

The apparent reasons for these general trends in the T–L industry have been discussed elsewhere in some detail. However, one of the most frequent observations is that the small lodging operation doesn't provide enough service to the traveler or vacationist and hence finds it increasingly difficult to compete in the lodging market. Or, to put it another way, it has been postulated that the T–L establishments which offer the most services are the ones most likely to stay in business longer.

This study is an attempt to test the latter supposition by selecting a single important factor, i.e. *food service,* and determining its relationships to the survival of lodging establishments over a recent 5-year period 1964–68. This factor was selected because it could be readily identified through the issuance of restaurant permits by the Wisconsin State Board of Health. During each of the years concerned, the presence (or absence) of such permits was cross-referenced on the records of all lodging-business inspections made by the Board of Health. Thus, reliable counts of T–L businesses holding restaurant permits were available for each year of this study, and the type, size and seasonality of each establishment having restaurant services (RS) was readily determined.

Incidentally, it is our belief that those T–L establishments that offer food service are more likely to provide various additional

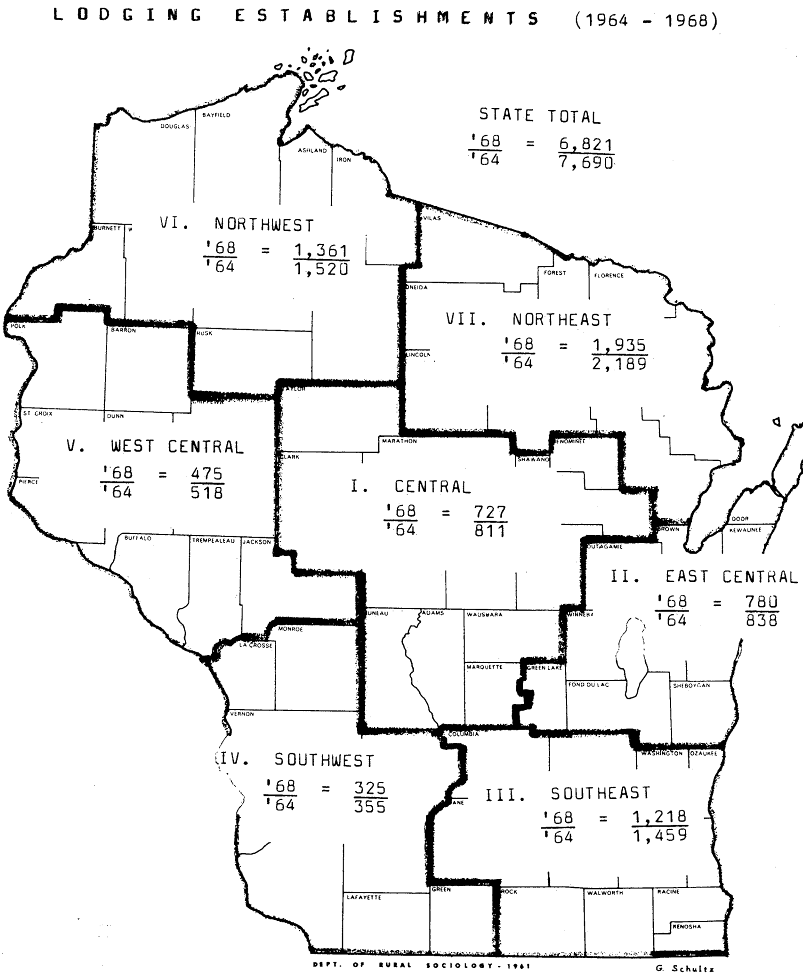

FIGURE I. Tourist–Lodging Establishments in Wisconsin by Regions. (Comparing September 1964 with September 1968)

services as well. If this is true, then the restaurant permits may serve to identify those establishments which offer, in general, a greater array of guest services to their special clientele and other travelers too.

Figure II shows the regional distribution of restaurant permits in Wisconsin, comparing 1964 and 1968 figures. These data include all types of food-service businesses with the exception of temporary operations, such as hot-dog stands at county fairs, which obtain a special short-term permit. It should be noted that the total number

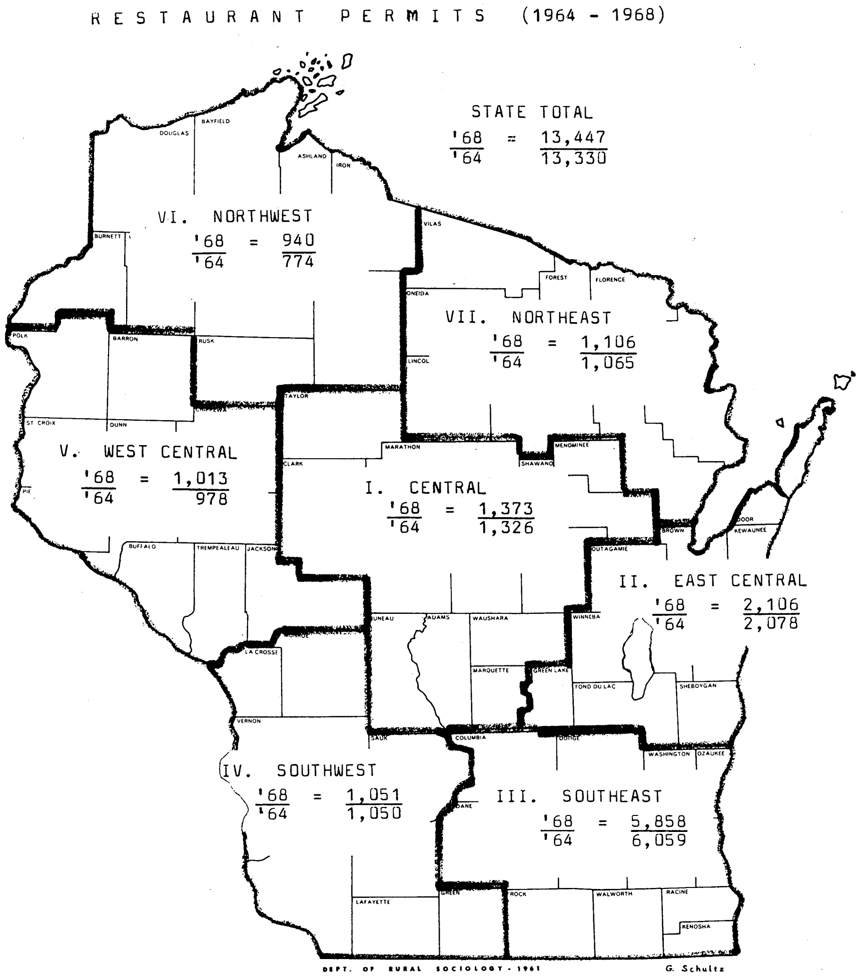

FIGURE II. Restaurant Permits Issued in Wisconsin by Regions, comparing January 1964 with January 1968. (Temporary Restaurant Permits are not included.)

of restaurant operations, unlike the T–L establishments, remained fairly constant during the 5-year period. All regions of the State showed modest gains, with the exception of the southeast district (including Milwaukee) which lost 200 food establishments, a decline of 3.3%. However, the over-all increase, statewide, was only 0.9%. Of the 13,330 restaurant permits in 1964, 11.1% (1,484) were issued to T–L establishments. In 1968, when the total was 13,447 permits, 10.5% of them (1,414) were associated with lodging business.

In order to obtain basic data on the relationship between restaurant services and the number, type and size of T–L establishments involved, Wisconsin Board of Health inspection records and mailing lists for the years 1964 through 1968 were used. The appropriate data were then coded for each establishment, transferred to IBM cards, and the results compiled by data-processing techniques. Five major categories were used in classifying T–L businesses: (1) Hotel type; (2) Motel type; (3) Resort type; (4) Cottage type; (5) Other. The distribution of restaurant permits among the various T–L businesses was then determined for all types and sizes of establishments. The data are presented in a series of tables, which follow.

General Findings

Table I summarizes the findings of this 5-year study relative to the restaurant permits issued to all T–L establishments. In 1964, 19.3% of all T–L businesses had food services, whereas in 1968 the corresponding proportion was 20.7% However, this small increase of 1.4% may not be of much significance, since the sum total of lodging establishments had declined from 7,690 in 1964 to 6,821 in 1968, a net decrease of 11.3%.

In view of this general decline in the number of T–L businesses, a more definitive measure of the effect of restaurant services on the survival of lodging establishments would be the comparative rates of decline for establishments with and without food service. For example, if the net decrease during the 5 years is 11% for all T–L businesses, but is only 4.8% for those establishments with restaurants (as in Table I), we can assume that food service is associated with a lower business-mortality rate in the case of such establishments. Similarly, Table I shows that the net decrease in

Table I. Total of Lodging Establishments with and without Restaurant Operations (1964–68).
(RS = Restaurant Services)

Year	With RS	% Total Estab.	% of 1964 Base	Without RS	% Total Estab.	% of 1964 Base	Total Estab.
1964	1,484	19.3	100.0	6,206	80.7	100.0	7,690
1965	1,482	19.8	99.8	5,984	80.2	96.4	7,466
1966	1,440	19.9	97.0	5,848	80.1	94.2	7,288
1967	1,417	19.9	95.4	5,687	80.1	91.6	7,104
1968	1,414	20.7	95.2	5,407	79.3	87.1	6,821
Total Change in 5 Years	(—70)	+1.4	—4.8	(—799)	—1.4	—12.9	(—11.3%)

T–L businesses without restaurant facilities (using 1964 as the base year) was 12.9%—a drop that is somewhat greater than the general rate of decline for the industry.

Table II illustrates the rates of increase or decrease in the number of establishments, grouped into size categories by bedroom units (B.U.), with and without restaurant facilities. Within the 1–4 bedroom unit grouping, both establishments with and without restaurant facilities have decreased. However, using the number of 1964 establishments as a base, there appears to be a greater rate of decrease in those establishments without restaurants (—19.1 percent) in 1968 compared to those which provided restaurant facilities (—13.5 percent) in 1968. In the 5–19 room grouping this same relationship is also apparent. Those establishments without restaurant facilities had, by 1968, decreased to 89.6 percent of the number of lodging operations existing in the base year of 1964. Meanwhile, those establishments with restaurant operations declined only slightly and still comprised 97 percent of the base year.

The next size grouping (20–29 rooms) indicates a reversal of the relationship illustrated in the first two size groupings. Although there was a decrease in establishments both with and without restaurant facilities, the greatest decrease, using the 1964 base, had occurred in those establishments which *provided restaurant facilities*. Establishments with restaurant facilities decreased to 91.4 percent of the 1964 base, while 1968 establishments without restaurants represented 98.9 percent of the base-year total. This reversed relationship becomes even more apparent in the next size grouping of 30–99 rooms. Here establishments which provided restaurant facilities have showed a slight decrease to 98.9 percent of the base year, while those without restaurant facilities increased to 128.8 percent of the 1964 total.

Finally, the last size grouping (100 B.U. or more) showed no change in establishments without restaurants, while there was an increase of 17.3 percent in establishments with restaurant facilities.

In looking at all classes of lodging establishments, it appears that as one moves from smaller size categories to the larger, the trend in number of establishments *without* restaurant facilities changes from a negative to a positive relationship relative to the base year. However, the trends in those establishments which provided restaurant facilities become less clear as one moves from the smaller to the larger establishments. It appears that restaurant facilities (in the house) may play a less significant role in medium-to-large establishments than they do in the smaller establishments (if we omit the 100-plus category).

TABLE II. TREND IN LODGING ESTABLISHMENT NUMBERS, WITH AND WITHOUT RESTAURANT SERVICES, BY VARIOUS SIZE GROUPS (1964–68).
(RS = Restaurant Services)

1. SMALL ESTABLISHMENTS:

	(A) 1 TO 4 BEDROOM UNITS				(B) 5 TO 19 BEDROOM UNITS			
	No. Estab. w/RS	% w/RS	No. Estab. wo/RS	% wo/RS	No. Estab. w/RS	% w/RS	No. Estab. wo/RS	% wo/RS
1964...........	267	100.0	2, 584	100.0	809	100.0	3, 212	100.0
1965...........	248	92.8	2, 430	94.0	821	101.4	3, 133	97.5
1966...........	247	92.5	2, 332	90.2	783	96.7	3, 088	96.1
1967...........	250	93.6	2, 260	87.4	775	95.7	2, 973	92.5
1968...........	231	86.5	2, 092	80.9	785	97.0	2, 878	89.6
Change........	—36	—13.5	—492	—19.1	—24	—3.0	—334	—10.4

2. MEDIUM-SIZE ESTABLISHMENTS:

	(C) 20 TO 29 BEDROOM UNITS				(D) 30 TO 99 BEDROOM UNITS			
	No. Estab. w/RS	% w/RS	No. Estab. wo/RS	% wo/RS	No. Estab. w/RS	% w/RS	No. Estab. wo/RS	% wo/RS
1964...........	187	100.0	293	100.0	175	100.0	104	100.0
1965...........	180	96.2	283	96.5	181	103.4	117	112.5
1966...........	181	96.7	293	100.0	179	102.2	122	117.3
1967...........	172	91.9	302	103.0	170	97.1	139	133.6
1968...........	171	91.4	290	98.9	173	98.8	134	128.8
Change........	—16	—8.6	—3	—1.1	—2	—1.2	+30	+28.8

3. LARGE ESTABLISHMENTS:

	(E) 100+ BEDROOM UNITS			
	No. Estab. w/RS	% w/RS	No. Estab. wo/RS	% wo/RS
1964...........	46	100.0	13	100.0
1965...........	50	108.6	13	100.0
1966...........	50	108.6	13	100.0
1967...........	50	108.6	13	100.0
1968...........	54	117.3	13	100.0
Change........	+8	+17.3	0	0

The Relationships Vary

What possible conclusions might be drawn from the above data? First, it appears that within the smaller size categories (1–19 bedroom units), the decrease in lodging establishments and the lack of restaurant facilities is directly related. It could be hypothesized that the lack of such facilities has resulted in the greater rate of decrease for establishments without restaurants versus those with restaurants. An alternative hypothesis might be that those establishments which do not have restaurant facilities are economically worse off than those which do provide restaurant services. One could say that the greater decrease in the case of smaller establishments without restaurant facilities is more likely to be a result of economic considerations than the fact that they do not provide such facilities.

Conversely, those smaller establishments which do provide restaurant facilities might do so only because of better economic success with their lodging operation, which may account for the lower rate of decrease in the number of these establishments. To determine if the restaurant operation in smaller establishments has enhanced their survival, or if the success of the lodging operation has resulted in expanding into restaurant services, still remains open to consideration.

Secondly, with establishments of 30 to 99 bedroom units, there seems to be a trend toward constructing establishments without restaurant facilities in the house. At any rate, there has been no net increase in establishments with restaurants (in fact a slight decrease), while there has been a substantial net increase (within this size grouping) of establishments without restaurants. There has been a tendency for new motels in this medium-size range to rely on "outside" restaurants near the premises.

The trend in large establishments with more than 100 B.U. showed no change in number of lodging operations without restaurants. However, a net increase of eight establishments having restaurant facilities was recorded over the 5 years, a gain of 17 percent.

At this point, it might be concluded that the net increase in operations containing restaurant facilities (1.4 percent of total establishments) can be attributed to the large net decrease in smaller establishments without restaurants. The effect of such a net decrease has been to increase the proportion of existing establishments which provide restaurant facilities.

Hotel–Motel Businesses

Table III illustrates the relationship of restaurant facilities to types of establishments. Again, using the base year of 1964 as a standard of comparison, it appears that provision of restaurant facilities is related to both increases and decreases within the several types of lodging establishments.

The hotel category shows a significant difference between the net decrease rates for establishments which do and do not provide restaurant facilities. Hotels without restaurants showed a greater net rate of decrease (—16.9 percent) than those which do provide restaurant facilities (—4.9 percent). Again, the cause-and-effect relationship is unknown and can only be speculated.

Table III illustrates that motels with and without restaurants have increased over the base year 1964. The rate of increase, however, has been greater for motels *without* restaurant facilities (+9.6 percent) than those which provided restaurant facilities (+3.9 percent). This seems in line with the findings in Table II in that there has been a net increase in establishments without restaurants within the 30–99 bedroom unit size group. Many of the new motel entries fall within this size grouping, thus accounting for the larger net increase of establishments without restaurants in the motel category. This still does not answer the question why motels are not emphasizing restaurant facilities, at least in this size category. The most probable explanation appears to be that these medium to medium-large motels are locating in areas where there is an independent restaurant operation available *in the immediate area,* there being no necessity to provide a restaurant facility for the guest's convenience. Other considerations might include past experience, space allocation and available capital.

TABLE III. TREND IN NUMBERS OF LODGING ESTABLISHMENTS WITH AND WITHOUT RESTAURANT SERVICES, GROUPED BY TYPE OF OPERATION, 1964–68.

TYPE OF ESTABLISHMENT	WITH RESTAURANT SERVICE				WITHOUT RESTAURANT SERVICE			
	1964 Total	1968 Total	1968 as % of 1964	% Change	1964 Total	1968 Total	1968 as % of 1964	% Change
Hotels.........	312	297	95.1	— 4.9	237	197	83.1	—16.9
Motels.........	204	212	103.9	+ 3.9	795	872	109.6	+ 9.6
Resort-type.....	655	602	92.0	— 8.0	1,783	1,622	90.9	— 9.1
Cottage-type....	104	90	86.5	—13.5	2,230	1,786	80.0	—20.0
Other..........	209	213	101.9	+ 1.9	1,161	930	80.1	—19.9
Totals.......	1,484	1,414	95.2	— 4.8%	6,206	5,407	87.1	—12.9%

Other Establishments

There appears to be no significant relationship in the decrease of establishments with and without restaurants for the resort category, and only a slight relationship is found within establishments classified as "cottages." However, there appears to be a pronounced relationship between restaurant facilities and the survival of establishments classified as "Other." In this case, interpretation should be approached with caution. Those establishments (classified as "Other") without restaurants have decreased 19 percent and those with restaurant facilities have increased 1.9 percent. The important fact to recognize is that this category is composed of a great number of heterogeneous types of establishments which could not be classified in the above categories. It would be unwise to make comparisons because of the widely differing characteristics of the various establishments.

Table IV illustrates the change in average size, measured in bedroom units, of lodging operations which do and do not provide restaurant facilities. The data indicated that lodging operations with restaurant facilities increased in size an average of 2.0 bedroom units per establishment from 1964 to 1968, while those without restaurant facilities have increased an average of only 0.7 bedroom units per establishment. Table IV also indicates that T–L establishments with restaurant operations are more sizable businesses (21.9 bedroom unit average) than those without restaurant facilities (9.1 bedroom unit average).

Table V provides a more detailed analysis of the average size of operations. Both seasonal and year-around operations with and without restaurant facilities are considered. Between 1964 and 1968 there was no significant difference between the increase in size of seasonal establishments with restaurants (0.1 bedroom units) and those without (0.2 bedroom units). However, note the difference in the average size of seasonal businesses with restaurants for 1968 (14.5 bedroom units) and seasonal operations which did not provide restaurant facilities (7.4 bedroom units).

Table IV. Changes in the Average Size of Lodging Establishments with and without Restaurant Services, 1964–68.
(RS = Restaurant Services)

Availability of RS	Ave. Size in 1964 (in B.U.)	Ave. Size in 1968 (in B.U.)	Size Change (in B.U.)
With RS	19.9	21.9	+2.0
Without RS	8.4	9.1	+0.7

TABLE V. AVERAGE SIZE CHANGE FOR SEASONAL AND YEAR-AROUND LODGING ESTABLISHMENTS, WITH AND WITHOUT RESTAURANT SERVICES, 1964–68.

Availability of RS	Seasonal			Year-around		
	Ave. Size 1964 (in B.U.)	Ave. Size 1968 (in B.U.)	Size Change (in B.U.)	Ave. Size 1964 (in B.U.)	Ave. Size 1968 (in B.U.)	Size Change (in B.U.)
With RS	14.4	14.5	+0.1	27.6	30.5	+2.9
Without RS	7.2	7.4	+0.2	13.0	15.1	+2.1

Year-around operations show a more pronounced difference relative to the change in average size of establishments with and without restaurants for the five year period. Although the difference is slight, operations with restaurants have increased 2.9 bedroom units while those without restaurant facilities have increased only 2.1 bedroom units. As with seasonal operations, the average size of year-around operations with restaurant facilities is much larger (30.5 bedroom units) than those establishments without restaurants (15.1 bedroom units).

HIGHLIGHTS

Slightly over 10% of the 13,400 restaurant permits issued by the State of Wisconsin are issued to tourist-lodging (T–L) establishments.

Slightly over 20% of Wisconsin's 6,800 T–L establishments obtain a restaurant permit and provide a food service for their guests. This study included all of the establishments that were inspected by the Wisconsin State Board of Health during the years 1964 to 1968, inclusive. It attempts to determine relationships between the availability of food service at T–L establishments and the subsequent increase or decrease in the numbers of such establishments.

There was a net decrease of 11.3% in the total number of lodging businesses between 1964 and 1968. However, the State's total housing capacity for travelers, in terms of bedroom units (B.U.), remained substantially the same over the period. Those establishments which provided restaurant services (RS) declined 4.8% during the 5 years, while those without RS decreased 12.9%.

Small T–L establishments (1 to 19 B.U.), as a category, showed a much higher survival rate where restaurant facilities were provided. It was 94.4% after 5 years, compared to only 85.7% where no food services were offered.

Medium-sized T–L establishments (30 to 99 B.U.) seem to be placing less emphasis on restaurant services "in the house." During the 5-year period the number of properties with food service remained virtually unchanged, while those without restaurants increased from 104 to 134, about 29%.

Lodging establishments with 100 or more B.U. showed no decline in the small number that did not provide RS between 1964 and 1968. However, the total for those that had restaurants increased by 17%.

The number of hotels without restaurant facilities declined 17% during the 5 years, while those with food service dropped only 5%. Motels, on the other hand, gained in both categories; those with restaurants gained 4% in number, and those without such facilities increased by 10%.

The biggest declines in numbers occurred in the case of cottage-type establishments. Those with food service showed a net decrease of 13.5%, while those without restaurant permits dropped 20% between 1964 and 1968.

Both seasonal and year-round establishments which provided restaurant services were considerably larger than those which did not have them, averaging about 100 percent bigger in both groups.

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THE REMAKING OF "AMERICAN LITERATURE"

Donald Emerson

"American Literature" in quotation marks, for one must distinguish between the raw bulk of what may be included by generous definition, and the more or less official "American Literature" of which I wish to speak. Generous definition has come to include many things not always accorded status as contributory to the literature—for example, the types of fiction, verse, and orally-transmitted tales and anecdotes these days designated as The Literature of Popular Culture. This is partly a matter of intellectual class distinctions, but if New England once had a Brahmin caste, the general levelling tendency has brought it low, to the point where articles are now written on the decline of WASP culture in the United States. And in much the fashion of anti-discrimination statutes and compensatory programs for the disadvantaged in the social sphere, there is these days an effective attitude of intellectual anti-discrimination, accompanied by active attention to the literature of ethnic minorities. Both tendencies lead today to an active redefinition of "American Literature."

It may be foolish to speak of a more or less official American Literature when in fact no such thing exists. There is no prestigious Academy-of-Something-or-Other to sanctify American literary gospels, no Federal-Office-of-This-or-That to proscribe unworthy works. The literary historian who should attempt to define the scope of American literature of the past half-century by reference to the most distinguished literary awards would make himself laughable. Even the international Nobel Prize guarantees Mrs. Pearl S. Buck no standing whatever. As is customary in the United States, a vague consensus is reached in quite unsystematic, even chaotic, fashion. This shifting consensus loosely defines "American Literature" at any given moment. The active parties include the writers, scholars, and critics whose judgments are effective with the mass of relatively passive culture-customers. The Dun and Bradstreet volumes of this "American Literature" are the anthologies, which reflect the decline of once successful ventures and the establishment and consolidation of new enterprises.

Anthologies exist in great variety to meet differing demands and expectations. I refer particularly to the anthologies imposed on students who wish to understand something of the growth and development of literature in the United States. In the context of this discussion "American Literature" (note the continuing marks of quotation) refers to that minimum of authors and selections the anthologist feels he must include to keep himself honest. Or to put it another way, "American Literature" for this discussion includes whatever the anthologist feels he can't afford to leave out for the students who are to have only an overview of the field, with little expectation of more intensive studies. I am talking about the "American Literature" of college sophomores, not of doctoral candidates, and I note that instructors further anthologize. They select for assignment only part of what must seem, to those sophomores, God's plenty in excess of all reasonable appetite. In this they contribute to the consensus which produces for each year's class an "American Literature" which has undergone an annual model change. The students make their contribution by responses on the scale from apathy to enthusiasm, and not many instructors willingly repeat assignments which eventually bore even themselves in the absence of student response. And there comes a point where every anthology is beyond hope of revision and must simply be abandoned, for "American Literature" has become something other, and the addition of new selections will not modernize it.

Two principal approaches to the problem have been made through literary history and esthetic judgment, neither of which ever operates apart from the other, and both of which have greater and more continuing importance than the temporary pressures of the times. Of political history Carl Becker remarked that "History is not what happened but what we think about what happened," and I suggest that the dictum applies to literary as well as to political history. Both are efforts at understanding from the vantage point of distance. But greater distance alters the landscape of the past, and as Becker further observed, each generation must rewrite its histories, and, in the literary context, also remake its anthologies as the result of remaking its histories. In the process, "American Literature" is effectively changed. I obviously now mean by "American Literature" what each generation, or, if you will, each historian understands American literature to be. Content and emphasis both vary. As Professors Henry Pochmann and Gay Wilson Allen point out in the Introduction to their *Masters of American Literature,* the history has been seen from various points of view: Vernon Louis Parrington read American literature as an essentially native phenomenon to be understood in the continuing clash of the forces of liberalism and conservatism. Howard Mumford Jones related the literature to three animating forces in American culture: the cosmopolitan spirit; the frontier spirit; and the middle-class spirit. Oscar Cargill discussed the literature in terms of "ideas on the march," while Norman Foerster examined the interplay of foreign importations and native conditions in terms of four broad factors: Puritanism; romanticism; realism; and the frontier spirit.

Pochmann and Allen themselves emphasize a diversity which has received even greater emphasis in the twenty-some years since they wrote:

> For upwards of two centuries Boston and Cambridge held a position of primacy, and the conventional history treated American literature as the peculiar province of New England, with the result that these earlier studies read strikingly like histories of Harvard College . . . . Scant attention was given to the cavalier tradition of the South . . . , to the literary coteries in Baltimore, Richmond, and Charleston during the nineteenth [century], or, for that matter to the dissenting groups in Puritan New England herself; while the evaluation of so-called "foreign" (that is to say, non-English) strains or influences in American literary culture was entirely neglected until recently.

I shall wish to pursue later that matter of cultural diversity in emphasizing trends which have become clearer since Pochmann and Allen wrote, but for the moment I wish to cite the evidence of a variety of approaches to the presentation of "American Literature" to the consuming public. I shall have to cite, at possibly tedious length, the statements of anthologists in the prefaces to their awkwardly-heavy volumes. And I shall cite dates, for they seem to me significant. Mr. Pochmann and Mr. Allen made their very sensible statement in 1949, after World War II. Three statements of principle published shortly before it may illustrate the diversity of possible approaches, the ways in which, late in the decade of the Depression, two respectable editors could insist on the sole validity of their estheticism while others clung to their sense of a social and historical approach, and yet a third composed his excellent anthology in anticipation of a coming war against totalitarianism.

1938; William Rose Benet and Norman Holmes Pearson, editors of *The Oxford Anthology of American Literature:*

> A man may look at writing as he chooses. We have regarded it as literature. Undoubtedly by the introduction of a social approach, an interest in the history of American letters has been enormously stimulated. This has been occasioned partly by a general concern with social matters and social history; but it has been mostly seized on with a defensive enthusiasm for one quality when the presence of another, the purely literary was not certain. While the endowment of a novel with proletarian significance, or the identification of an essay with the deistic movement, or the recognition of the spirit of democracy in a poem may form the basis of useful estimates, they leave unanswered the stubborn questions of literary values.

The editors themselves answer stubborn questions of literary values only through their selections, and at this point in time some of their discriminations seem, at the least, curious.

1939; Milton Ellis, Louise Pound, and George Weida Spohn in *A College Book of American Literature:*

> All the phases of our literary development have had careful consideration and an effort has been made to combine selections which embody reflections of the political and social history of the age with those which embody their authors' best literary art, without allowing either tendency to go to an extreme.

This is hedging one's bets, but it is at least ninety degrees away from the avowed estheticism of Mr. Benet and Mr. Pearson. A more forthright declaration was made by Bernard Smith in *The Democratic Spirit,* 1941. He was anthologizing for a nation about to go to the wars:

> The motive for the creation of this volume should be obvious. In these days, when we are one of the few peoples that can still cherish democracy, it behooves us to recollect our peculiar tradition and to review its growth so that we may know exactly what it is and not be led into believing it is something else. Here is a noble heritage. We must know it well if we are not to lose it. There are always forces at work to deprive us of it.

By a later shift of interest which Mr. Smith could not have anticipated, his thirty-year-old anthology is more "modern" in the world of 1971 than any which followed it for the next thirty years. Because he worked from the tradition of American idealism he included the work of such black writers as Frederick Douglass, W. E. B. DuBois, Langston Hughes, Countee Cullen, James Weldon Johnson, Claude McKay, and Richard Wright; and he also included Sacco and Vanzetti, Michael Gold, and Albert Maltz, "minority writers," as they are all termed in the very latest anthology, writers almost entirely ignored in other, and very successful anthologies.

By 1956 Sculley Bradley, Richmond Croom Beatty, and E. Hudson Long had produced *The American Tradition in Literature,* probably the most successful anthology of the decade.

> Our effort has been to represent major authors in the fullness of their stature and variety. Besides the titans, we have included writers of lesser stature whose works endure; but no author was introduced primarily for the purpose of illustrating literary or social history. In the same way, works of popular literature and humor have been admitted as literature, not as social or cultural documents.

By 1967, there have been further recognitions for the third edition:

> Since time has brought changes in the prevailing evaluations of American literature, we endeavor to reflect these here, preserving at the same time that organization and editorial attitude which has best served the ever-

> evolving American tradition in literature. The most significant revaluation is, perhaps, the desire to study in greater depth certain nineteenth-century masters—Hawthorne, Melville, Thoreau, Emerson, and Henry James. Another revaluation results in the greater attention paid to the best writers of our own century.

So it goes, and here is the latest statement, from *Literature in America,* 1971, under the general editorship of Robert C. Albrecht:

> This anthology is not a social history despite an organization of topics that could be considered extra-literary. For example, slavery and theology were important to authors of the early period, and they wrote about them in works of indisputable worth. On such issues, we have carefully chosen selections that reflect both the concern of the authors and the quality of their work. We accept a broad definition of literature, yet insist upon the substantial differences between a social-problems reader and a literature anthology.

The publisher is somewhat more forthright in proclaiming the virtues of the anthology, in a letter to Professors of American Literature:

> Now especially, at a time of heightened racial and ethnic awareness, these volumes can serve you remarkably well. *The Modern Age,* in the section titled "Minority Reports," contains the largest selection of works by minority writers of any introductory literature text; included are works by Black, Indian, Jewish, and Hispano–American authors. *The Founding of a Nation* offers a number of works by and about Indians and slaves. *A Century of Expansion,* also rich in material that bears heavily on previously "hidden" aspects of our history, contains works by Black writers, abolitionists, and fragments from the untapped riches of our Indian heritage.

There is an obvious state of tension. The modern anthology is to preserve literary values; it is also to reflect the spirit of the age by presenting the work of minority groups, and this is touted as one of the claims of virtue. It may be virtue, but it is virtue lately revealed.

Besides the changes in "American Literature" which are the product of a changing sense of history—one's way of understanding the past—there are more purely literary considerations which ought to be mentioned, for they, too, change "American Literature." It is not altogether a matter of that changing sense of literary history which I mentioned earlier. For one, there is discovery. The great example for our age is the discovery of the Dead Sea Scrolls, but here at home there was an interesting development in Puritan poetry. No anthology before 1937 includes the work of Edward Taylor, for his manuscript volume passed unregarded through generations of his family until Thomas H. Johnson found it in the Yale library and transcribed the works. Every sophomore now knows that Edward Taylor was the principal Puritan poet, even if Taylor's contemporaries and the scholars of two and a half centuries didn't.

Emily Dickinson is another interesting example. At her death in 1886 she had published few verses, but from manuscripts discovered after her death six hundred and sixty-eight poems were brought forth in successive volumes between 1890 and 1945; and in 1955 Thomas H. Johnson prepared the three-volume variorum text which is the definitive edition of her work. That sophomore, secure in his knowledge of the place of Edward Taylor, also knows that Emily Dickinson was, with Walt Whitman, one of the great poets of the second half of the nineteenth century, although her reputation was made in the twentieth.

There is the other process of rediscovery or revival of interest. Herman Melville suffered neglect until 1924, when Raymond Weaver produced a biography and in the course of research discovered the manuscript of "Billy Budd." Henry James was comparatively unregarded from the second decade of the century until 1934, when a Henry James issue of *Hound and Horn* marked the beginning of an interest that created a scholarly industry. When Malcolm Cowley set out to anthologize *The Portable Faulkner* in 1945, none of William Faulkner's novels were in print, although he had completed the bulk of his best work. The combination of the Cowley volume and the award of the Nobel Prize in 1950 stimulated an interest, and it shows no signs of diminishing. Faulkner, like Taylor, Melville, Dickinson, and James, is safely placed in "American Literature," although the places of all of them have been lately defined.

Conversely, there is the redefinition of the literature by elimination. Everyone understands the disappearance of very popular but admittedly poor work after its day has passed, but I refer now to the destruction of great and lasting reputations when the intellectual and spiritual climate in which they flourished has passed away. Henry Wadsworth Longfellow was the universally known and admired poet of his time, and his reputation abroad was immense; he is the only American honored in the Poet's Corner of Westminster Abbey. Yet it may not be too many years before *The New Yorker* can carry a cartoon of one American tourist looking up at the bust and asking another, "Who the hell was Henry Wadsworth Longfellow?" unless, of course, the editors fear the point will be lost on their readers. Longfellow is not mentioned in the 1963 anthology *Poetry in English* of Warren Taylor and Donald Hall which includes the work of twenty-eight American poets beginning with Philip Freneau. Nor does the name of James Russell Lowell appear. Yet the likenesses of both were familiar to me from one of those framed holy pictures of American middle-class culture heroes which adorned the parlor of my childhood. My mother taught me their verses from memory. They have been eliminated by one of those great changes of climate which destroy whole species.

These discoveries and revaluations are part of what I consider the perennial process of remaking "American Literature." There are conspicuous forces which act over shorter periods of time. In the Thirties, the general concern with social problems led to great emphasis on the literature of social action. A novelist like Thornton Wilder was berated for writing of pre-Christian Greece when Michael Gold demanded to know, "Mr. Wilder, are you a Greek or an American?" and indicted him for frivolity in not writing of the labor struggles of Depression America. The Seventies already oppress me with a sense of *deja vu,* even if the terms have somewhat changed, for the spokesmen of the New Left sound remarkably like the Marxists of the Thirties, like Michael Gold, or Granville Hicks before he left the Communist party. Again there is the equation of literary value and social usefulness in a cause. The New Leftists have made T. S. Eliot their test case. Eliot is open to censure on several grounds—his snobbishness, his anti-Semitism, his neo-fascist attitudes. A teacher of literature who includes Eliot, it is now claimed, is hopelessly reactionary; he should be teaching the literature of protest, or better, not teaching literature at all, but the gospels of Herbert Marcuse or Norman O. Brown. Departments of English should teach sociology or be abolished.

But this seems to me possibly as transitory an emphasis as that of the Thirties. Far more noteworthy is the way in which, travelling down the Mississippi of our literature, we passed the Ohio in the mid-Forties, and the Missouri in the early Sixties. I refer thus metaphorically to recognition of the great contribution of American Jewish writers and American Negro writers. I name the Jewish writers first, for although their claims date only from the turn of the century, they were earlier recognized; Black Americans have a claim going much further back, but only since the activist years of the Sixties have they passed that anthology test. Now there is great eagerness to recognize the claims of other minority groups. And this is good, but over the next decade we shall see the general revaluation process operating, as it always does. The "American Literature" of 1981 will require a new anthology.

DISCONTINUITIES IN DEMOCRATIC SYSTEMS AND MASS SOCIETIES

Charles Redenius

INTRODUCTION

The linkages between democratic political systems and mass societies are explored in this paper. Specifically, an attempt is made to show that there are serious discontinuities between the political system and the social system by examining certain interactions of these two systems. The paper itself is divided into three parts. The first section is largely analytic. It attempts to elucidate the environmental and cultural features that led to the presence of a democratic political system within the context of a mass society. The driving force behind this development has been, and remains, economic modernization. The result of this movement into an industrial culture has been a serious dislocation between the political and social spheres. Although it is widely recognized that certain conditions must be met before it is possible for a democratic political system to emerge, it is not recognized to the same extent that these conditions are not the same as the conditions that sustain a mature democratic political system. Both sets of conditions are set forth and explored in this section.

The second section of the paper describes the discontinuities between the democratic system and mass society. It tries to do this in three principal ways. First, it is argued that democratic theory has remained very stable and has undergone little evolution since the Industrial Revolution. This is not the case with the structure of society. Indeed, it would not be incorrect to say that there have been fundamental changes in the social system. The second method used to describe the discontinuities between the political and social system examines the internal structure of both a traditional society and a mass society. Finally, the discontinuities are described by noting the violations of the laws of social change. The conclusion that is reached is that the dislocations occurred as the result of the failure of democratic theory to evolve, rapid social change, and the fact of inadequate response to the demands generated by the industrial culture.

The third, and final, section is largely prescriptive. This part of the paper tries to show what steps need to be taken in order to bring about a realignment between the political and social systems.

The underlying assumption here is that the political system, or more precisely, the government can bring about the necessary changes.

Since this section is prescriptive, the values behind it should be spelled out. These values are only made explicit here. Neither here nor in the body of the paper are there any arguments to sustain these values. They are simply posited. The values are: that abundance is better than want; that ecological balance is better that ecological imbalance; that fraternity is better than prejudice; and that peace is better than war.

The discussion in this part of the paper centers around four primary areas; the need for new myths to replace the exploded ones; the strengthening of voluntary associations, the basic instrument of the democratic system; the need to stabilize our growing population which aggravates myriad other problems; and a necessary change in our foreign policy from militarism to economic assistance. In short, we must more successfully address ourselves to the changes, and the consequent problems, wrought by the Industrial Revolution.

This research is cross-disciplinary or inter-disciplinary in nature. The footnotes will provide ample evidence of that. With few exceptions, however, the bulk of the research was done in either the behavioral sciences, or those fields with a behavioral orientation. Survey data from opinion polls conducted by both academic and commercial pollsters were an important source that were used in this analysis. The data from these polls were used in two ways: first, as evidence supporting the arguments presented in the body of the paper; and secondly, as an empirical "screen" for assumptions made by authors who either did not utilize such data, or did not consider such data germane to their subjects.

I

Democratic political systems have been in existence for roughly three hundred and fifty years. We can date the emergence of democratic political systems from the seventeenth century where the conflict between absolutism and liberalism was first resolved in favor of the latter.[1] These democratic systems were linked with traditional societies until the advent of the Industrial Revolution. To describe the conjunction of the political system and the social system in this pre-industrial era such terms as classical democracy, aristocratic democracy, and even traditional democracy have been

[1] John H. Hallowell, *Main Currents in Modern Political Thought* (New York: Holt, Rinehart and Winston, 1950), p. 71.

used.[2] Nevertheless, the root meaning of democratic theory remained the same regardless of the social system qualifier used. The qualifiers though did introduce some confusion. This confusion centered around the failure to distinguish clearly between what constituted the political system and what constituted the social system. Indeed, this failure to distinguish between the political and the social has persisted to this day.[3] Although not a part of this paper, the same confusion and failure of discrimination exists in regard to the linkages between the political system and the economic system in the minds of many people, and not all of them laymen.

Thus, by keeping the concepts political system and social system distinct in our minds, we can see that it is both possible and probable that democratic political systems can be and will be linked with social systems having radically different internal structures. This does not mean that such conjunctions will necessarily be harmonious ones. Indeed, the opposite is true in certain cases where dislocations are bound to exist.

The Industrial Revolution can be viewed as the watershed in terms of the internal structure of social systems. Prior to the Industrial Revolution there was only one type of society, the traditional society, although many variations of this type existed. The advent of industrial modernization destroyed this single form of social organization. There now exists three primary types of social systems.[4] First, there still remains the traditional society which is pre-industrial and has not yet begun the move toward economic modernization. Next, there is the transitional society which is gripped by internal conflict between the traditional elite and the industrial managers over the issue of the modernization of the economy. Finally, there is the modern, or the mass, or the industrial society. The terms are used interchangeably in this paper. In this form of social organization economic modernization has been, or is virtually completed. There are, of course, many variations on each of these major types. Indeed, in any organization as complex as a social system it is unlikely that a "pure" type exists.

Thus, the Industrial Revolution created an environment that led to the emergence of mass societies linked with democratic political systems. This development has been accompanied by serious dislocations between the political and social systems. The structure

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[2] Joseph Schumpeter, *Capitalism, Socialism and Democracy* (New York and London: Harper and Bros., 1947), Chapters xxi and xxii; A. D. Lindsay, *The Modern Democratic State* (New York: Oxford University Press, 1962), p. 12.

[3] Sheldon Wolin, *Politics and Vision* (Boston: Little, Brown and Company, 1960), pp. 286–94; David Easton, "An Approach to the Analysis of Political Systems," *World Politics*, IX (April, 1957), p. 383.

[4] William A. Faunce, *Problems of An Industrial Society* (New York: McGraw-Hill, 1968), pp. 27–29.

of the social system linked with a democratic political system changed radically while the structure of democratic theory underwent little change. It should occasion no surprise that the discontinuities in the linkages between the two systems stand in dire need of realignment.

Despite the fact that industrialization led to the transformation of the structure of social systems, it did not immediately work the same transformation on the structure of political systems. Indeed, the effect of industralization on the structure of political systems was a conservative one. The structure of both democratic and non-democratic systems remained relatively stable. Overall, industrial modernization had two primary effects on political systems. First, modernization did not lead to the decline of non-democratic political systems. Secondly, the transformation of the social system that led to discontinuities between the social system and the political system in democratic systems produced the same results in non-democratic systems.

Thus, the societal conditions that act as part of the linkage between the political and social system, and that make a democratic political system possible can be considered only as necessary conditions. They are not the necessary *and sufficient* conditions. Indeed, the possibility of the emergence of a democratic system does not mean the necessity nor does it indicate the degree of probability of such emergence. These societal conditions, then, permit development of radically different political systems.[5] The impact of the Industrial Revolution, which transforms the structure of society, merely continues the further development of these different political systems. Historically, the political systems that have continued their development since the drive toward economic modernization began range from syncratic politics on the right of the political spectrum to stalinist politics on the left.[6] This development has included the linkage of democratic systems with economic systems as different as capitalism, socialism, and the welfare state.

The linking conditions that make a democratic system possible are not the same conditions that sustain a mature democratic political system, that is, a democratic system linked with an industrial mass society. By examining first the conditions that make a democracy possible, and then, the conditions that sustain a mature democracy, it will be possible to observe the discontinuities in part of the linkages between the political and social systems. The conditions that make a democracy possible are four in number. First,

[5] Kenneth Boulding, *The Meaning of The Twentieth Century* (New York: Harper and Row, 1964), pp. 175–76.

[6] A. F. K. Organski, *The Stages of Political Development* (New York: Alfred A. Knopf, 1967), pp. 7–16. The terms are broadened to include all totalitarian systems regardless of their stage of economic development.

there must exist some measure of widespread economic security.[7] In other words, the biological requisities of food, clothing, and shelter must be met in a relatively satisfactory manner. Widespread poverty and want is not conducive to political freedoms. The biological drives of survival and hunger are the two strongest instinctual drives in human beings. If these drives occupy a position uppermost in a man's mind, he will not have time for, or be concerned with, such luxuries as freedom of speech and freedom of association. There exists a hierarchy of needs for human beings, and economic needs must be satisfied before humans concern themselves with political ideals.

Second, the society as a whole must have a relatively high literacy rate.[8] There are no precise parameters to indicate how high this literacy rate must be, but it is safe to assume that it must be well over fifty percent. Literacy is an essential element in the socialization process that must occur if a society is to view itself as a political unit, and as fit to govern that political unit. Without a relatively high literacy rate, this socialization process cannot occur among the entire society, it will be restricted to an elite. Literacy makes possible the communication and interchange of political ideas throughout the entire structure of society.

Third, an acceptance of the dignity of human life is necessary if a democracy is to succeed.[9] The first two conditions seem to be necessary if this one is to be recognized. However, the notion of an intrinsic moral worth of every individual is so central to democratic theory that it must be stated separately. This condition provides the framework for the ideal of political equality—that all men are equal. More than this is meant, however. Men are more than equal to one another, they are brothers. The relationship between democratic citizens is one of fraternity. Non-democratic systems are always paternalistic in some way. The relationship between rulers and ruled in a democracy is one of equals. The same relationship is a non-democratic system is one of superordinate and subordinate.

The final condition that makes a democratic system possible is that there must be a widespread acceptance of the exchange system.[10] This involves a consequent rejection of the threat system. The key difference between a democratic system and a non-

[7] Marian D. Irish and James W. Prothro, *The Politics of American Democracy* (Englewood Cliffs, N. J.: Prentice–Hall, 1965), p. 80.

[8] Lucian Pye, "Transitional Asia and the Dynamics of Nation Building," in Marian D. Irish (ed.), *World Pressures on American Foreign Policy* (Englewood Cliffs, N. J.: Prentice–Hall, 1964), pp. 154–72.

[9] Weston La Barre, *The Human Animal* (Chicago: The University of Chicago Press, 1954), pp. 315–18.

[10] Kenneth Boulding, *The Impact of the Social Sciences* (New Brunswick, N. J.: Rutgers University Press, 1966), pp. 57–58.

democratic system in regard to this condition is that use of the threat system is viewed as normal in a non-democratic system whereas in a democratic system threats, force, and the use of violence are considered extraordinary, and thus, illegitimate. The basic instruments of democracy are the bargain and the compromise, which are the heart of the exchange system.

These, then, are the societal conditions that make a democratic system possible. The democratic systems that emerged were linked with a traditional society. With the coming of the Industrial Revolution the internal structure of society was radically altered. Following industrialization, democratic systems were linked with mass societies. The conditions that sustain a mature democratic system, as noted above, are not the same as the conditions that make a democratic system possible. By contrasting the sustaining conditions with the necessary conditions, the dislocations between the democratic system and the mass society will be readily apparent. The sustaining conditions are also four in number.[11] First, symbols and forms that have continuity and that speak men's language, that is, excite their imagination, must exist. Economic modernization is a traumatic experience. Without the appropriate symbols, that shock may be more than the political system can absorb. The process of modernization necessarily involves the debunking of myths found in the traditional society. The modern democratic system has failed to replace the symbols that have been displaced.

Second, a mature democracy is sustained by a modernized economy and culture. Modern democracies have faltered here because industrialization is an uneven process. Certain parts of the economy are left relatively unaffected by modernization. It is the task of democratic government to direct the forces of industrialization to those parts of the economy. A modernized culture is a by-product of the industrial process. By removing economic backwardness, democratic government insures that the culture does not remain backward.

Third, there must be a reasonable distribution of wealth and power in the community to sustain a modern democratic system. The necessary conditions for a democracy call for a widespread measure of economic security. In a mature democracy the concern shifts from economic security to the distribution of wealth and power. The concentration of wealth and power in the hands of a few violates the pluralism that is an essential part of a modern democracy.[12] The power to redistribute the resources of a modern

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[11] Charles Frankel, *The Democratic Prospect* (New York: Harper and Row, 1962), p. 24.

[12] *Ibid.*

society rests only with the government. The mature democratic systems have failed to act on this responsibility. By not acting in a resolute manner democratic governments have actually encouraged the drift toward greater inequalities in wealth and power. This drift will not correct itself; governmental action is necessary to redress the inequalities.

Finally, mature democratic systems are sustained by civil liberties and a framework of vigorous private groups and associations. The basic civil liberties are effective instruments for maintaining men's loyalty to a political system even when they disapprove of many of the actions of that system. The erosion of civil liberties, and the stifling of dissent, destroys that loyalty and undermines the very basis of democratic government—government by consent. The basic instrument of the democratic citizen, the instrument through which he exercises his civil liberties, is the voluntary association. Democratic governments have been vigorous in protecting civil liberties. The same is not true for voluntary associations. Thus, the exercise of one's civil liberties is often an exercise in futility. Freedom of speech is ineffective without freedom of association.

The role of the government, then, marks the greatest contrast between the democratic system linked with a traditional society and the democratic system linked with a mass society.[13] In the traditional democracy, the role of government is essentially a negative one. It allows, or permits, and in rare cases, promotes, the transition from a traditional society to an industrial society. In the mass democracy, the role of government is essentially a positive one. In addition to promotion, it must also regulate and supervise many of the activities that occur in an industrial society. The contrast between the necessary conditions and the sustaining conditions reveals this change in role very vividly. A large share of the discontinuities between the democratic system and the mass society can be directly attributed to the extreme reluctance of both political leaders and followers in accepting this necessary change in the role of democratic government. These vestiges of cultural lag can be eradicated only by a social learning process that will reeducate both the political leaders and the masses as to the proper role of government in a mass democracy. However, before this social learning process can occur, the seeming stability of democratic theory in the face of extensive structural changes in society must be broken down. That is the task of the second section of this paper. But before turning to that task the figure presented on next page will summarize the arguments of the paper to this point.

[13] Lindsay, *op. cit.*, p. 116, and pp. 245–48.

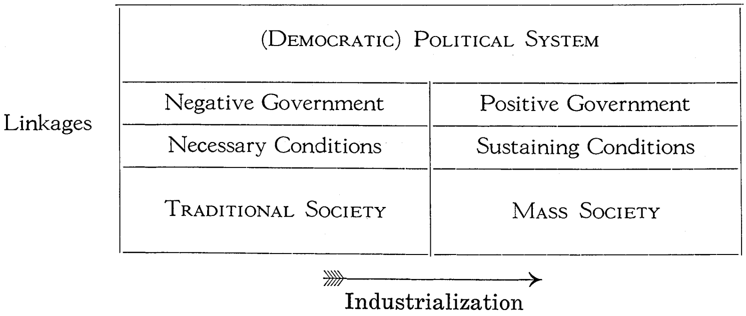

Figure 1.

II

The evolution of the democratic political system has been retarded by the lack of fundamental change in democratic theory. Despite the widespread changes occurring in the economic and social systems, democratic theory has remained very stable. The proof of this stability can be demonstrated by examining four different facets, all of which concern democratic theory. First, the authors writing about democratic theory today are merely restating what authors since the seventeenth century have been saying.[14] In some cases it is refinement of the basic tenets of democracy, and in other cases, it is a working out again of the logical consequences of those basic tenets. In either case, however, the basic tenets of democratic theory—popular sovereignty, limited government, and political equality—have remained virtually unchanged.

Next, democratic political systems have manifested different institutional arrangements, yet the same theory is used regardless of the institutions in the system.[15] Indeed, a particular institutional arrangement takes on a definitional aspect when it is defined as something a democracy is not, such as, democracy is not separation of powers, checks and balances, federalism, and judicial review. This diversity of institutional arrangement in the political system and the unitary quality of democratic theory seems to suggest that the linkages between systems and theory are in need of further exploration. If such an exploration were successful, it might be found that different democratic systems are supported by different democratic theories. On the other hand, the results might show why a single theory permits diverse institutional arrangements to develop.

Third, democratic systems have been linked with economic sys-

[14] Frankel, *ap. cit.*, pp. 33–48.
[15] Schumpeter, *op. cit.*, chap. xxi.

tems that are radically different.[16] Thus, the same argument that was used in the second point would seem to be valid here. Without satisfactory knowledge of the linkages between the political system and the economic system, it is impossible to say why democratic systems are linked with different economic systems. The traditional response to the problem posed here, and in the second point, is to assume that democratic theory remains the same, that is, stable, while the economic system evolves independently of the political system. The fact of the matter might be that democratic theory only appears to be stable, it is quite possible that it evolves right along with the social and the economic systems.

Finally, the greatest revolution in democratic systems since the Industrial Revolution, it seems, has concerned the role of the mass citizenry. This revolution has often been confused with a revolution in the tenets of democratic theory. However, that is not the case. The tenets have remained the same. In the traditional democracy, it was assumed that the citizen was highly interested in, and informed about, political issues. This atomistic individual made rational decisions in pursuit of his self interest. The voting behavior studies have shown that the mass citizenry do not conform to this model.[17] Despite these findings, the voting behavior studies have not brought about dramatic changes in democratic theory. The response has been a call for participatory democracy. The thrust of this movement has been an attempt to remove the obstacles blocking participation in the *system*. Through it all, again, democratic theory appeared to remain unchanged.

Thus, the stability of democratic theory has contributed to the discontinuities between the democratic system and mass society. By examining first, the structure of a traditional society, and then the structure of a mass society, the dislocations between the political and social systems can be described in a second way.

A traditional society is characterized by extended family ties, a face-to-face society, and mechanical solidarity.[18] Social cohesion and integration is the result of the sharing of a common culture or way of life. In this type of society there is very little mobility either in terms of geography or social status. Given this limited mobility there are strong ties to, and a strong sense of, community. Control of behavior is not normally a problem because of the reliance of the internalization of the community's norms. This is

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16 Schumpeter, *op. cit.*, chap. xxii.

17 Paul F. Lazarsfeld, et al., *The People's Choice* (New York: Duell, Sloan and Pierce, 1944); Bernard Berelson, et al., *Voting* (Chicago: University of Chicago Press, 1947); Angus Campbell, et al., *The American Voter* (New York: John Wiley and Sons, Inc., 1960); Angus Campbell, et al., *Elections and the Political Order* (New York: John Wiley and Sons, 1966).

18 Faunce, op. cit., pp. 28 and 170.

the result of a socialization process that stresses internal, or primary, controls rather than external, or secondary controls.

One of the ideals of the traditional society was that of craftsmanship, or imitation. Thus, the pace of change was very slow. Innovation was not a major virtue. Indeed, it occupied a very low place in the hierarchy of communal values, and in some cases, it was even suspect. Thus, continuity, rather than change, was institutionalized in the social system. The coming of the Industrial Revolution transformed the structure of society. The process of economic modernization destroyed the traditional society, and in its place, a mass society arose.

Mass society means more than simply density of population. It means a society where the traditional controls have been shattered.[19] Control of behavior becomes a problem, and increasing reliance is placed on external controls. The specific form of these external controls is the modern bureaucracy. These controls are necessary because there is confusion over the values of the society.

More particularly, a mass society means the breakdown of extended family ties, and the loss of the face-to-face mechanical society. These are replaced by the nuclear family, and the "faceless", organic society. This type of society, for the most part, rests on the fact of interdependence and not on a sense of community. Social cohesion is imperfect and social integration is never fully accomplished. The result is the loss of a sense of community. The effects of this loss are compounded by the shift of the population from small rural towns to large urban centers. Thus, the industrial society is characterized by a high degree of mobility both in terms of geography and social status. Social change is very rapid due to the institutionalization of change at all levels of the society. Innovation replaces continuity as the leading virtue.

The democratic system fails to keep pace with the changes that are occurring, and have occurred, in the social system. The result is serious dislocations between the two systems. Up to this point in time, the democratic systems have still failed to adequately respond to the challenges of industrialization.

The causes for the divergence between democratic systems and mass societies can be described by a third method. That method is to examine the violations of the laws of social change.[20] First, industrial societies, and non-industrial societies that have been affected by economic modernization, have failed miserably to check population growth. Even the most successful countries have only slowed such growth. No country has stabilized its population nor has any country been able to reduce its population.

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[19] *Ibid.*

[20] Kenneth Boulding, *The Organizational Revolution* (Chicago: Quadrangle Books, 1968), pp. 77–80.

Second, although it is widely known today that the culture patterns of a society are transmitted mainly through the instrument of the family, the transition from a traditional to a mass society altered the basic structure of the family almost without notice. This alteration in basic structure left the family unable to adequately carry out its historic function of acculturation. Due to the fact of rapid social change, society also seems incapable of developing the necessary adjunct to the family that would work together with the family to carry out this socialization process.

Third, organizations of all kinds have an optimum size. In the social system today, the most acute problem is how to organize large masses of people without sacrificing liberty and even decency. The political system is faced with the breakdown of its hierarchy. Large democratic organizations with an elaborate hierarchy are faced with a dual problem: the failure of communications from ruled to ruler (and vice versa); and the obvious fact that hierarchy violates the democratic principle of political equality.

Next, there is the social law of oligopoly. This law states that if the number of independent interacting organizations is few a situation of acute instability and conflict will be created. The economic systems of most mass democracies are dominated by oligopolistic firms. The international political system is dominated by three or four great powers. The instability in both of these systems is too obvious to need further comment.

On the other hand, the social law of instability states that the uncontrolled interaction of a large number of organizations produces unacceptable consequences. The Great Depression, for example, was one of those unacceptable consequences. Thus, the political system, or more precisely the government, must steer a middle path between the instability caused by oligopoly and the instability caused by unregulated interaction.

Finally, there is the social law of the persistence of role. Despite the transformation of the social system, the political system has persisted in its role developed for an earlier time. This problem is essentially the same one that has been discussed from two points of view; the stability of democratic theory, and the changes from traditional society to mass society. Therefore, any further discussion of this problem will be unnecessarily redundant.

To say that the causes of the divergence between the political and social systems are clear does not mean that the remedies are going to be easy to implement. Indeed, here is the crux of the problem. We have not developed any instruments that can exercise effective control over these causes. The laws of social change are known to us, but are not controlled by us. The techniques and innovations that are necessary to insure the continuance of democratic systems within the context of a mass society have not yet been discovered, or if discovered, have not been fully utilized and implemented. We have for too long a period of time worked at cross purposes with our biological and social natures. The challenge of our times is to see that mass democratic systems meet and master the problems generated by the industrial culture. If the mass democracies fail, the world will surely turn to the obvious alternative, the non-democratic systems, to view their response to this set of problems.

To summarize the conclusions up to this point, we can state that the discontinuities between the democratic system and the mass society occurred as the result of the failure of democratic theory to evolve, the transformation of the structure of society, and the violation of the laws of social change. Here is a classic example of cultural lag. The ideas of society have not kept pace with technical innovation. This is a consequence of social inertia, that is, a tendency to persist in past modes of thought, and vested interests, a conscious attempt on the part of a few to block change in order to preserve the status quo. It is the task of the final section of this paper to point out some ways which will reduce cultural lag and bring about a better alignment between the political and social systems.

III

The relationship between the democratic system and the mass society as this paper has shown is not one of isomorphic models. Societal changes have led to discontinuities between the two systems. The problem, simply stated, is to remove those discontinuities. The solution to this problem will not be a final one. The best that can be hoped for is that we can bring our problems under rational control and then keep them manageable.[21] It seems rather senseless to waste our time searching for permanent solutions. In a dynamic system change is inevitable. But, given the fact that change is inevitable, we can learn to cope with the dislocations that will occur. Our first step must be to bring the industrial culture under rational control.

An optimum strategy would seem to call for at least the implementation of the following four points. All of these points call for vigorous leadership by the government. The need for such positive government was demonstrated earlier. As these points are operationalized other features may be called to our attention that need amelioration. But the time is past for continued speculation, there is a need for action now.

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[21] Charles Lindblom, "The Science of 'Muddling Through'," in Raymond Wolfinger (ed.), *Readings in American Political Behavior* (Englewood Cliffs, N. J.: Prentice-Hall, 1966), pp. 211–226.

First, there should be a deliberate attempt made to foster new symbols and ideologies for our democratic system.[22] We need new myths to replace the ones exploded by the process of industrialization and by the transformation of society from a traditional base to a mass base. This problem is an especially acute one since politics has replaced religion as the central concern of our time.[23]

It is useless to try to reconstruct the solidarity of the face-to-face society. The unit upon which society relied for the transmission of cultural patterns, the extended family, has been destroyed for the most part by the Industrial Revolution. Even if the extended family had remained intact throughout the transition it would still be impossible to retain the solidarity of the face-to-face society because the values transmitted by such a family structure are the ones that were broken down in order that the process of economic modernization might occur. There is no going back, new values must be fostered, not old ones recaptured. The family unit, now the nuclear family, will still be the primary transmitter of values, but it will be transmitting new values.

What must these new values be like? First, it must be accepted that these values stand somewhere between science and religion, but not contradicting either. Second, these new values must be viewed as relative values and not absolute ones. There is no set hierarchy involved, nor is there a definite content to these values. We must learn to live with openness (uncertainty) and forsake comprehensiveness. Finally, we must also forsake some of the logical constraints of ideology. Democratic values necessarily involve a tension between competing values such as liberty and order, or excellence and equality. There can be no final resolution of these tensions. The incomplete nature of these values allows for their continued evolution. This is a process that is unending if the lessons of history remain true.

Second, the basic instrument of the democratic citizen, the voluntary association must be strengthened.[24] The failure of the democratic system to provide mechanisms that will enhance private groups is one of the discontinuities between the political and social system that is felt most strongly. As mentioned earlier, one of the key differences between traditional society and mass society is the transition from the face-to-face society to the "faceless" society. In this transition there is lost what is perhaps the heart of the traditional society—a sense of community. A sense of community is built on voluntary rather than economic relationships. In the mass society, economic relationships dominate interactions between

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[22] Frankel, *op. cit.*, pp. 20–22.
[23] Ernst Cassirer, *The Myth of the State* (New Haven: Yale University Press, 1961).
[24] Frankel, *op. cit.*, pp. 64–71.

citizens with only one clear exception, the nuclear family. Economic relationships do not seem capable of providing the milieu in which a sense of community can develop. Part of the inadequacy of democratic theory is its failure to recognize the need for a sense of community, that is, vigorous private groups and associations. The principal tenets of democratic theory are clearly negative in character. They have allowed or permitted the rise of a mass democracy but they have not fostered nor encouraged the voluntary associations that would make for a healthy mass democracy.

Specifically, how do we strengthen voluntary associations? First, we must counter non-democratic forms of organizations in our private groups. These groups are the training grounds for democracy, and if they are allowed to deteriorate the socialization process necessary for democratic participation is sure to deteriorate also. Second, participation in a voluntary association must foster more than a sense of involvement, it must also foster a sense of efficacy. Democratic governments can encourage this development by recognizing the vital role voluntary associations play. Private associations are effective intermediaries between the democratic citizen and democratic government when the government is influenced by the opinions of the group. Refusal by the government to listen to the petitions of private groups is sure to lead to feelings of alienation and helplessness. Finally, democratic governments can encourage voluntary associations by providing easier access to the mass media. The technical facilities for strengthening the organizations of private groups are available. We are not making full use of our technical capabilities at a time when it is most important that we do so.

Third, there is a crying need to stabilize the population of mass democracies.[25] As noted earlier, the problem of controlling the size of the population is basically unsolved; no country has a stationary population. Without a stable population it will be nearly impossible for a democratic (or a non-democratic) government to cope with the institutional problems of an industrial society. Such ecological problems as air, land, and water pollution cannot be brought under control when confronted with ever greater and greater demands upon these resources. Many of the urban problems of our society such as waste disposal, education, crime, traffic, and housing are aggravated by population pressure.

The problems of population pressure go beyond national boundaries. Population control is perhaps mankind's most serious long-run problem. We have been practicing death control in both developed and under-developed countries. Indeed, one of the first

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[25] Boulding, *The Meaning of the Twentieth Century*, pp. 121–37.

"benefits" of a developed society that is introduced into an underdeveloped country is death control. Unfortunately, neither society is practicing birth control. One of the effects of unrestricted population growth is the exacerbation of international conflicts. Who can forget Hitler's cry for "Lebensraum." Factions who oppose birth control must face the fact that they are engaged in dangerous warmongering.[26] One author goes so far as to say that the only sound biological solution to the problem of war is massive depopulation.[27]

It would seem that population equilibrium will be achieved only if we can accomplish some of the following: first, we must reform those factions who oppose birth control. This will mean, for example, that the Catholic Church must be convinced of the necessity of adopting a more realistic attitude. Next, we must create social institutions to control population growth. It is social institutions which are dominant in determining population growth and not mere individuals with knowledge of the physiology of reproduction. Thus, the "pill", or other methods of contraception, alone are not enough. Such groups as Planned Parenthood must be fostered, and others created, to insure efficacious population control. Finally, a vast reeducation on the role of marriage and the family in society must be undertaken. Marriage and the family must be viewed now and in the future as primarily an institution of companionship and not procreation. For this reason, the Women's Liberation Movement ought to be supported.

The fourth and final step that is proposed here as necessary to realign the democratic system and mass society calls for a shift from a militaristic foreign policy to one based on economic assistance.[28] It seems a stark fact of life that huge defense expenditures have not increased our security. Increasing defense expenditures beyond what they are today would merely continue a counterproductive policy. Internally, outsize defense expenditures have seriously distorted our domestic priorities. Social and economic inequalities persist, and in some cases, are exacerbated by lack of funding for programs designed to eliminate or reduce these inequalities. In terms of international relations, the "traditional" policies have been miserable failures. This is especially the case with "Third World" countries. Racism and poverty are at least as important a factor as ideology, whether left or right.[29] The white-have world cannot continue to confront the non-white, have-not world with a policy designed to contain communism. That policy does not fit

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[26] *Ibid.;* Desmond Morris, *The Naked Ape* (New York: McGraw-Hill, 1967), p. 178.
[27] Morris, *op. cit.*, p. 177; E. E. Schattschneider, *In Search of a Government* (New York: Holt, Rinehart and Winston, 1969), p. 14.
[28] Edward H. Carr, *The New Society* (Boston: Beacon Hill, 1951), p. 92.
[29] *Ibid.*

the facts very well. We desperately need to return to a foreign policy similar to that carried out under the Marshall plan. Simply stated, instead of continuing arms shipments we should shift to capital investment and technical aid in a scheme of planned international trade. This would enable underdeveloped countries to combat totalitarianism by meeting the requisites of democracy. The surest defense against communism is economic security and not military security. This does not mean we should neglect military security but rather that we should recognize that it is of a lower priority than economic security. The limitations of, and after a point, the counter-productive nature of military security should have alerted us a long time ago to the need for a more viable defense policy.

CONCLUSION

The crisis of our times is not, as commonly depicted, one of ideological confrontation. It goes far deeper than that and actually dwarfs ideological clashes. Indeed, the crisis is more "revolutionary" than the struggles that are occurring. The crisis of our times is the fact of inadequate response on the part of mass democracies to the challenges generated by the industrial culture.[30] This paper has made an attempt to analyze the way in which the discontinuities between the political and social system developed. These discontinuities in the linkages between the two systems were described and the reasons for their persistence, and in some cases, for their exacerbation, were examined. The results of this examination revealed the causes for mass democracy's insufficient reaction to the problems of industrialism. Finally, some of the steps that will be necessary to bring about a realignment of the democratic system and mass society were spelled out. Unless the dislocations between the two systems are removed, it will be impossible for a mass democracy to successfully meet the challenges wrought by the Industrial Revolution. The resources which are necessary to launch this challenge already exist. This paper has demonstrated there is information enough for action. All that is apparently lacking is political will.

[30] Paul Meadows, *The Culture of Industrial Man* (Lincoln, Nebr.: University of Nebraska Press, 1950), p. 2.

THE FIFTH PAN AMERICAN CONFERENCE: PROVING GROUND FOR WARREN G. HARDING'S LATIN AMERICAN POLICY

Kenneth J. Grieb

President Warren G. Harding and Secretary of State Charles Evans Hughes sought to promote friendship with Latin America, and endeavored to reverse the long trend of interventions which had characterized United States relations with that area of the globe through the administrations of Theodore Roosevelt, William Howard Taft and Woodrow Wilson. Harding and Hughes sought stability in Latin America, but proposed to attain this by peaceful means. The United States would continue to act as "big brother" to the Latins, but would rely on diplomatic persuasion and calm counseling instead of force. In this way, with the exercise of a little patience, the desired objectives could be achieved without the expense and ill feeling involved in armed intervention. Harding and Hughes perceived that stability would facilitate American financial penetration far more effectively than military occupation, and hopefully would also terminate the frequent disputes that inevitably entangled the United States. The Harding administration avoided sending troops to Latin America, and by the time the Fifth Pan American Conference assembled in Santiago, Chile in March, 1923, had completed arrangements for the withdrawal of the troops from the Dominican Republic, recalled the detachment from Cuba, and turned most police duties in Haiti over to a native constabulary.[1]

The President went to considerable lengths to demonstrate his cordial feelings toward Latin America. For example, in May, 1921, he attended a Pan American Union reception honoring the Foreign Minister of Venezuela, a gesture which impressed Latin diplomats. Harding also opened a personal correspondence with President Arturo Alessandri of Chile, after Alessandri, in congratulating Harding on his inauguration, commented upon their common affiliation with the Masonic order. Immediately recognizing the oppor-

[1] For the Dominican Republic, see Kenneth J. Grieb, "Warren G. Harding and the United States Withdrawal from the Dominican Republic," *Journal of Inter-American Studies*, XI, 3 (July, 1969), pp. 425–440. For the Cuban withdrawal see Russell H. Fitzgibbon, *Cuba and the United States: 1900–1935*, (Menasha, Wisconsin, 1935), p. 161, and New York *Times*, January 27, 1922. The instances of Cuba and Haiti, will be treated more fully in a volume dealing with Harding's Latin American Policy, which the author is presently preparing.

tunity, Harding responded in a letter addressed to "My dear and worthy brother Alessandri," stressing their union in "fraternal friendship." Although the succeeding missives seldom touched on important questions, they did promote understanding, especially in view of Latin *personali-smo*.[2] This correspondence may well have influenced Chile's decision to accept arbitration of the Tacna–Arica dispute by Harding. To further demonstrate United States' friendship, the President dispatched Hughes to the inaugural session of the Brazilian Centennial exposition of 1922 in Rio de Janeiro. Harding and Hughes went beyond declamations, and endeavored to demonstrate their sincerity through actions. Instead of dispatching troops to Cuba under the Platt Amendment they relied on General Enoch Crowder, using political rather than military intervention.[3] In addition to the troop withdrawals previously cited, Harding devoted considerable effort to securing Senate approval of the treaty returning the Isle of Pines to Cuba, and also persuaded the Senate to give its advice and consent to the accord compensating Colombia for the seizure of Panama.[4] Both of these agreements had been previously rejected by the Legislature, and their approval removed longstanding grievances that had served as festering sores stimulating resentment in Latin America.

Harding also wished the United States to assume an active peacemaking role in settling disputes between Latin American states. His offer to arbitrate the Tacna–Arica controversy is the best known example, but was not his only effort.[5] In 1922, during an informal visit to the White House, President-elect Pedro Nel Ospina of Colombia requested American aid in reopening diplomatic relations with Panama. Harding enthusiastically wrote Hughes: "I realize very well that this is none of our affair. . . . However, so long as we play the role of big brother, I suppose we shall have errands of this sort to perform." The President suggested: "perhaps our Minister in Panama might make informal and wholly discreet inquiry as to diplomatic representation in Colombia. Please

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[2] Dr. Leo S. Rowe to Harding, May 12, 1921, Papers of Warren G. Harding, Ohio State Historical Society, Box 141; and Arturo Alessandri to Harding, March 21, 1921, and Harding to Alessandri, May 2, 1921, Harding Papers, Box 693. Other letters from the exchanges may also be found in the Harding Papers.

[3] See Charles E. Chapman, *A History of the Cuban Republic,* (New York, 1927), pp. 413–449, and David A. Lockmiller, *Enoch H. Crowder: Soldier, Lawyer, Statesman,* (Columbia, Missouri, 1955), pp. 230–246.

[4] For the Colombian Treaty see E. Taylor Parks, *Colombia and the United States: 1765–1934,* (2 ed. New York, 1968), pp. 440–460. There are no satisfactory treatments of the Isle of Pines Treaty available in secondary literature.

[5] The United States was also active in several other disputes, such as the Panama–Costa Rican war, and the attempt to form a Central American Federation. See for example, Kenneth J. Grieb, "The United States and the Central American Federation," *The Americas,* XXIV, 2 (October, 1967), pp. 107–121. For the Panamian–Costa Rican Conflict, see William D. McCain, *The United States and the Republic of Panama,* (Durham, North Carolina, 1937), pp. 206–221.

note that I make no suggestion of formal proceedings. If we can discreetly and helpfully broach the subject . . . it would be a wholly becoming thing to do."[6] Hughes proved reticent, but eventually mediation was undertaken. This incident provided a clear illustration of Harding's technique. As a practical politician, he realized the value of informal and friendly exchange, and was accustomed to working tactfully and discreetly, without a formal commitment. While the President was a neophyte in the field of foreign policy, and was unacquainted with the diplomatic background of the questions, his political training had provided him with a thorough understanding of the methods involved. Harding was well aware of his limitation, and constantly badgered the State Department for position papers and background memoranda.[7] When presented with the full particulars of a question, he had no difficulty perceiving the proper course, and recognized sound advice when it was provided. To facilitate their policies, Harding and Hughes sought able diplomats to represent the United States in Latin America. They carefully selected career envoys for the most sensitive posts, and the Chief Executive found other positions for political nominees, contrary to the image normally presented in standard texts.[8]

The Fifth Pan American Conference took place, therefore, during a period of improving relations between Latin America and the United States. Inevitably, such an assemblage of diplomats from throughout the hemisphere would provide both a barometer to measure the success of previous administration policy innovations, and a vehicle useful in advancing the administration's principal objective in the region—improving the diplomatic atmosphere by dissipating mistrust of the Colossus of the North. Harding and Hughes shrewdly perceived that such a conference could effectively contribute to a transformation of the milieu of inter-American relations, rather than serving as a forum for political settlement.

Selection of the American representatives was crucial. Hughes was "a little anxious about commitments that may be made at the White House," for the President was under "very great pressure"

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6. Harding to Hughes, May 5, 1922, Papers of Charles Evans Hughes, Manuscript Division, Library of Congress, Box 24.

7 There are many items in the Harding papers and State Department papers indicating that the President requested such memoranda. See for example Hughes to Harding, November 17, 1921, United States Department Papers, National Archives, RG 59, 813.00/1145a, in which Hughes transmitted a memorandum to the President "in accordance with your request." Hereinafter State Department Papers will be cited by slash number only.

8 The Harding image has been considerably distorted in standard historical texts, and considerable revisionism is presently underway, using the information revealed by his papers. The outstanding example to date which indicates the erroneousness of the standard Harding image, and reveals prudence in the appointments to many positions, is Robert K. Murray, *The Harding Era: Warren G. Harding and his Administration,* (Minneapolis, 1969).

from Senators "anxious to have constituents appointed,"[9] but the delegation was carefully chosen. The President named Henry P. Fletcher as chairman. Although Fletcher was then serving as ambassador to Belgium, he possessed extensive experience in and was widely known in Latin America, and had formerly served in the host country. A close friend of the President, Fletcher had served as Undersecretary of State throughout the first year of the administration, during which he was "a full member of the golf cabinet."[10] Fletcher's appointment was acclaimed by the American and Latin American press, and the President of Paraguay told the American minister in Asunción that: "He was particularly pleased with the selection of Mr. Fletcher, who from long experience with Latin temperament, will be able to accomplish more than any other person."[11] The selection of Dr. Leo S. Rowe, Director of the Pan American Union, provided the American delegation with another individual knowledgeable about and well known in Latin America. George E. Vincent, head of the Rockefeller Foundation, and Frank C. Partridge, a former minister to Venezuela, were also chosen. Contrary to the usual image of Harding, the Chief Executive side-stepped pressures from legislators in behalf of constituents, by selecting two Senators, Frank B. Kellogg of Minnesota, a Republican, and Atlee Pomerene of Ohio, a Democrat. Former Senator Saulsbury of Delaware and Washington attorney William E. Fowler completed the list.[12] By selecting Senators, Harding assured support for the ratification of any agreements. The delegation thus represented an astute compromise between ability and political expediency. Harding correctly discerned that Fletcher, by virtue of his experience and friendship with both the Chief Executive and the Secretary, would dominate the delegation.

There was considerable speculation that the Secretary of State would attend the conference and Harding strongly urged him to make an appearance. The President viewed this as a means of dramatizing American friendship for Latin America, and when Hughes proved reluctant, Harding placed considerable pressure upon him. As early as November 28, 1922, he wrote the Secretary: "If the circumstances are such that you can arrange to go and

[9] Dr. Leo S. Rowe to Henry P. Fletcher, November 10, 1922, Box 9, Papers of Henry P. Fletcher, Manuscript Division, Library of Congress; and Rowe to Fletcher, January 15, 1923, Fletcher Papers, Box 10.

[10] Hughes to Fletcher, January 5, 1923, State Department Papers, 710 E. 002/2a; Hughes to Harding, January 6, 1923, and Harding to Hughes, January 6, 1923, 710 E. 002/3; Fletcher to Harding, January 10, 1923, Fletcher Papers, Box 10, Fletcher to Hughes, January 10, 1923, Hughes Papers, Box 21, and New York *Times*, March 4, 1923.

[11] New York *Times*, March 4, 1923; and William J. O'Toole (United States Minister in Paraguay) to Hughes, February 12, 1923, reporting the remarks of President Ayala, 710. E. 002/85.

[12] Hughes to Fletcher, January 31, 1923, 710 E. 002/161.

open the conference I think it would be an exceedingly fine thing to do. . . . I think the benefits accruing from your visit to Brazil might be duplicated by a visit to Chile. I should be happy to promote such visits on your part as will tend to enhance our relations with South American states."[13] The Secretary however, had no desire to attend the conference, since he regarded Pan American Conclaves as mere "friendship festivals."[14] While assuring the Chief Executive that he would "do all in my power to aid our Latin American relations," he continued: "I confess . . . that I have no love whatever for speechmaking trips." Harding replied that he would discuss the matter with Hughes personally, indicating that he still favored an appearance by the Secretary.[15] Obviously, Harding was far more aware of the value of personal diplomacy than was Hughes, and in this sense the President was ahead of his time.

Hughes yielded to Harding's admonitions, and accepted a Chilean invitation to attend the inaugural session of the conference, but reversed himself at the last moment, citing the "press of work" in Washington, and ignoring renewed appeals from Harding.[16] The Secretary's action appears particularly regrettable in view of his success at the Sixth Pan American Conference in 1928, and in this context Harding was certainly perceptive in urging Hughes to attend the Santiago conclave. Yet, in retrospect, perhaps the absence of Hughes benefited the United States, for the appointment of Fletcher assured American success at Santiago. With his knowledge of Latin temperament, Fletcher was more subtle and less committed to rigid legalism than the Secretary, and consequently was able to secure American ends more tactfully, remaining pliant, stressing cooperation, and exuding friendship. This was the very embodiment of the tactics Harding advocated and hoped to make the basis of hemispheric understanding.

Problems began before the conference convened, as Mexico declined the invitation, citing the fact that its dispute with the United States denied it representation on the governing board of the Pan American Union, which prepared the conference agenda. That body's membership was limited to the representatives of the respective states in Washington, and diplomatic relations between the United States and Mexico remained severed. While Chile invited Mexico to the conference, the Mexicans considered it beneath

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[13] Harding to Hughes, November 28, 1922, Harding Papers, Box 361.

[14] Charles Evans Hughes, *The Pathway of Peace,* (New York, 1925), pp. 137 and 160, and Murlo J. Pusey, *Charles Evans Hughess,* (New York, 1951), p. 55.

[15] Hughes to Harding, November 28, 1922, Hughes to Harding, December 1, 1922, and Harding to Hughes, December 1, 1922. Harding Papers, Box 361.

[16] Hughes to Fletcher, January 5, 1923, 710 E. 002/2a; New York *Times,* January 14, 1921, January 31, 1921, February 27, 1923, March 4, 1923, and William Miller Collier (United States Ambassador in Chile) to Hughes, March 3, 1923, 710 E. 022/66.

their dignity to attend after being unable to contribute to the agenda, and charged that the Yankees were deliberately seeking to exclude them. When Chile and Brazil informed Washington that they desired Mexican participation, Hughes replied that although the United States did not object to the presence of Mexico at the Santiago conference, and despite continuing negotiations with Mexico, "It would be quite impossible for this Government to enter into treaties with a government which has not been recognized."[17] Hughes' inflexible stand forced the Latins to choose between Mexico and the United States, but this caused little difficulty in view of Mexican intransigence.

The governments of Peru and Bolivia also abstained from participating in the conference. These nations feared that the conclave might attempt to compel them to accept some settlement of the Tacna–Arica dispute, and also objected to a meeeting in the capital of the nation which they felt had committed a transgression.[18]

When the conference convened on March 25, 1923, Ambassador Fletcher immediately became the focal point. Chilean crowds lining the streets cheered him as he passed through the city, and delegates applauded when he entered the inaugural session. Senator Pomerene was awed by the "most flattering ovation" Fletcher received, and wrote Hughes: "You have named the right man for chairman of our delegation." Chilean President Arturo Alessandri, who opened the conclave, presented the original manuscript of his keynote address to Fletcher, a gesture which clearly demonstrated both the ambassador's popularity with Latin diplomats[19] and the success of Harding's policies.

The chairman of the American delegation deftly worked to secure maximum benefits for the United States, without ruffling Latin feelings. Fletcher needed all his diplomatic skill to blunt the vestiges of suspicion of the United States, since the conference agenda was studded with political topics, which appeared in greater profusion than at previous Pan American conferences. Debate on any one of these controversial questions could become anti-American, and the chairman of the American delegation was compelled to oppose some of the aspirations of the Latin diplomats which clashed with American policy. Fletcher had to simultaneously promote good will and defend his country's interests.

Realizing that the Latins would raise the question which had kept Mexico from the conference, Dr. Leo S. Rowe Director of the Pan American Union, offered a proposal to broaden the pow-

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[17] New York *Times*, January 13, 1923, and Hughes to Fletcher, March 5, 1923, Hughes Papers, Box 21.

[18] New York *Times*, March 25, 1923.

[19] Atlee Pomerene to Hughes, March 28, 1923, 710 E. 002/89; and Fletcher to Arturo Alessandri, April 5, 1923, Fletcher Papers, Box 10.

ers of the Union, and permit it to consider political questions. Costa Rica proposed a board composed of delegates accredited directly to the Union, to enable a government denied United States recognition to retain its representation. Most of the Latin American nations supported this plan. The resulting compromise sanctioned appointment of a special representative by any government that so elected, accepted Rowe's proposals, and also provided for an elected board chairman, terminating the automatic appointment of the American Secretary of State; though the practice of electing the Secretary continued.[20]

Given Latin American membership in the League of Nations, questions relating to the world body were implicit throughout the conference. Agustín Edwards, a Chilean diplomat then serving as President of the League of Nations, was elected President of the Pan American Conference. Edwards saw no conflict in this dual post, contending that the League had promoted Pan American solidarity by bringing the Latin nations together in a voting block at the world body.[21] Yet such parallels raised suspicions in the United States, due to the passionate feelings aroused by the dispute over League membership. The New York *Times* commented satirically that the discussion of "League plans" at Santiago "will compel the State Department to admit that the League of Nations exists, or else walk out of the conference. If our delegates walk out," the *Times* continued, "Pan American harmony will have been destroyed; if they admit that there is a League of Nations, Henry Cabot Lodge will be stultified, and Heaven knows what harm may happen to the Republic."[22]

In accordance with a suggestion by Uruguayan President Dr. Baltasar Brum some three years earlier, several delegations advocated the formation of an American League of Nations.[23] The proposed Charter contained a provision continentalizing the Monroe Doctrine that caused considerable debate. Dr. Brum advocated Latin support for the Doctrine, in order to transform it into a multi-lateral instrument, which would be enforceable jointly, but the United States steadfastly insisted that the Monroe Doctrine must remain a unilateral policy.[24] Although the proposal died in the face of determined opposition by the United States, the fact that the American delegation had not prevented discussion of the idea was significant. A Costa Rican suggestion for an all American Court of Justice, raised another question the United States

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[20] New York *Times,* April 5, April 10, April 17, and April 19, 1923.

[21] "The Fifth Pan-American Conference," *Current History,* XVII (1923), pp. 184–188, and Augustín Edwards, "Latin America and League of Nations," *Current History,* XVII (1923), pp. 181–183.

[22] New York *Times,* July 11, 1922.

[23] New York *Times,* July 16, 1922.

[24] New York *Times,* March 24, and May 2, 1923.

preferred to avoid, but the Latins themselves were by no means agreed on the establishment of a court, and the proposal was deferred.[25]

Arms limitation provided an additional perplexing issue. The futility of seeking agreement on limitation of ground forces was readily apparent, and discussion was restricted to naval limitation, following the example of the Washington Disarmament Conference. Naval limitation, in turn, hinged on agreement between Argentina, Brazil, and Chile, which possessed the largest fleets. But the A.B.C. countries deadlocked, and the only result was an agreement to continued talks between them.[26]

The outstanding development of the Fifth Pan American Conference that resulted in a concrete agreement was the adoption of the Treaty to Avoid or Prevent Conflicts between the American States, also known as the Gondra Treaty, after its sponsor, Dr. Manual Gondra of Paraguay. The signatories pledged to submit all outstanding disputes to an International Commission of Inquiry, which would tender a report after a six month study. While the decision would not be binding, the respective states would be required to refrain from initiating war preparations during the investigation and the succeeding six months.[27] Thus the treaty functioned in the same manner as the Bryan "cooling off" treaties, merely multilateralizing the process. The plan assumed that postponing hostilities would prevent their outbreak by allowing time for negotiations. Presumably the other American states would apply pressure for a settlement during the interim, although the treaty did not commit them to do so.

The delegates also codified a number of technical matters. A convention providing for publication of passport regulations and standardization of forms to facilitate intercourse among the several states was approved. Another agreement established standard nomenclature for commercial shipping of merchandise, to stimulate trade. The conference also approved a convention providing reciprocal protection for copyrights, trademarks, and commercial names.[28]

Fletcher's ability to uphold American policy in a subtle manner drew praise when the conference adjourned May 3, 1923. Dr. Rowe hailed "the masterly way in which you have handled the work of the Delegation," while Senator Pomerene wrote Harding: "You

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[25] New York *Times,* April 6, and April 29, 1923.

[26] Washington *Post,* April 7, 1923, and New York *Times,* April 12, April 18, and April 19, 1923. See also *Current History,* XVIII (1923), pp. 924–925.

[27] Washington *Post,* April 16, 1923; New York *Times,* May 12, 1923; and Pan American Union, *Tratados y convenciones suscritos en la Quinta Conferencia Internacional Americana, Serie sobre derecho y tratados,* No. 19, (Washington, 1949).

[28] New York *Times,* April 3, 1923, and Pan American Union, *Tratados convenciones suscritos en la Quinta Conferencia, passim.*

made a ten strike in naming Ambassador Fletcher as chairman of this Delegation. He is very popular here among the Chileans and all South Americans."[29]

From the viewpoint of the Harding administration, the conference was a resounding success. A change in atmosphere was the key objective, and the United States delegation attempted to exude good will and allow the Latins to feel free to express their views. Despite the fact that Fletcher became the focus of attention at the conclave, he nevertheless refrained from commenting on the questions under consideration until the Latin delegates had stated their positions. This change in the role of the United States delegation constituted the pivotal factor in setting the mood of the conference. As a result, in the words of one observer, for "the first time in the history of these conferences . . . the Latin Americans felt they could freely speak their minds." So successful was the American delegation at cultivating good will and listening to Latin views, that domestic press criticism of the conclave was answered from Latin America. Taking exception to a New York *Evening Post* editorial criticizing the defense of the Monroe Doctrine as "imperialism," *El Mercurio* of Santiago replied: "The North American delegation observed such a deferential and respectful attitude toward all the other republics that without a doubt they succeeded in convincing all the delegations that the United States does not follow an imperialistic policy, nor seek to impose its policies, but seeks harmony of interests, and cordiality founded on mutual respect and equality of treatment."[31] Such a comment would scarcely have been possible at earlier Pan American conclaves, and it reflected the success of the Harding policy.

Fletcher reported to President Harding and Secretary Hughes that: "The frank, free, full discussions had made the conference a success as far as the establishment of better and more friendly relations among the American nations was concerned."[32] The Americans did not go to Santiago seeking any spectacular agreements. The Harding administration desired only to dissipate the residue of ill feeling that remained from previous American actions, and create a new spirit to facilitate mutual understanding. Withdrawing objections to the discussion of political issues was one way to show the new policy of friendship, but this did not mean sanctioning the policies. The Americans desired only an airing of views. That they succeeded in obtaining this without an excessive

[29] Alessandri to Fletcher, May 7, 1923, Fletcher Papers, Box 10; Rowe to Fletcher, May 3, 1923, Fletcher Papers, Box 10; and Pomerene to Harding, May 4, 1923, Fletcher Papers, Box 10.

[30] *Current History*, XVII (1923), p. 923.

[31] *El Mecurio* (Santiago), August 22, 1923.

[32] New York *Times*, June 1, 1923.

amount of anti-American tirades, was certainly an accomplishment.

If the results of the conference appear somewhat limited at first glance, this is because the item of greatest significance, the change in atmosphere, could not be recorded in an agreement. The New York *Times* noted editorially that the results would disappoint the idealists but cheer the realists.[33] Discussion of numerous political questions represented a significant step along the road of Pan Americanism, and although the resulting disputes could not be resolved, the airing of the controversial issues was an important transition. The accomplishments of the conference were more extensive than the treaties indicate.

The Harding administration thus secured its ends at the Fifth Pan American Conference, and this accomplishment indicated the skill with which it pursued its goals. Harding shrewdly focused upon realistic objectives, and prudently selected a delegation chairman whose skill matched his objectives. The combination of careful advance preparation and able representatives brought success for Harding's practical common sense approach to diplomacy. Thus the Fifth Pan American Conference both contributed to his objectives and demonstrated the success of his policies.

[33] New York *Times,* May 12, 1923, and Samuel Guy Inman, "Pan-American Unity in the Making," *Current History,* XVII (1923), p. 919.

FOOD HABITS OF THE COHO SALMON, *ONCORHYNCHUS KISUTCH*, IN LAKE MICHIGAN

Margaret A. Harney and Carroll R. Norden

ABSTRACT

The stomach contents of thirty-six coho salmon, *Oncorhynchus kisutch,* taken from southern Lake Michigan were examined. The contents were identified and the numerical and volumetric methods used to analyze the data. The results indicated that the coho salmon in Lake Michigan is primarily piscivorous. Fish comprised 96.9 percent by volume of the coho's diet and the alewife accounted for 62 percent of the total stomach contents. Other items included in the coho's diet were smelt, stickleback and insects.

INTRODUCTION

The coho salmon, *Oncorhynchus kisutch,* were stocked in Lake Michigan in the spring of 1966 by the Michigan Department of Natural Resources (Borgeson, 1970). They were stocked in the lake to serve as a predator on the alewife and to convert their fish flesh into a valuable sport fishery. Since the 1950's, the alewife population in Lake Michigan has increased dramatically. The increase in the alewife population followed the decline and virtual extinction of the lake trout as a result of changing lake conditions and to the marine lamprey. As often happens, when a top predator is lost from an ecosystem, the organism that had served as its prey increased unchecked. It was hoped that coho stocked in the lake would replace the lake trout as one of the top predators and would help to control the alewife population. The objectives of this study were to determine the food habits of the coho in Lake Michigan and to determine whether the coho were in fact preying upon the alewife.

MATERIALS AND METHODS

The stomach contents of thirty-six coho salmon were examined. The coho were caught by gill net in Illinois waters of Lake Michigan between March 28 and May 1, 1968. Two main collections were made, one on April 11, 1968 and the other on April 22, 1968. The stomachs were removed by severing the gullet and the intestine behind the plyoric caeca and then placed in 10% formalin. A binocular microscope was used to identify the stomach contents.

Contents rendered unrecognizable either through mastication or digestion were classed as unidentifiable. The quantitative analysis was done by water displacement in which the volume of each item of food was expressed as a percentage of total volume of stomach contents. The frequency of occurrence was recorded as the number of samples in which each food item occurred and as a percentage of the total number of specimens which contained food. The relative importance of each food item was also determined using the numerical method. The results were reported as a percentage of the total number of organisms consumed (Lagler, 1956).

RESULTS

The coho salmon in Lake Michigan was mainly piscivorous and fish comprised 96.86 percent by volume of their diet (Table 1).

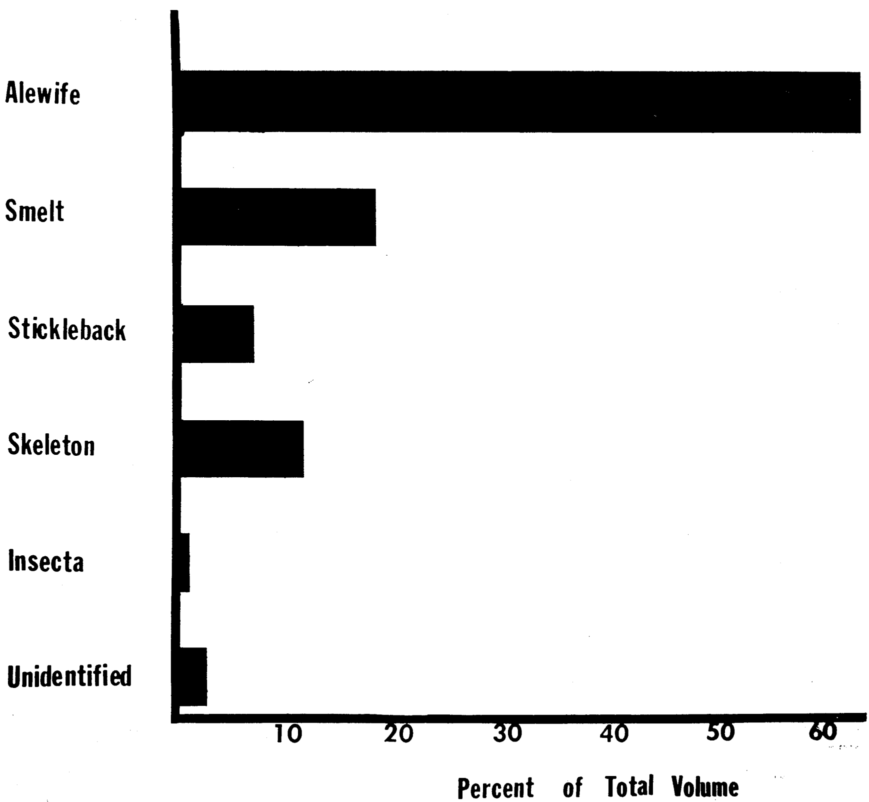

FIGURE 1. Percent of total, by volume which each food item contributed to the diet of the coho salmon taken from southern Lake Michigan during the spring of 1968.

Alewives comprised 62 percent of the total volume followed by smelt with 17 percent (Fig. 1). Stickleback and other fishes made up an additional 18 percent whereas insects were of minor importance, less than one percent (Fig. 1). Alewives were found in 50 percent of the stomachs which contained food (Fig. 2) and accounted for the largest amount of food by volume (Table 1). They were not, however, the most numerous organism in the stomach but this was due to the fact that two coho stomachs contained many small smelt. In addition to alewife and smelt, the cohos also consumed several sticklebacks. These three species were the only species of identifiable fish found in the cohos' stomachs.

Discussion

It was found that 14 stomachs or 38.9 percent were empty. This was considered a rather high proportion of empty stomachs. LeBrasseur (1966) caught four species of Pacific salmon in gill nets set for 10-hour periods (overnight). He analyzed the stomach

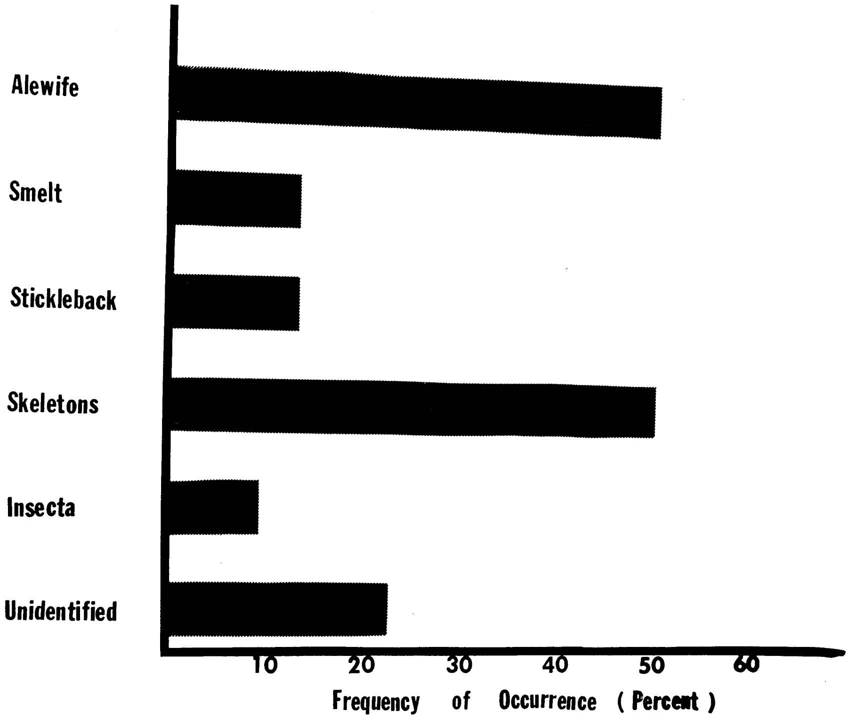

FIGURE 2. Frequency of occurrence of each food item in the diet of the coho salmon taken from southern Lake Michigan during the spring of 1968.

TABLE 1. FOOD OF COHO SALMON TAKEN FROM SOUTHERN LAKE MICHIGAN DURING THE SPRING OF 1968.

ITEM	NO. STOMACHS WITH ITEM	FREQUENCY	NO. OF ORGAN-ISMS FOUND	% OF TOTAL ORGANISMS	VOLUME CC.	% OF TOTAL VOLUME	% OF FISH CONSUMED BY NUMBER	% OF FISH CONSUMED BY VOLUME
Alewife	11	50.00%	12	21.05%	132.4	62.01%	27.90%	64.07%
Smelt	3	13.63	26	45.61	36.6	17.14	60.46	17.69
Stickleback	3	13.63	5	8.77	13.1	6.14	11.62	6.33
Skeletons	11	50.00	12	21.05	24.7	11.57	—	11.84
Insecta	2	9.09	2	3.50	0.8	0.37	—	—
Unidentified	5	22.72	—	—	5.4	2.53	—	—
Total			57	99.98	213.5	99.76	99.98	99.93

Total Number Stomachs Examined	36	
Stomachs Empty	14	38.88%
Stomachs with Food	22	61.11%

Volume of Fish and Fish Parts	206.8 cc.	96.86%

contents of the four species and found that the coho had the highest incidence of empty stomachs, up to 43 percent whereas the chum salmon had the least, only three percent. LaBrasseur (1966) postulated that chum fed early in the evening as the nets were being set whereas pink, coho and sockeye tended to feed in early morning about the time the nets were being retrieved.

In Lake Michigan the principle food of the coho was fish, (96.86 percent) whereas in other studies crustaceans and insects formed a much greater share of the coho's diet. Stanley (1937), Hasler (1938) and Hasler and Farner (1942) reported that the main foods of coho in Crater Lake, Oregon was daphnia, midges and caddis flies. The food of the coho salmon in certain Oregon streams consisted mainly of Diptera and Ephernormoptera (Rees, 1959). The principle food of the coho salmon in Cultus Lake, British Columbia (Ricker, 1946, 1952) was midges, particularly in the spring.

Most of the food studies of coho have been done on fish taken in open waters off the coast of Oregon and British Columbia. The diet of coho in the northeast Pacific consisted of squid, fish (including smelt, anchovies, herring, lantern fish, hake, whiting, other coho, black cod and rockfish) crustaceans such as amphipods, euphasids, and crab larvae, and jellyfish, (Prichard and Tester, 1943; Fraser, 1946; Oregon Fish Commission, 1949; Van Hyning, 1951; Prakash and Milne, 1958; Roos, 1960; Prakash, 1962; Reimers, 1964; LeBrasseur, 1966; Grinolds and Gilt, 1968; Manzer, 1968, 1969; Ueno, 1969).

The relative importance of each type of food depended on where the fish was caught and what was available in the environment at the time of capture. A number of the authors commented on the wide variety of food eaten by coho and expressed the idea that the coho is an opportunistic feeder, feeding upon what is available at the time (Prakash, 1962; Reimers, 1964; LaBrasseur, 1965).

LeBrasseur (1965) compared the diets of pink, sockeye, chum, coho and steelhead trout taken from different areas of the northeastern Pacific Ocean. He found more correlation of stomach contents among all species from one area than among members of one species taken from the four fishing areas. He also noted that a small change in the availability of some organisms could produce significant changes in the stomach contents.

In the present investigation, alewives made up a major portion of the stomach contents of the coho probably because they are opportunistic feeders and the alewife is the most abundant fish in Lake Michigan (Smith, 1968). Crustacea were an insignificant part of the diet of Lake Michigan coho as compared to Pacific coho because the open lake lacks the numbers of crustacea that are present in the Pacific.

ACKNOWLEDGEMENTS

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LIMNOLOGY OF SOME MADISON LAKES: ANNUAL CYCLES

Kenton M. Stewart and *Arthur D. Hasler*

ABSTRACT

Detailed studies of Lakes Mendota, Monona, and Waubesa at Madison, Wisconsin, provide a comparison of their annual cycles and the influence of climatic variations on their thermal regimes. Lake Waubesa integrates the influence of wind velocity, air temperature, and solar radiation most rapidly whereas Lake Mendota responds most slowly. Although Lake Monona is still dominated generally by climatic influences, the cultural influences of thermal discharges now causes the ice to depart in spring at a significantly earlier date than the other two lakes. The clarity of the Madison lakes generally decreases from Mendota to Monona to Waubesa.

Although all three lakes are basically eutrophic dimictic lakes with anoxic conditions developing in the lower waters during summer stratification, Lake Waubesa may have aperiodic overturns during summer.

Comparisons of temperature, oxygen, Secchi disk, photometer readings, and ice thickness in Lake Mendota show relatively little change from the early studies of Birge and Juday several decades ago.

I. *Introduction and Background*

The fascinating thing about lakes is that they provide their own variety. The task of the limnologist is to measure and interpret this variation whether it concerns physical, chemical, or biological phenomena.

This paper is an attempt to compare the annual cycles of selected variables, measured during the same time period, in Lakes Mendota, Monona, and Waubesa at Madison, Wisconsin.

In temperate dimictic lakes, the greatest range of variation for any variable occurs sometimes during the annual cycle. Therefore, an examination of selected variables over the course of at least one annual cycle, provides some tentative limits by which to judge past, present, and future events in the system. As the number of years of investigation increases, the limits and expected changes become defined more clearly and valuable base line data are established. In addition to the fluctuations of the annual cycle, there are seasonal, daily, and some second-by-second changes that challenge the interpretation of the investigator. A lake may serve as a multi-ring circus in which it is impossible to observe everything at one time, but if one attends frequently a more thorough appreciation and understanding of the whole system can be gained.

Early illustrations of annual cycles in Lake Mendota were provided by Birge and Juday (1911), and some unpublished data of Birge (Neess and Bunge, 1956, 1957). In the latter references, several years data on lake temperatures were presented. Even these data, though extensive, were accumulated mostly during the ice-free season of the year. The general lack of winter data, when compared to those of the summer season, is common for limnological investigations throughout the world and provides a summer bias in our interpretation of lake events.

In addition to their studies of annual cycles of temperature and oxygen, the contributions of Birge and Juday (1929, 1931, and 1933), concerning solar radiation and transparency in water, were significant.

It is surprising, in light of Birge's interest in comparative lake studies, that investigations of other Madison lakes besides Mendota were so slighted. How much better would we have been able to understand lakes generally and changes in the Madison lakes specifically if Birge had concentrated his efforts in comparative studies there?

II. *Methods and Procedures*

The thermal measurements were made with a Whitney thermometer at four selected stations (Fig. 1) in the three Madison lakes considered in this paper. The accuracy of the thermometer was maintained at $\pm$ 0.1°C and rechecked frequently with precision mercury thermometers.

Measurements of transparency and light were made by several different instruments. A Secchi disk (20 cm diameter, all white) was used to gather general transparency information. The G. M. Photometer with a Weston photronic cell (Model N. 8564R) and cosine filter were used to measure the 1% level and extinction coefficients. Measurements for microstratification were taken with a Whitney transmissometer or turbidimeter (one meter path length, a modified version of the earlier instrument by Whitney, 1938).

Physical and chemical data were secured during the summer by use of a boat and during the winter by hauling the equipment over the ice on a toboggan. During dangerous periods of winter, e.g., at the time of initial ice formation or in the last several days of rotting ice, a small aluminum boat with a motor was dragged over the ice to the sampling site(s). Whenever the ice broke K. M.

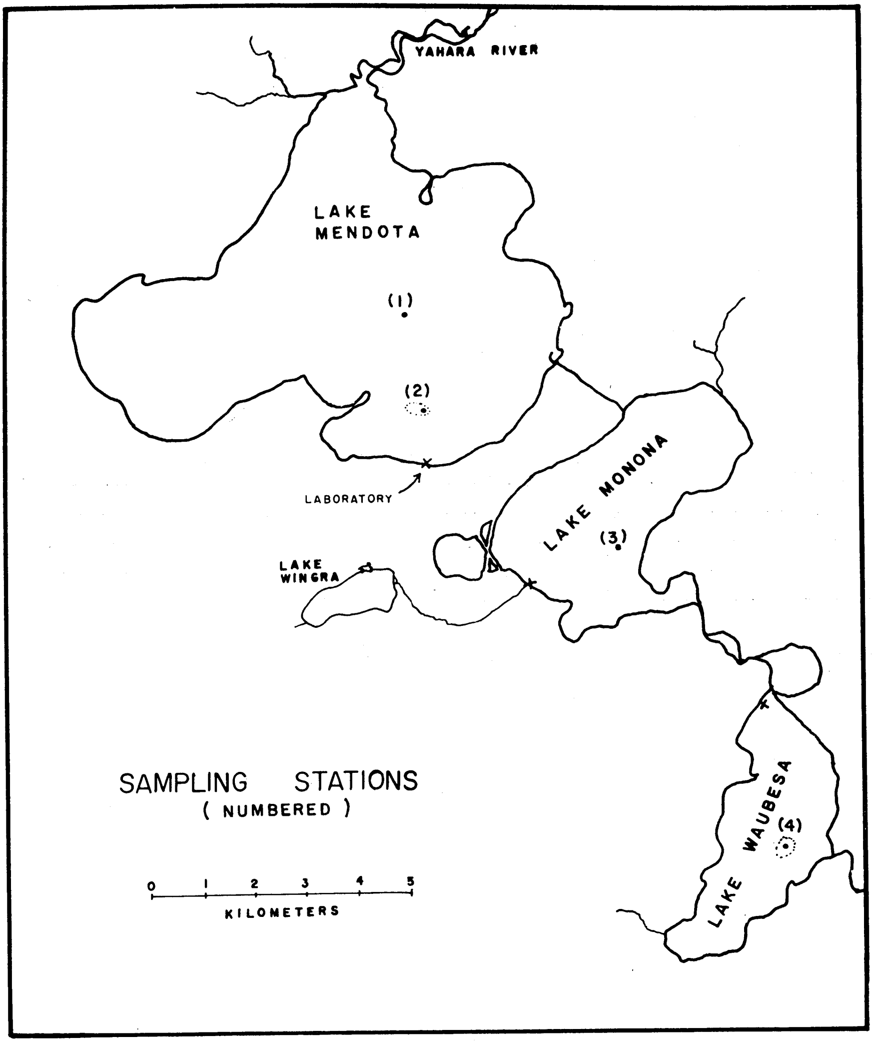

FIGURE 1. The Madison lakes and the sampling stations.

Stewart got into the boat and used the powered boat as a miniature icebreaker until the ice was firm enough to hold or until the sampling site or shore was reached. Under certain conditions of smooth but thin sheet ice, it is possible to sit in a boat and push oneself along with a spiked pole. However it is advisable to have a dependable motor along in case the boat breaks through the ice—as it usually does. These practical expediencies allowed acquisition of data at a most interesting and little studied time in the annual cycle of a lake. As a further bit of practical information, the period of risk (depending on meteorological conditions) is usually shorter during early ice formation than when the ice is wasting.

The water samples were acquired with a Kemmerer sampler from preselected depth intervals in each of the lakes investigated. The azide modification of the Winkler method was used for all oxygen determinations (Standard Methods, 1960). Reagents were added in the boat and the samples were titrated immediately upon return to the laboratory.

Information concerning solar radiation, air temperature and wind velocity (means of 24 measurements daily for 1960–1963 and eight measurements daily for 1966), was obtained from the published data of the U.S. Weather Bureau Station at Truax Field in Madison, Wisconsin (Annual Climatological Data, 1959–1966). Radiation data of the Weather Bureau were compared to and augmented occasionally by the data of the Solar Energy Laboratory at the University of Wisconsin when the radiometer at the Weather Bureau malfunctioned.

III. *Results and Discussion of Harmonic Time Series*

A. *Annual Cycle: Weather Data*

In most of the graphs in this paper concerning annual cycles, the day-to-day variation of air temperature, wind velocity, and solar radiation has been smoothed by plotting only the moving ten-day averages.

However, one year (1962) has been selected to illustrate the enormous detail apparent when comparing daily readings of wind velocity and direction, air temperature, and incoming radiation over an annual cycle. The daily means of 24 measurements of wind velocity and direction have been plotted (Fig. 2). Solid lines above and below the zero value indicate winds from the south to west, and north to east respectively, with the maximum velocity for that date indicated by a solid dash. Winds from the east–southeast to south–southwest and west–northwest to north–northwest are indicated by dotted lines above and below the line respectively, with separate dots for the fastest velocity.

The 24-hour daily means of weather data (Fig. 2), owing to their great variability and without further smoothing, would tend to mask the plots of lake data. Therefore computer calculations of moving ten-day means for winds, air temperature, and solar radiation have been plotted for easier comparison of climatological variables and lake trends over an annual cycle.

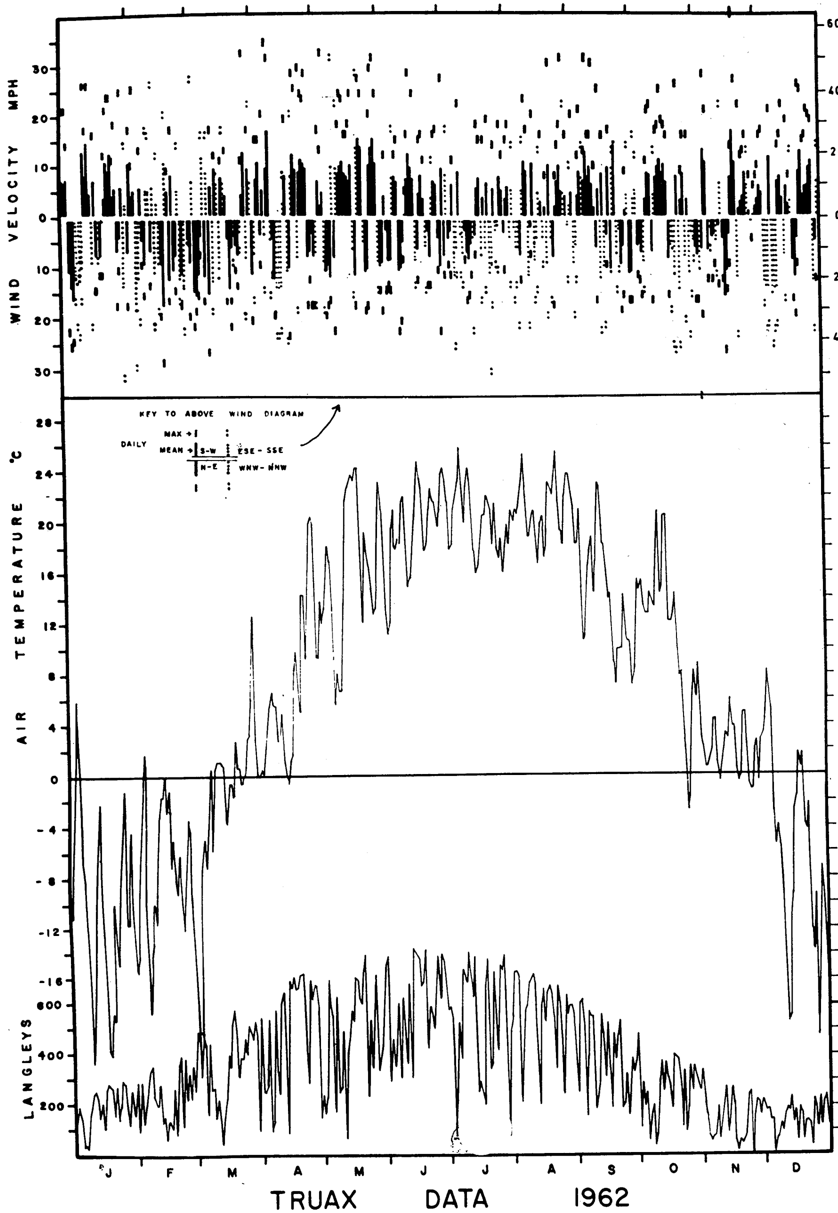

FIGURE 2. Data from the U.S. Weather Bureau at Truax Field in Madison, Wisconsin. Values of wind velocity and direction are the resultant (this figure only) means of 24 hr with maximum velocities for each day indicated by dots. The 24 hr mean of air temperature and 24 hr total of solar radiation both demonstrate great variability.

B. *Annual Cycles: Temperature and Oxygen, 1960–1964 and 1966*

1. Lake Mendota, Temperature and Oxygen

(a) 1960

The initial program for gathering data on temperatures began in 1960 (Fig. 3). Less information was collected in that year than in the succeeding ones. No measurements were made of dissolved oxygen in 1960 and all data were gathered at station 1 (Fig. 1). The 1960 climatological data from the U.S. Weather Bureau Station at Truax Field ($\approx$ 3.2 km from Lake Mendota) in Madison, Wisconsin, were plotted as moving ten-day averages on the tenth day.

The temperature of the water at 18 meters was about one to two degrees cooler in 1960 than the temperature at the same depth in 1961–1963 and 1966. This difference was not associated simply with a change in sampling position from station 1 (1960) to station 2 (1961–1963 and 1966). Both stations were compared occasionally in 1960 and only slight differences were noted. Furthermore, the data of Birge and Juday (1911) show temperatures at 18 meters from the area of station 1 in 1906 and 1907 similar to those of the latter years of this study. Therefore, specific episodes of wind velocities, air temperatures, and solar radiation must have combined during the critical vernal circulation to control the warming of the hypolimnetic waters. This supports some of the conclusions in Birge's (1916) paper on the work of the wind in warming the lake.

The response of the lake to the ten-day mean of air temperatures is illustrated best by temperatures in the first six meters (Fig. 3). The lag of water temperature, compared to that of the air, was prominent in all years and on all lakes to a varying degree.

(b) 1961

Temperature data were collected from Lake Mendota in 1961 (Fig. 4) more frequently than they were in 1960. Measurements were made of dissolved oxygen also. Data on both variables were relatively sparse during the first few months of 1961. Consequently the data taken during the spring missed completely the dramatic change in stratification normally associated with the disappearance of the ice.

More heat was distributed to the lower depths during spring circulation so that the lower waters began the summer season warmer than they were in 1960.

The depth of the lake where these data were collected was about 18.5 meters (Fig. 1, station 2) compared to about 21.5 meters

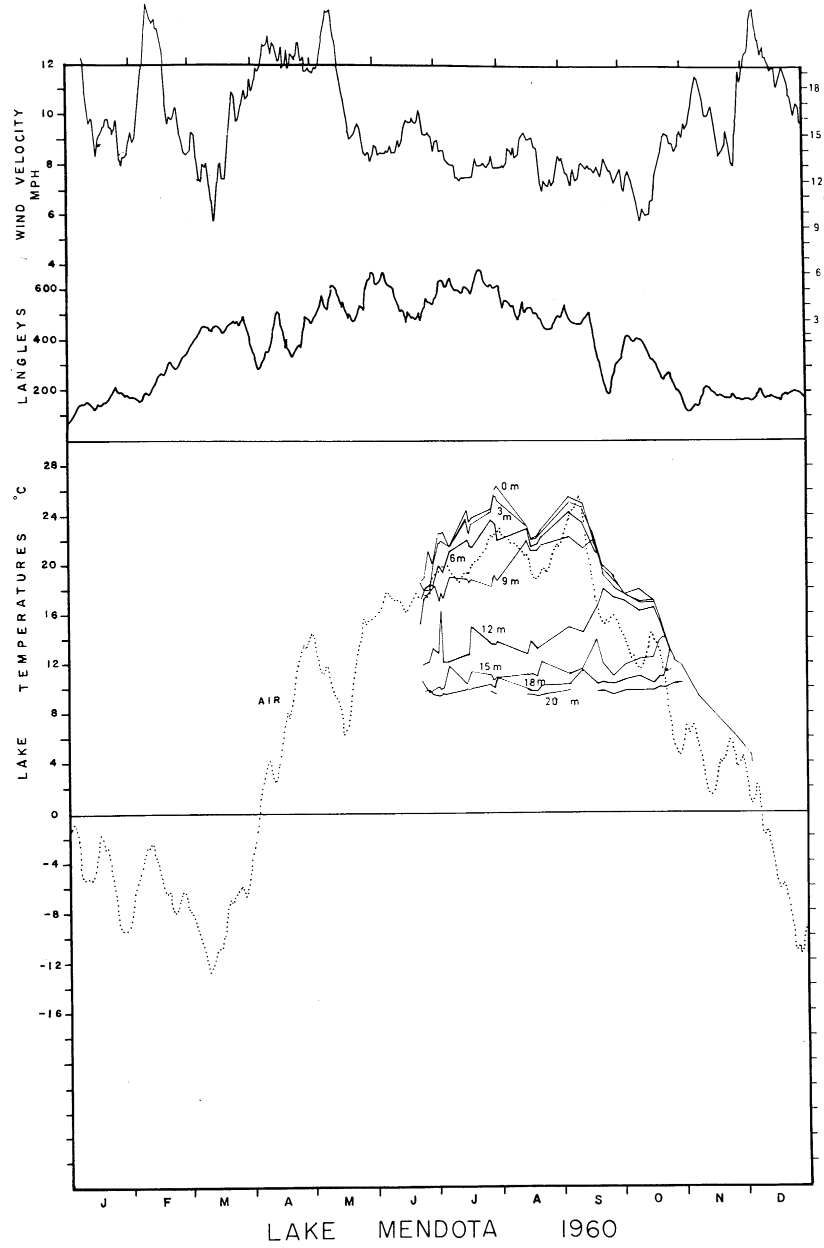

FIGURE 3. Lake Mendota temperature 1960. Wind velocity, solar radiation (Langleys), and air temperature are moving ten day means plotted on the tenth day.

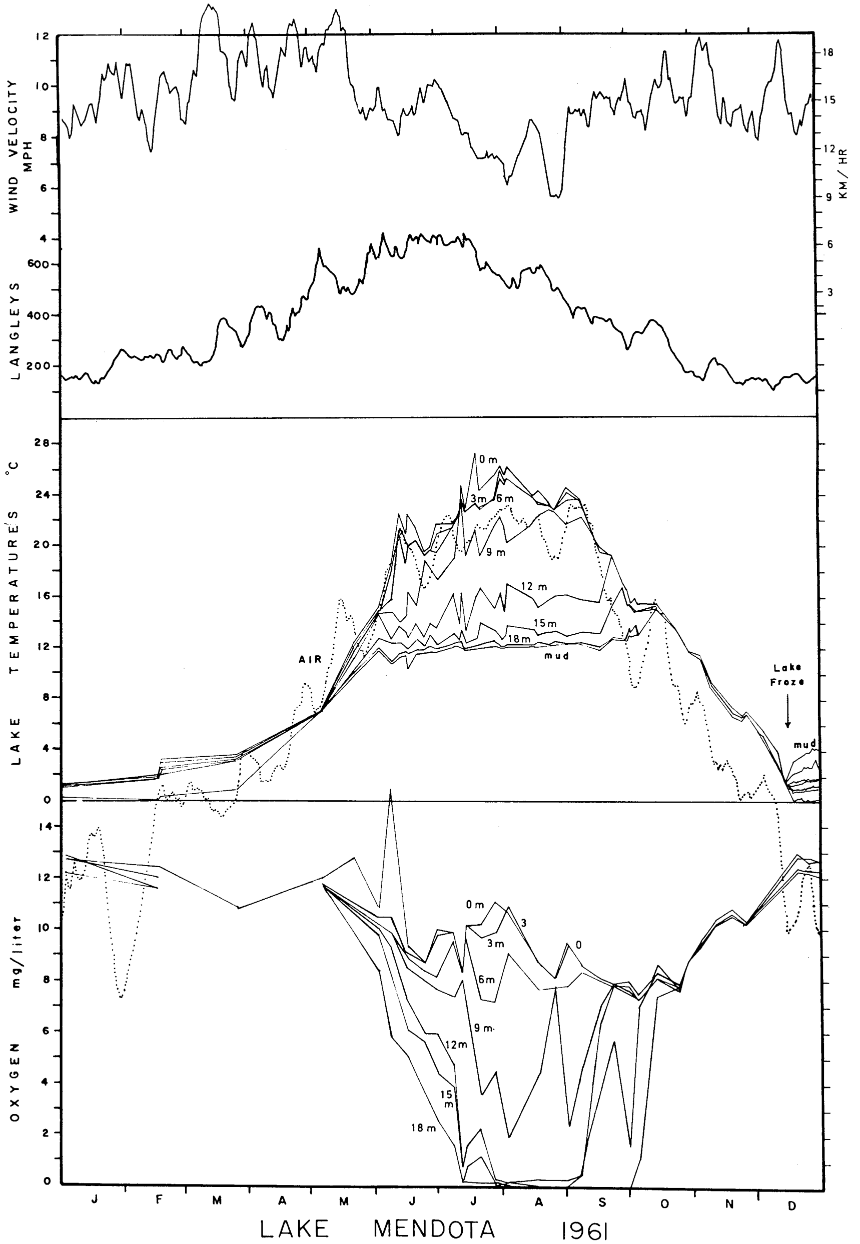

FIGURE 4. Lake Mendota temperature and oxygen 1961. Wind velocity, solar radiation (Langleys), and air temperature are moving ten day means plotted on the tenth day. Mean wind velocities are generally lower in summer.

for station 1, 1960. The probe of the Whitney thermometer was dropped into the mud for measuring the mud temperature. The depth of penetration by the perforated head of the thermistor probe varied with sediment-composition and rate of lowering. The penetration at these depths was approximately 20 to 30 centimeters. In soft bottoms, the mud–water interface felt poorly defined from a cable.

On 15 December 1961 the entire surface of Lake Mendota froze. The temperature of the water on the preceding day was 1.4°C. No measurement was made on the day of freezing. Note the immediate stratification of temperature following freezing. The mud and lower waters are warmer than the surface waters owing to the density anomaly.

There is a rapid stratification of oxygen after the spring "overturn". "Occasional blooms" of algae may cause super saturation as is indicated in early June. The dominant causative organism of that bloom was the blue–green alga, *Aphanizomenon*. The dissolved oxygen of the hypolimnion is utilized rapidly through decomposition of organic and planktonic material. A continuous "rain" of decomposing organisms from the epilimnion, contributes to an anaerobic condition in the hypolimnion of many lakes, as has been indicated by previous studies (Birge and Juday, 1911; Ruttner, 1966; Hutchinson, 1957).

(c) 1962

Thermal data were gathered from Lake Mendota on all but three days in 1962 (Fig. 5). The data were collected at station 2 (Fig. 1). The average time of sampling during the day for the entire year was 1418 hours with a standard deviation of one hour and 34 minutes.

Following the rapid freeze in December of 1961, the lake gradually increased its content of heat as noted by the slight rise in temperatures at most depths.

In the spring, two days before the ice melted completely, there were large areas of open water at the sampling station. However, a big sheet of ice moved across the lake the following day and arrived over the sampling station when the measurement was taken. Thus, there was no apparent refreezing on 10–11 April as Figure 5 might suggest. The remainder of the ice vanished during the night. Following the departure of the ice, vernal circulation occurred and the lake took that big inspiration of air, as Birge (1908) described, until the density differences overcame the influence of the wind and stratification began.

In 1962 and 1963 the calm clear days stand out in the form of sharp peaks (Figs. 5 and 6), as much heat is absorbed at the sur-

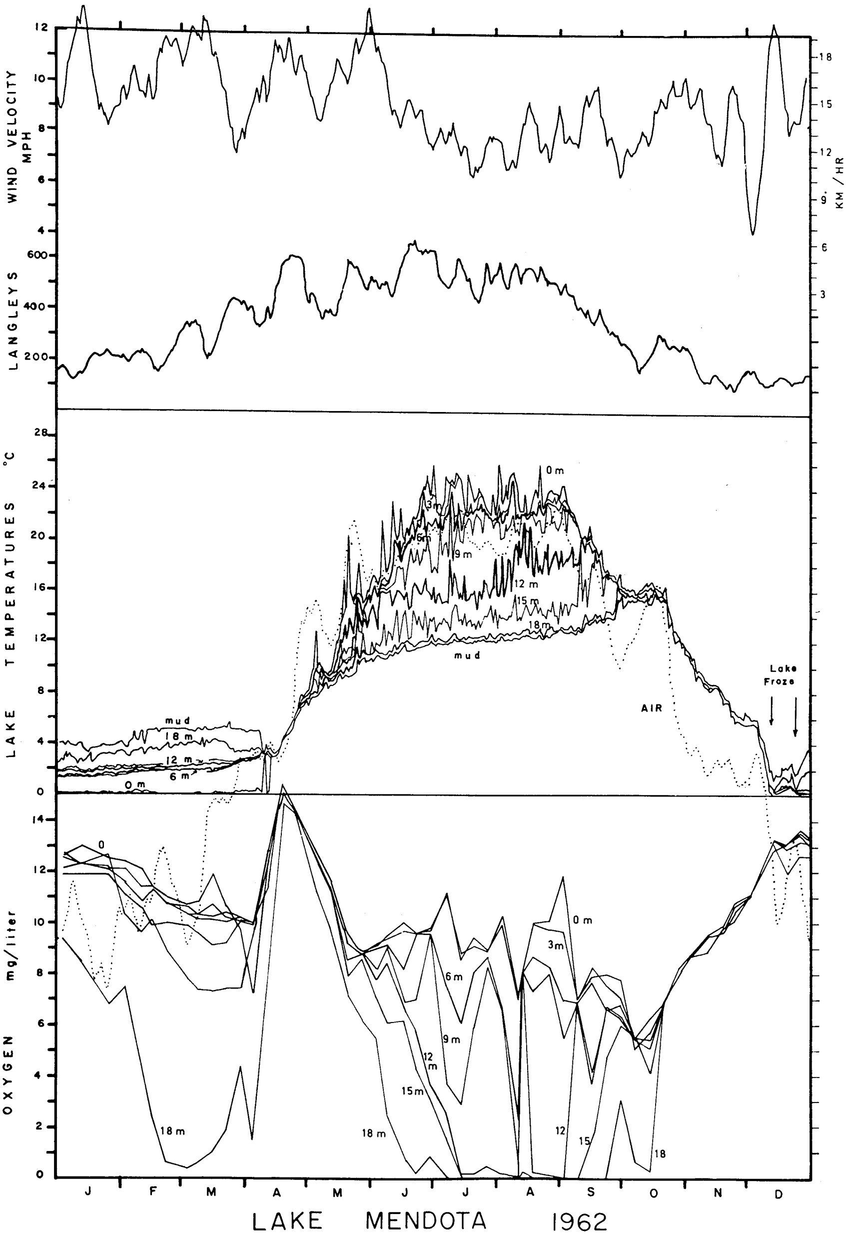

FIGURE 5. Lake Mendota temperature and oxygen 1962. Wind velocity, solar radiation (Langleys), and air temperature are moving ten day means plotted on the tenth day.

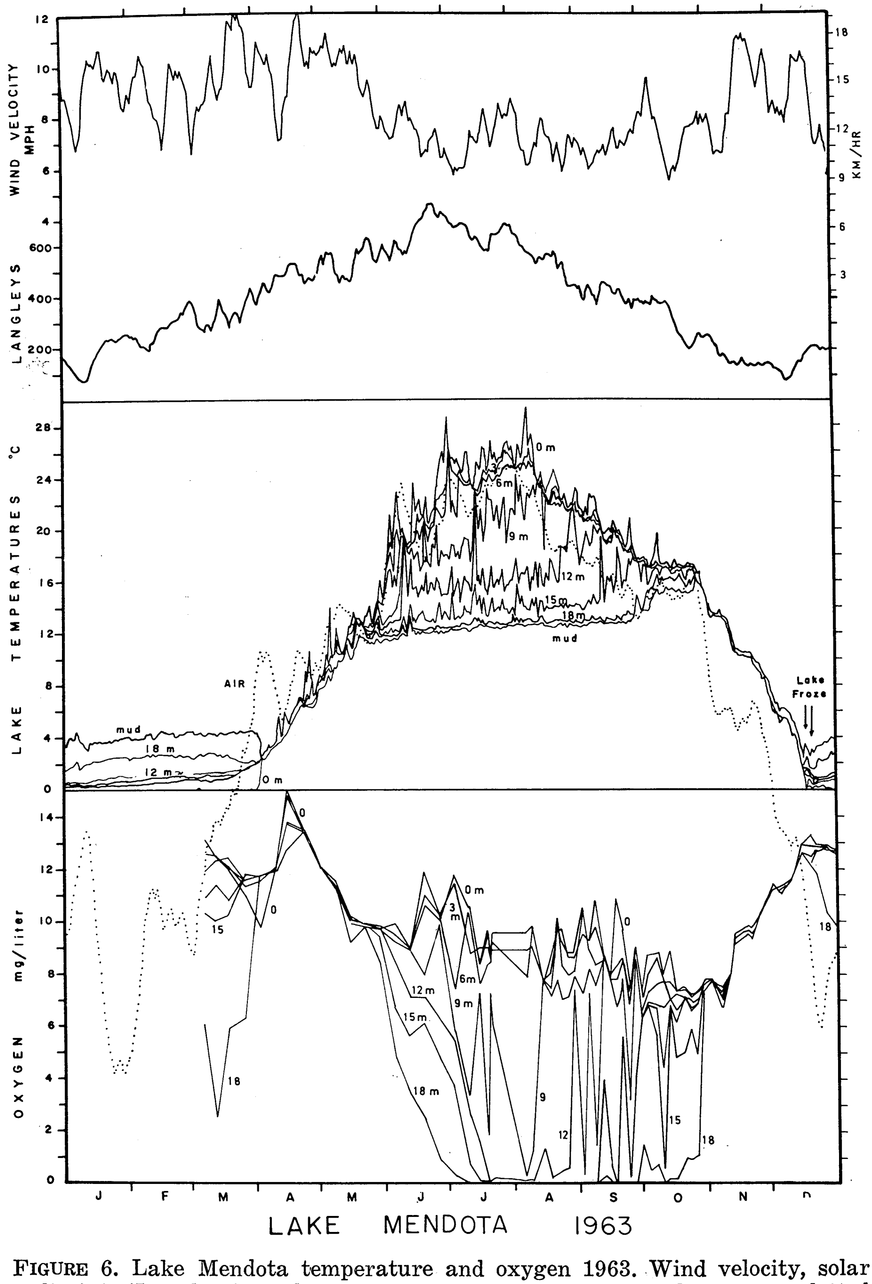

FIGURE 6. Lake Mendota temperature and oxygen 1963. Wind velocity, solar radiation (Langleys), and air temperature are moving ten day means plotted on the tenth day.

face. This sharp stratification at the surface is destroyed easily by winds. Temperatures on these calm days were taken within one centimeter of the surface with the bead thermistor of the Whitney thermometer. Diurnal variations at the surface are significant on calm days, particularly days associated with clear nights, owing to heat loss by long wave radiation. On windy days, the surface temperature was measured within the first 10 to 20 centimeters of the surface when a similar displacement either way made no difference in the value.

Thermal changes at the surface appear to be more rapid and dramatic in 1962 than in 1960 and 1961. However, these fluctuations reflect the plot of daily measurements instead of weekly or scattered data, as was the case in 1960 and 1961. Below six meters of depth, there is rarely any indication of diurnal variation. The temperature at 12 meters fluctuates greatly, but this fluctuation is a function of internal waves and not diurnal heat flux.

The rise of air temperature in the fall, during the period commonly known as "Indian Summer," does little to raise the temperature of Lake Mendota. Although the temperature of the air during the day may exceed considerably the temperature of the water, the evenings are usually cool. Consequently the average daily air temperature may differ but slightly from the water temperature. The integrating effect the heat capacity of water provides, may allow the mean water temperature to remain similar for several days. This is illustrated fairly well in 1962 but to a lesser extent in 1960 and 1961 owing to less frequent sampling. Lake Monona (Figs. 8–10), and Lake Waubesa (Figs. 11–13) particularly, tend to respond more rapidly than Lake Mendota to changes in air temperature owing to their lesser volumes and heat budgets.

After the relatively warm period, usually in October, there is a precipitous drop in air and water temperatures preceding the winter months. The remaining stratification is eliminated and complete autumnal overturn commences. Heat is then lost at a relatively rapid rate at all levels until freezing.

About 20% of the lake surface froze on 12 December. The water temperature was 0°C from the surface down to 10 meters on that day. This unusually cold temperature was verified with a precision mercury thermometer. This thickness (10 m.) of water at such low temperatures was apparently quite unusual for as Birge (Neess and Bunge, 1957, page 61) remarks:

> "It is not impossible, theoretically, that the water of a lake should reach, in whole or in great part, a temperature of 0 degrees C., but it is very improbable that such a low temperature should actually occur before the lake froze. When the temperature has fallen below 1 degree, ice forms

> on the lake if the air is cool, even during considerable wind. . . Still more easily does freezing occur if no wind blows. In either case the rate of conduction in water is so slow that the layer at a temperature of 0 would be very thin."

However, Birge (Neess and Bunge, 1957, pages 70–71) in the same article provided data (29 Dec 1911, the day after freezing) for a thermal structure which was remarkably similar to that recorded on 12 Dec 1962. Birge stated, "It is not likely that a lower temperature at freezing will be found than that of 1911." Obviously, time has at least provided an equal.

By 14 December, about 60 to 70% of the lake was frozen but strong winds broke up the ice-cover and reduced it to about 40% by 15 December. The lake did not freeze completely until 24 December. The circulation from 15 to 24 December set the stage for cooler water temperatures during the winter than the previous 1961–1962 winter.

Measurements of dissolved oxygen were made weekly at depth intervals of three meters (Fig. 5).

The utilization of dissolved oxygen in the lower waters proceeds more slowly in the winter owing to reduced temperatures. However, there is a significant reduction in the concentration of oxygen in the lower waters during the ice-cover.

Within a few days after the ice has melted, higher values of oxygen are present than at any other time of the year. This feature, recorded each year when timely data were available, is common to the three Madison lakes discussed and was recorded to a lesser degree by Birge and Juday (1911). However, the magnitude and rapid formation of this 1962 peak was somewhat unexpected because a winter oxygen deficit had to be removed before the peak and concomitant supersaturation with oxygen could occur. No similar peak occurred a few days prior to freezing even though the water was colder, could have held more dissolved oxygen, and the summer oxygen deficit had long since been repaid. In fact, compensation for the oxygen deficit of summer is seen at the end of the summer stratification when upper waters are mixing to greater depths with entrainment of hypolimnetic water and resultant lowering of upper oxygen values. Therefore, the main reason for the high values of oxygen after the ice goes out lies in the phytoplanktonic production of oxygen.

(b) 1963

Measurements of temperature were made at station 2 (Fig. 2) in Lake Mendota every day in 1963. The mean time of sampling was 1418 hour with a standard deviation of 1 hour and 37 minutes. The time of sampling was nearly identical to that of 1962.

After a relatively cold winter, the ice melted in a single day. Following this striking change in the thermal structure (Fig. 6), vernal circulation began and continued as in 1962 until the differences in density between the upper and lower waters required more energy than was available to maintain complete mixing. This period was described carefully by Birge (Neess and Bunge, 1956).

The two peaks of surface temperature on 1 July and 8 August were 28.8°C and 29.5°C respectively. The four highest surface maxima ever recorded on Lake Mendota by Birge, (Neess and Bunge, 1957) were 34.3°, 32.1°, 29.0°, and 29.9°C on 29 July 1916, 30 June 1910, 23 June 1911, and 20 June 1913 respectively. All of the above surface maxima were recorded between the hours of 1300 and 1600.

The general summer curve of both air and upper water temperatures is more abrupt in 1963 than 1962. This abruptness illustrates the correspondence between air and surface temperatures. As Birge (Neess and Bunge, 1956) noted:

> "There is far less correlation between the air and surface during autumn than during spring and summer. In spring, and especially in summer, the surface follows the air pretty regularly, though always with smaller range and with a decided lag which sometimes obscures the relation. But in autumn no such close relation is to be affected after the lake has become homothermous, partly also to the increased evaporation of warm periods which uses up more heat, and thus prevents a corresponding rise of surface temperature."

An extended warm period maintained a partial thermal stratification for three weeks in October. Note the step-like shape of the graph after the autumnal circulation commenced (Fig. 6). The lake froze initially on 17 December and finally on 20 December. With this fairly rapid closure, the temperatures at the six and 12 meter level were somewhat higher than they were in the first three months of 1963.

Measurements of dissolved oxygen in 1963 were initiated in March and, with the exception of one two-week period in late July and early August, were taken weekly until August after which time the lake was sampled every three to five days. Consequently the total number of measurements of oxygen in 1963 exceeded that of 1962. Again note the peak of dissolved oxygen shortly after the ice melted.

The more frequent sampling in 1963 provides additional detail that was not apparent from the 1962 graph of Lake Mendota (Fig. 5). Oscillations of the standing internal wave were responsible for some of the internal variation at the 9 and 12 meter level during August and September. The step-like variations of oxygen during autumn correspond fairly well to those of water temperature. Immediately after the lake froze, the lake restratified rapidly with respect to temperature and oxygen.

(e) 1966

Data were gathered weekly at station 2 (Fig. 1) in Lake Mendota from 19 March (three days after an early ice-out) to 30 August (Fig. 7). Cold weather followed the warming trend, which induced an early opening of the lake, and air temperatures dropped rapidly. Thus the lake actually lost heat in the first week after measurements were initiated. Then the customary rise in temperatures began during vernal circulation and the summer stratification developed later.

The winds certainly aided the loss and gain of heat to the lake during spring after ice-out but their reduced effect during summer provided no particular contrast to most previous years.

The maximum surface temperature recorded was 29.4°C on 1 July. The lack of several sharp temperature peaks, as noted in 1962 and 1963 (Fig. 5 and 6) reflects the longer interval between sampling and not the complete absence of hot calm days.

The concentrations of dissolved oxygen did not increase in such a striking manner shortly after ice-out as was noted in 1962 and 1963. In fact the 1966 spring curve was similar to the one recorded (Birge and Juday, 1911) in 1907. However, a prominent sub-surface maximum of oxygen was recorded at three meters on 1 July 1966. The dominant alga during mid-June and early July was *Aphanizomenon flos-aquae*. Lesser amounts of *Anabaena* and *Staurastrum* were also present during this period.

2. Lake Monona, Temperature and Oxygen

(a) 1961

All the sampling from Lake Monona was carried out in the deepest (21 meters) area at station 3 (Fig. 1). This deep zone of the lake is in a small area and is somewhat difficult to locate, there being less than 0.01% of the volume below 18 meters. Fewer measurements were made in 1961 (Fig. 8) than in either of the following two years.

The average depth of Lake Monona (7.7 meters) is intermediate to that of Lake Mendota (12.4 meters) and Lake Waubesa (4.6 meters). Its response to air temperature is intermediate also, i.e., it warms and cools more rapidly than Lake Mendota but less rapidly than Lake Waubesa. This is also substantiated by comparing the dates of freezing and opening of Lake Monona with Lakes Mendota and Waubesa (Bunge and Bryson, 1956, Parts I and II). The highest surface temperature recorded in 1961 was 28.8°C on 28 July.

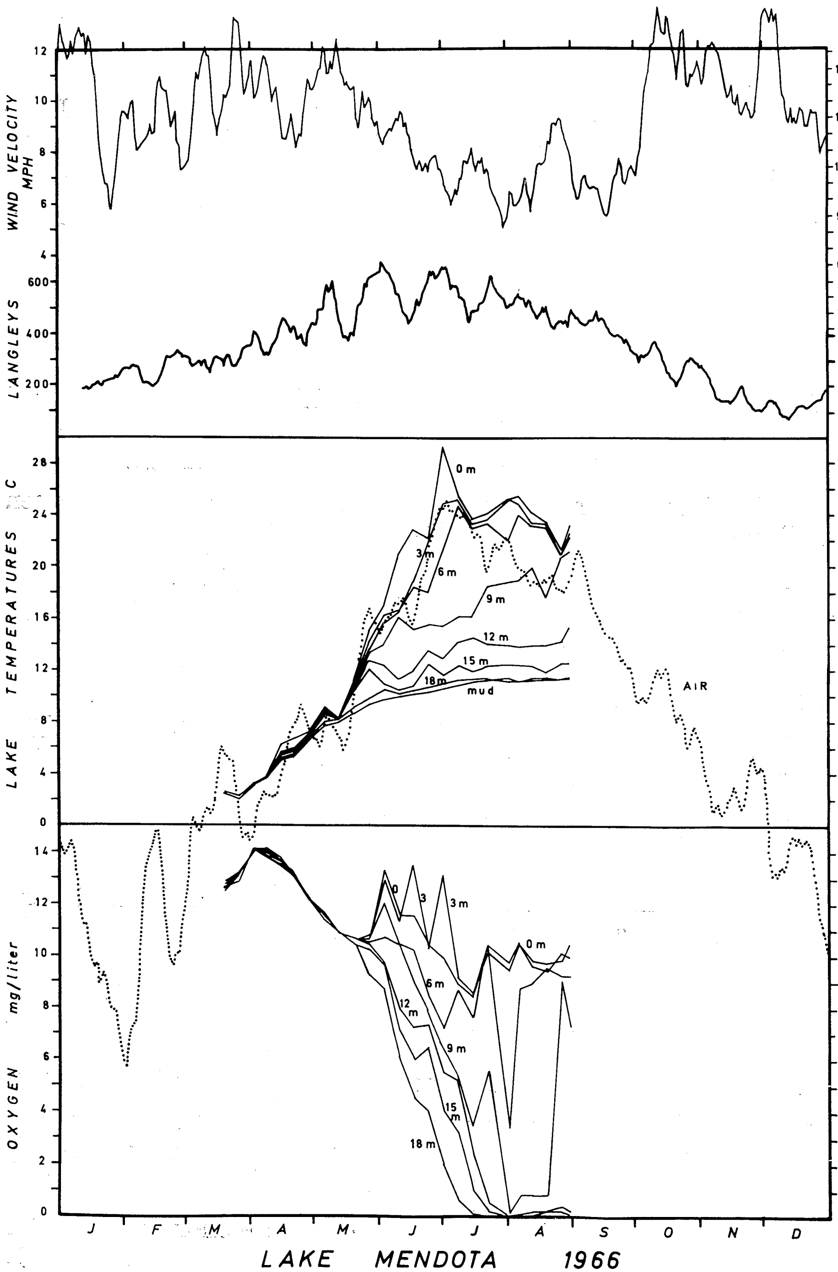

FIGURE 7. Lake Mendota temperature and oxygen 1966. Wind velocity, solar radiation (Langleys), and air temperature are moving ten day means plotted on the tenth day.

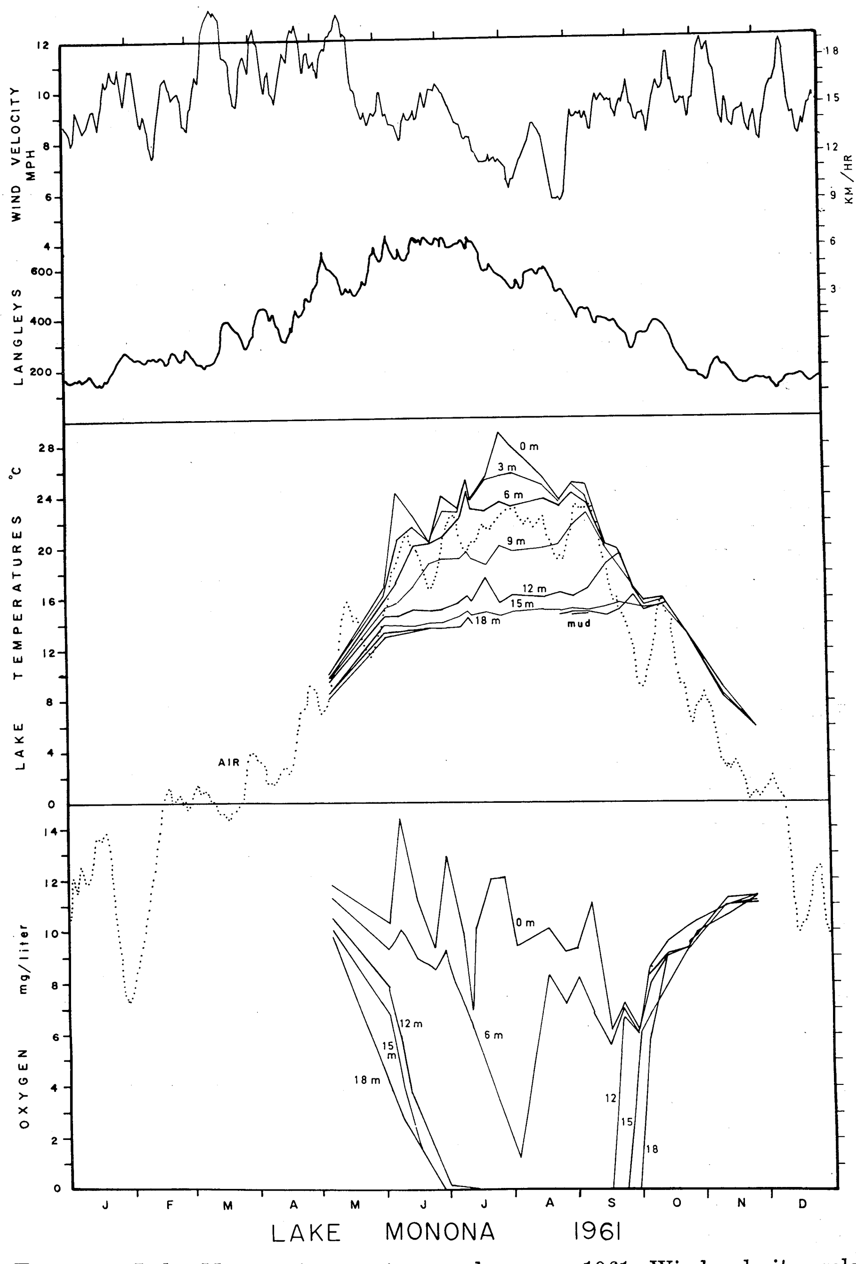

FIGURE 8. Lake Monona temperature and oxygen 1961. Wind velocity, solar radiation (Langleys), and air temperature are moving ten day means plotted on the tenth day.

Lake Monona has apparent "plankton blooms" more frequently than Lake Mendota but less commonly than Lake Waubesa.

The dissolved oxygen becomes depleted rapidly in the lower waters. Furthermore, it is not uncommon to have low oxygen values within six meters of the surface.

The early onset of anaerobic conditions in the lower waters of Lake Monona reflects the small hypolimnetic volume and slightly warmer temperatures when compared to Lake Mendota.

Lake Monona receives an unnatural inflow of warm water year round. The major source of this warm water is the thermal discharge from the Madison Gas and Electric Company. Water is withdrawn from Lake Monona at a depth of approximately 4.6 meters through two intakes located about 106 meters from shore off Blount and Livingstone Streets.

The cooling water from Lake Monona is heated in the condensers of the power plant and returned to the lake with its temperature increased about 10°C above the ambient lake temperature. The power plant, with a maximum capacity of 594×10^3 m^3/day (157 mgd), discharges the heated water through two surface outfalls, also at Blount and Livingstone Streets (Zeller, 1967).

The thermal discharge of the Madison Gas and Electric Company appears to have an influence on the departure of ice from Lake Monona. This influence is apparent in spring when the area of open water, expanding outward from the thermal discharge, allows wind and wave activity to break up the remaining ice more readily. Although the mean opening date of Lake Monona (5 April) over the past 115 years precedes Lake Mendota (6 April) by only one day, the opening date in the 15 year period (1950–65) for Monona (20 March) precedes Mendota (8 April) by 19 days (Data from Ragotzkie, 1960; personal records of K. M. Stewart; and records of Capital Times Newspaper, Madison, Wisconsin, 1966).

A second minor source of heated water is from a local meat packing company which discharges some water through a viaduct into the Yahara River, which in turn empties into Lake Monona. The physical and biological impact of this water may be important at the immediate site of the discharge but, owing to its lesser volume and irregular nature, appears to have little significance for Lake Monona with respect to thermal structure.

In fact, other than locally, the overall influence of the relatively warm water from both of these companies to Lake Monona was slight at the time of this study when compared to the influence of the general climatological conditions. However, it is likely that the thermal discharge of the Madison Gas and Electric Company will have an increasing impact on the formation and departure of ice on Lake Monona as the power demands of the City of Madison, and consequently the volume of cooling water increases. Some detailed information on the local biological effects is being studied (Magnuson, 1970).

(b) 1962

Measurements of temperature and dissolved oxygen in Lake Monona in 1962 began in April and continued until early December (Fig. 9).

The thermocline is usually less dictinct in Lake Monona than it is in Lake Mendota. The maximum surface temperature recorded in 1962 was 28.4°C on 30 June.

The general profiles of dissolved oxygen were fairly similar to those of 1961. The two highest concentrations of oxygen at the surface were 15.5 and 15.9 mg/l on 7 June and 30 June respectively. Water withdrawn from the hypolimnion in Lake Monona in August smells more strongly of H_2S than anaerobic water from either Lakes Mendota or Waubesa. The stronger odor of H_2S at this time follows a longer period of anaerobiosis in Lake Monona than the other two lakes. The quantity of dissolved oxygen in the upper waters is lowered prior to full autumnal circulation. The amount of lowering or raising of the oxygen content reflects the oxygen demand of the hypolimnetic waters and sediments.

(c) 1963

Over 80 trips were made to Lakes Monona and Waubesa in 1963 (Fig. 10 and 13). Temperature and oxygen measurements were made twice a week except for a two week period in the latter part of July and early August, when only temperatures were measured. To determine the daily variation, temperatures were measured 20 out of 21 consecutive days during late June and early July.

The highest temperatures at the surface were 29.6°C, 29.9°C and 28.8°C on 1 July, 19 July, and 8 August respectively. The temperatures in the lower waters of Lake Monona were roughly 2 degrees higher than those in Lake Mendota and 4 degree lower than those in Lake Waubesa. Note the very rapid restratification of temperature and oxygen after the freezing date on 16 December 1963.

The high value of oxygen (15.7 mg/l) on 16 April, represents at least a portion of the early peak after complete ice-out (3 April, 1963). This supersaturated condition indicates a large production of oxygen by phytoplankton as was noted in Lake Mendota and as will be apparent in Lake Waubesa. The other high value of oxygen recorded was 14.4 mg/l and occurred on 8 September.

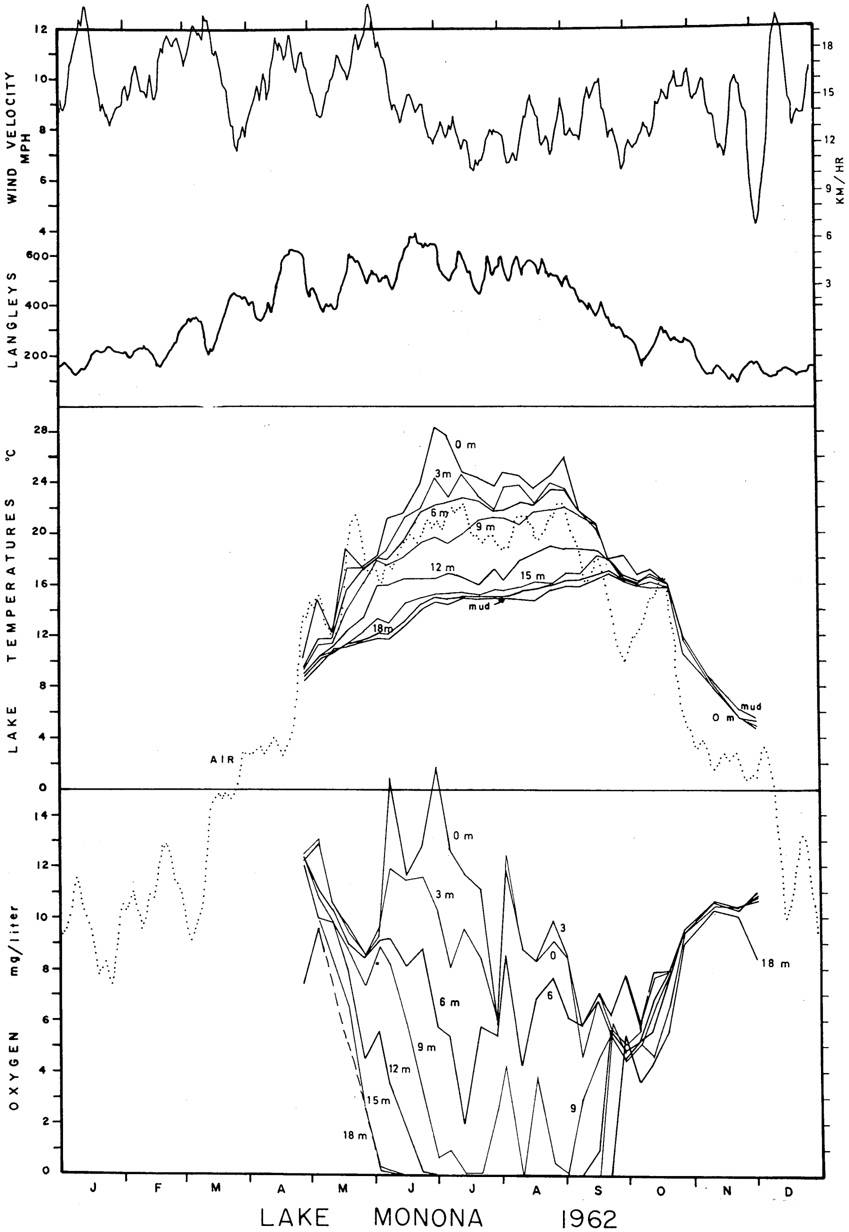

FIGURE 9. Lake Monona temperature and oxygen 1962. Wind velocity, solar radiation (Langleys), and air temperature are moving ten day averages plotted on the tenth day.

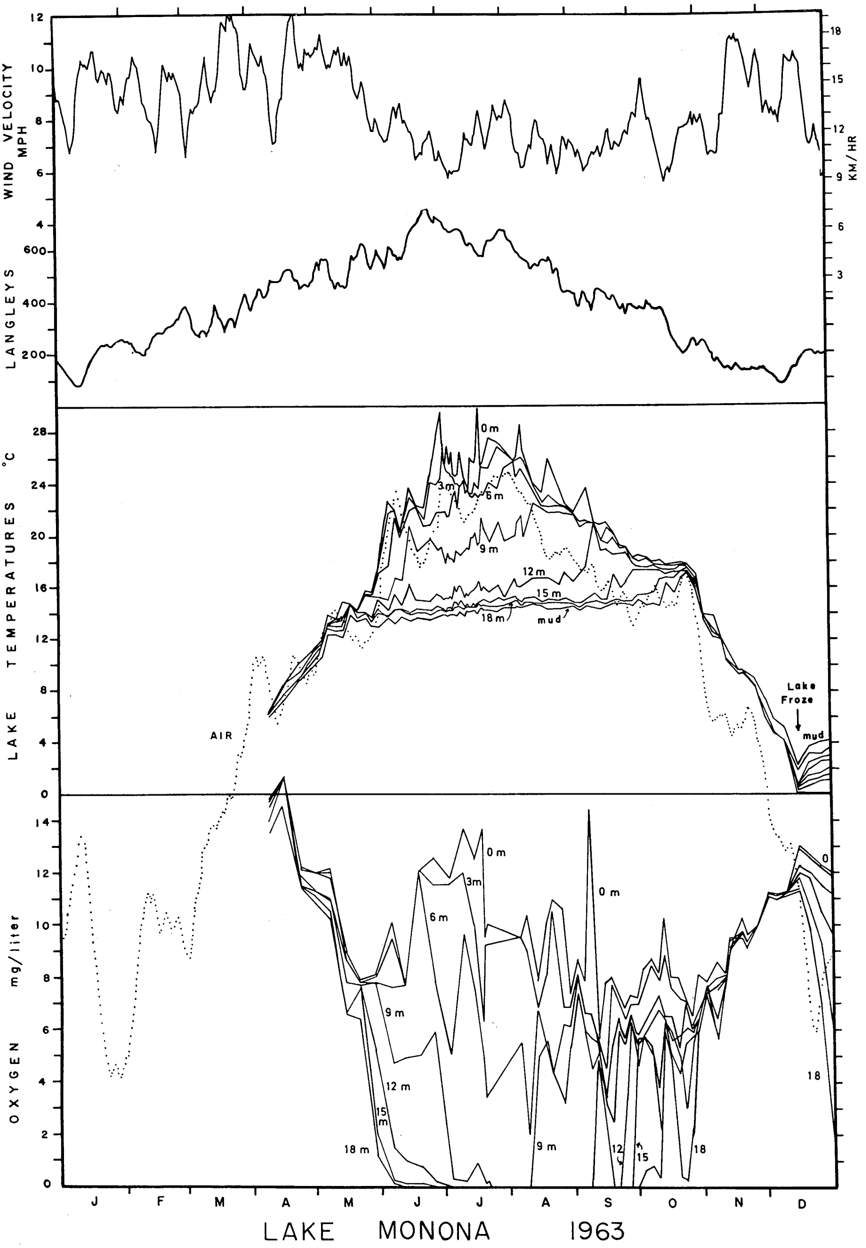

FIGURE 10. Lake Monona temperature and oxygen 1963. Wind velocity, solar radiation (Langleys), and air temperature are moving ten day averages plotted on the tenth day.

3. Lake Waubesa, Temperature and Oxygen

(a) 1961

The sampling position for all years in Lake Waubesa is indicated at station 4 (Fig. 1). Some prominent limnological features of Lake Waubesa (Fig. 11), when compared to Lakes Mendota and Monona, are the high mean summer temperatures and the rapid response to wind and air temperature changes as reflected by dramatic changes in stratification.

The highest temperature recorded on the surface was 29.5°C on 28 July. Lake Waubesa stratifies but this stratification may be broken down even in mid-summer. Less difference exists in Lake Waubesa between the temperature of the surface and of the lower waters than in Lakes Mendota or Monona. Lake Waubesa would actually be quite stable during summer were it not for changing air temperatures. However, as the air temperature drops the water temperature also falls. Because a small change in temperature is associated with a relatively large change in density at higher water temperatures, the stability of stratification can change quickly and the lake circulates.

Lake Waubesa begins its autumnal overturn about one month earlier than Lakes Mendota or Monona.

Oxygen concentrations were measured at three depths during this first year of sampling on Lake Waubesa. Frey (1940) noted a thermal and marked oxygen stratification in Lake Waubesa earlier. Figures 11–13 (this paper) show this even more clearly. We mention this because there is a local belief that Lake Waubesa circulates freely all summer and does not stratify.

(b) 1962

The relatively rapid response of Lake Waubesa to climatological conditions is noted again this year (Fig. 12). For example, the spring warming of Lake Waubesa exceeded the rate of warming in Lakes Mendota and Monona. A practical index of this warming is noted by the earlier swimming in Lake Waubesa. During October, the temperature of Lake Waubesa rose briefly but there was no corresponding rise in Lakes Mendota or Monona. Waubesa is generally the first of the Madison lakes, excluding little Lake Wingra, to freeze and open. The highest surface temperature recorded in Lake Waubesa during 1962 was 28.7° on 6 July.

Lake Waubesa appears to be in a state of almost perpetual algal "bloom" and the concentration of dissolved oxygen varies considerably. The surface waters are supersaturated frequently. Continuous measurements of dissolved oxygen were not made on Lake Waubesa, but if they were, greater diurnal variation of oxygen in the surface waters would be expected than in the other

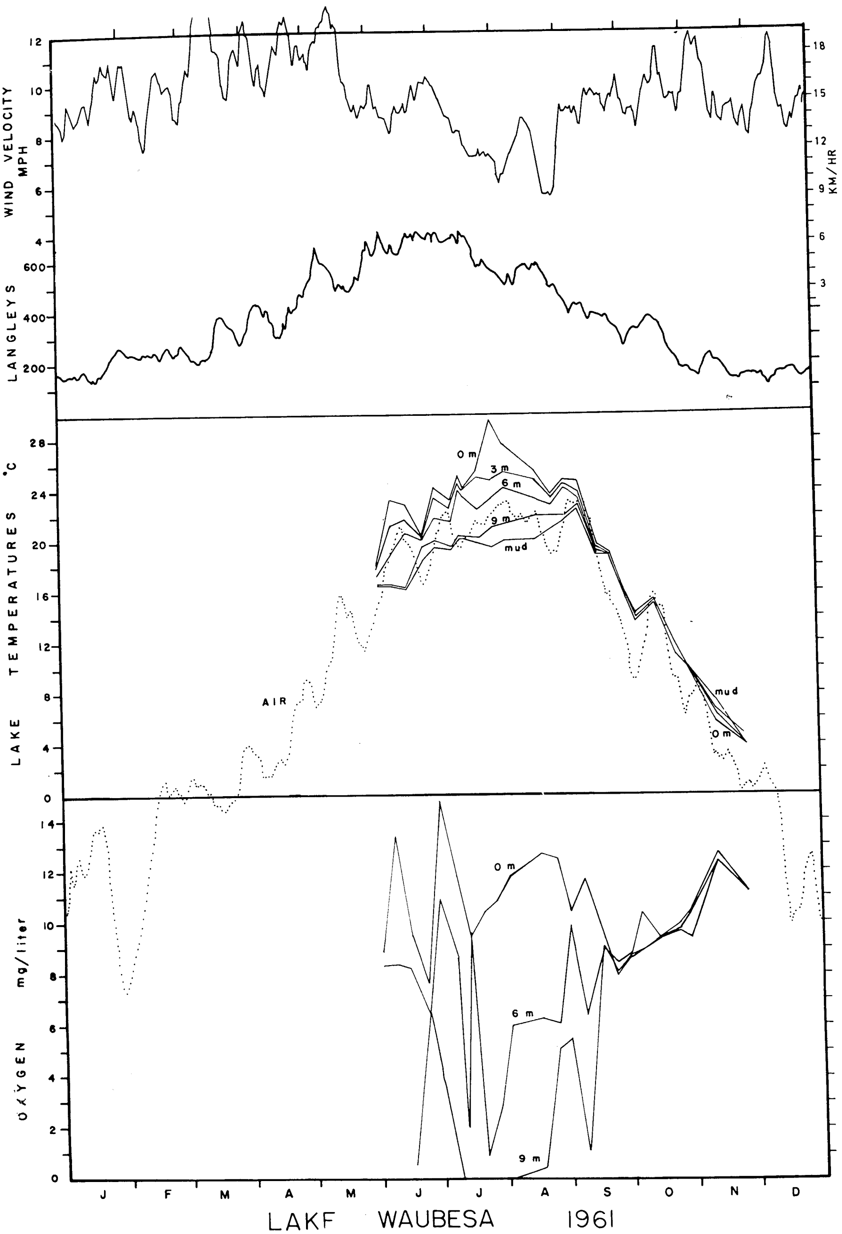

FIGURE 11. Lake Waubesa temperature and oxygen 1961. Wind velocity, solar radiation (Langleys), and air temperature are moving ten day averages plotted on the tenth day.

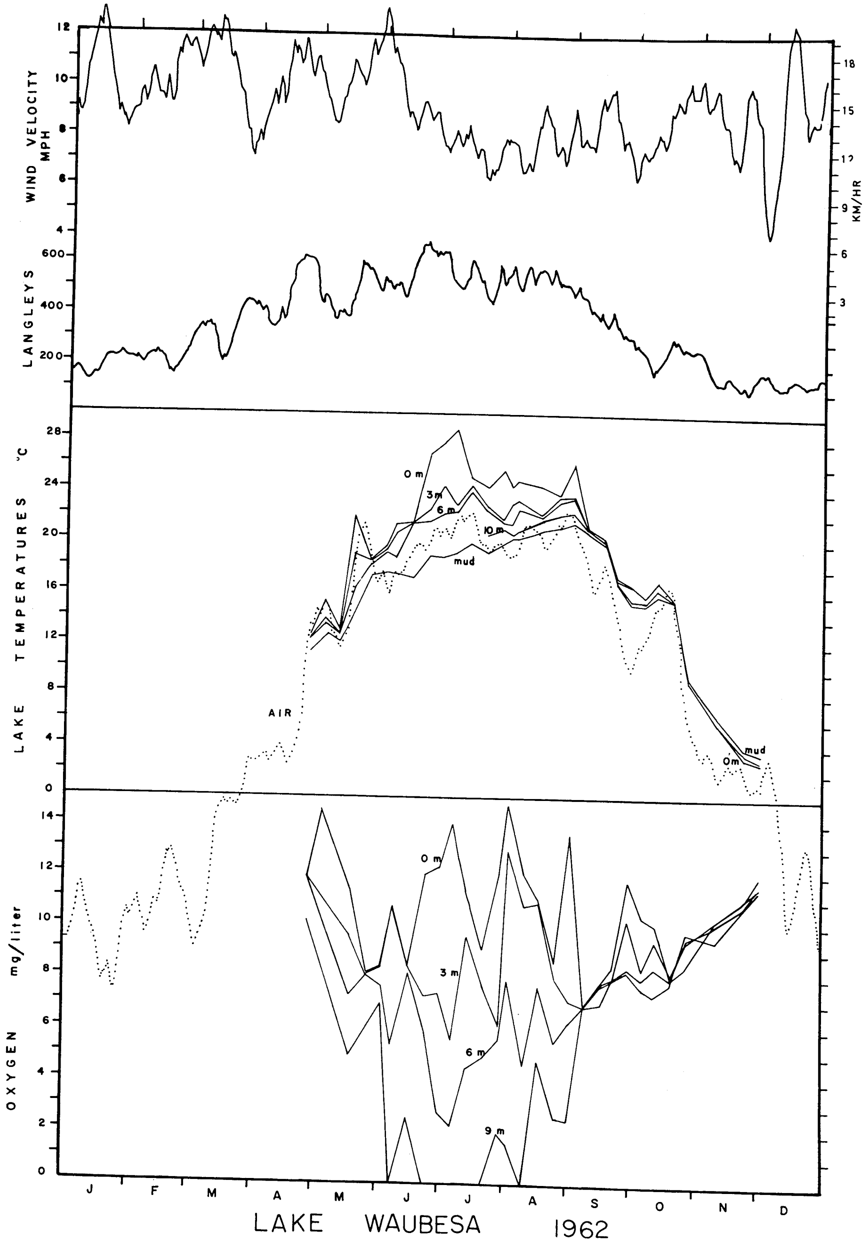

FIGURE 12. Lake Waubesa temperature and oxygen 1962. Wind velocity, solar radiation (Langleys), and air temperature are moving ten day averages plotted on the tenth day.

two lakes. Therefore, potential programs for sampling Lake Waubesa should retain limits on the time of sampling to provide relative data.

(c) 1963

The ice disappeared 3 April 1963 and the measurements of temperature and dissolved oxygen began on 9 April (Fig. 13). Data were collected more intensively and over a longer period of time than in any previous year. The highest temperatures recorded at the surface were 29.8°C and 30.4°C on 29 June and 1 July respectively. The many sharp peaks and general variability of lake temperatures in early July also reflect the limited period of increased sampling.

In conjunction with changes in air temperature, it is interesting to note how much more closely the crest of water temperatures in Lake Waubesa follows the crest of solar radiation (Langleys) than in Lakes Monona or Mendota.

Following the departure of the ice, high values of dissolved oxygen are prominent. However, within the next six weeks the oxygen content of the lower waters plummets nearly to zero. A few days after this, the passage of a cool front caused a lowering of the water temperature. Then, even with relatively low winds, the lake essentially "turned over". This pattern, which affects the mid-summer stratification of temperature and oxygen, is demonstrated several times in 1963. The algal "blooms" create supersaturated conditions quickly. For example, the concentration of dissolved oxygen on 21 August was 21.7 mg/l, which after correcting for water temperature (25.8°C) and altitude, meant a saturation of 271%.

The somewhat intermittent summer stratification and mixing in Lake Waubesa may raise serious problems for individuals trying to interpret deposition in sediment cores.

The lake froze completely on 14 December.

C. *Ice Thickness: (Lake Mendota only)*

The earliest studies of ice on Lake Mendota were conducted by Buckley (1900) and Birge (Neess and Bunge, 1957) and his co-workers. Buckley was concerned with fracturing and expansion of ice as well as the physical effects of ice ramparts on the shores of lakes. Birge investigated the rates of growth and decay, thickness of ice, temperatures within the ice-layers, and insolation beneath the ice. Measurements of the thickness of the ice were conducted over 12 to 14 winters prior to and including the winter of 1916–17. The data from nine of those years were plotted (Fig. 14) by Birge* (Neess and Bunge, 1957, Fig. 45). The maxi-

*Birge continued his interest in ice beyond 1916–17 and, as Bunge and Bryson (1956, Part I) noted, "Collected at least 27 years of ice thickness data and about 30 years of winter water temperatures from 1894 to 1930".

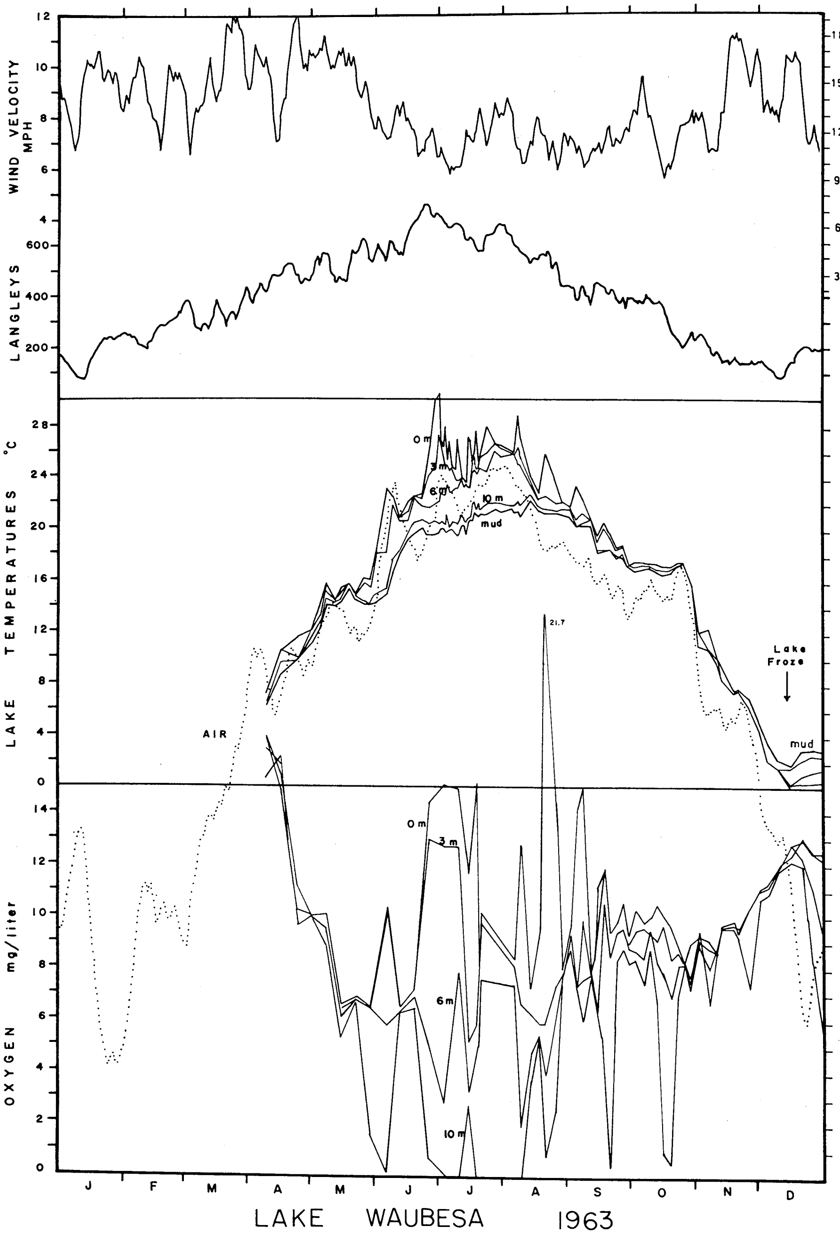

FIGURE 13. Lake Waubesa temperature and oxygen 1963. Wind velocity, solar radiation (Langleys), and air temperature are moving ten day averages plotted on the tenth day.

mum thickness recorded by Birge in those years was 75 cm in 1899. Only 30 cm were found in 1913. The maximum thickness recorded in this more recent study was 64 cm in 1963.

Birge (Neess and Bunge, 1957) separated winter into three periods with respect to ice, namely, a period of increase in thick-

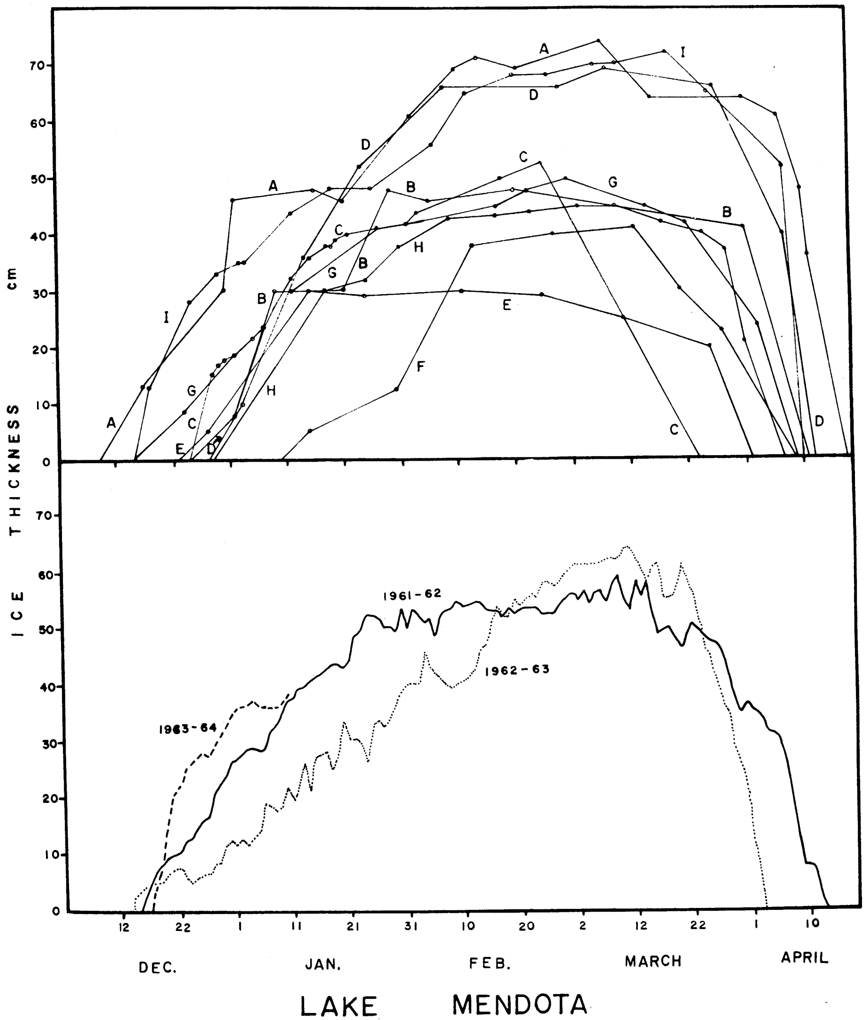

FIGURE 14. Ice thickness on Lake Mendota. Top half of figure illustrates earlier data of Birge for the years 1898–99 (A), 1900–01 (B), 1902–03 (C), 1911–12 (D), 1912–13 (E), 1913–14 (F), 1914–15 (G), 1915–16 (H), 1916–17 (I). Lower half of figure illustrates more recent data on ice thickness, measured every day in the winter of 1961–62, 1962–63, and the first portion of 1963–64.

ness, a period of stationary thickness during February and part of March, and the period of rapid decrease in thickness.

During 1912, Birge (Neess and Bunge, 1957) observed that the melting of ice took place mainly at the surface with but a small fraction of ice melting at the ice-water interface. In a more recent ablation experiment, Scott and Ragotzkie (1961) found that during approximately the last two weeks prior to ice out, the total ice melt on the surface exceeded the bottom melt about twofold. Independent of whether the ice melt from the bottom is less than or equal to one half of the surface melt, it is apparent that most of the calories required for melting the ice do not come from the water itself. Juday (1940) was aware of this when evaluating the annual energy budget of Lake Mendota.

The inverse correspondence between ice thickness and air temperature is fairly obvious during the early growth and later wasting of ice. However, the period of "stationary thickness" appears less subject to change from fluctuating air temperatures.

Following the rapid freeze of smooth sheet ice on 15 December 1961, measurements of the ice thickness were made daily from 20 December 1961 for the remainder of the ice cover. The thickness of the ice was also measured daily in 1962 and 1963, and for part of the 1963–64 winter. All data were collected at or near Station 2 (Fig. 1). The measurements were made by inserting a meter stick, with a bar at right angles to the base of the stick, through a hole in the ice. The thickness was that distance from the bar, brought up against the underside of the ice, to the top of the ice.

The curve (Fig. 14) for 1961–62 is based on an average of two measurements each day taken approximately 200 meters apart. The curves for 1962–63 and 1963–64 are based on one measurement each day in new holes that were chopped or drilled in an area of fairly uniform ice thickness. Care is required during measurement because it is easy to have day-to-day differences in the measured thickness of ice that are not indicative of climatic changes. Scott and Ragotzkie (1961) have shown that significant variations in ice thickness may exist a few meters apart when clear ice (thicker) and snow-covered ice (thinner) are compared. Birge (Neess and Bunge, 1957) would have noticed this difference also had his ice data been collected more frequently during the winter.

Rather dramatic increases in ice thickness are noted after a midwinter melting of snow followed by refreezing. This "quick" growth of new ice is not always apparent when drilling a hole unless the lake is sampled regularly or unless a bubbly or crusty surface remains.

A "lens" of warm water beneath the ice is a common phenomenon in the last few days of ice cover. This warm "lens" is usually over and underlain with colder water thereby giving an impression of hydrostatic instability. For example, on 7 April 1962, five days prior to the disappearance of ice, a water temperature of 5.7°C was recorded at 53 cm below the ice-water interface. The ice was 22 cm thick. The temperature at 128 cm below the ice was 3.2°C. Birge (Neess and Bunge, 1957) also recorded these warm layers during late winter. Doubts as to the stability of these layers are usually allayed by measurements of electrical conductivity, which when converted to a common temperature, indicate an increase in electrolytes which counters the thermal differences.

The mean dates of freezing and opening for the years from 1852 to 1965 are 19 December and 6 April respectively. (Ragotzkie, 1960; Capital Times, 1966; and personal records of senior author, K.M.S.) The specific days at which these events take place are influenced greatly by weather conditions in the immediate preceding days. Thus, as mentioned earlier, Lake Mendota may freeze partially, then reopen partially, and so on until complete closure.

D. *Aspects of Light*

1. Secchi disk

Although the results of Secchi disk readings will be described in more detail elsewhere (manuscript in preparation), it is of interest to note that the clarity of Lake Mendota in 1961, 1962, and 1966 was equivalent to or better than it was in 1916 from the data of Birge (Neess and Bunge, 1957).

Comparing 45 measurements in Lake Mendota and 30 in both Lakes Monona and Waubesa, all in 1962, the mean values of the Secchi disk were 4.6, 2.0, and 0.92 meters respectively. Generally there is a noticeable decrease in transparency as one travels from Mendota to Monona to Waubesa.

The Secchi disk was viewed at 13.2 meters in Lake Mendota on 22 March 1969 while the lake was covered with ice. This is a new record for transparency on the Madison lakes.

2. Submarine Photometer

Separate results from the submarine photometer were also utilized to measure changes in the clarity of water over time (Fig. 15). From the variability observed, it is obvious that measurements of the extinction coefficients (computed as in Hutchinson, 1957, p. 381) (ranging from .303 to 1.227 for data between 1 to 5 meters) may be valid for only one day. "Representative" slopes on a semi-log graph may be difficult to obtain for one lake. The

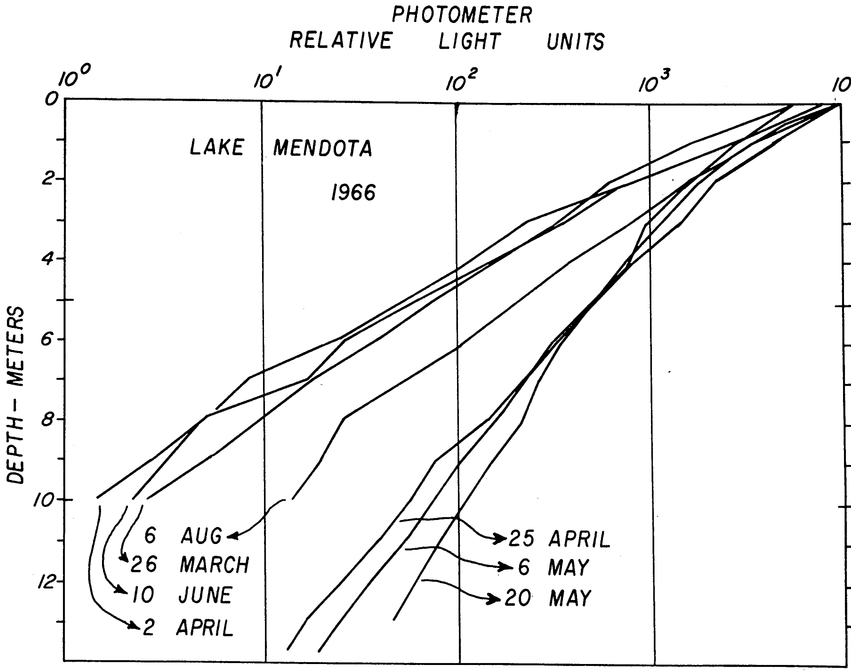

FIGURE 15. Range of variation in the submarine photometer readings in Lake Mendota (1966).

excellent early investigations by Birge and Juday (1929) on the transmission of solar radiation would have shown this overlap more clearly if several readings had been taken on each lake besides Mendota.

3. Transmissometer

A transmissometer (one meter path length) was lowered horizontally to measure microstratification within the three lakes, at half meter intervals, from August through December 1963. This period extended from times of significant thermal, chemical, and biological stratification, through the autumnal overturn, and into the initial stages of ice-cover. The results for Lake Mendota are illustrated in greatest detail by isometric projection in Figure 16. Separate standard inserts in the upper left and lower right of the same figure provide comparisons with Lakes Monona and Waubesa.

During late summer, Lakes Mendota and Monona were still stratified but the water clarity improved markedly below the thermocline. Although very slight thermal stratification remained in

Lake Waubesa on 14 August 1963, the microstratification, as measured by the transmissometer was gone and the water was very turbid from top to bottom.

The relatively turbid epilimnetic waters of Lakes Mendota and Monona might be expected owing to the normally increased quantity of phytoplankton in the euphotic zone. However, Whitney (1938) using essentially the same instrument in Lake Mendota, found a decrease in transparency below the thermocline. He attempted to relate microstratification to bacterial populations.

There were occasions, noted by Whitney (1938) and in this more recent study, when there was a temporary decrease in transparency within or just below the thermocline during the descent of the thermocline. One explanation for this metalimnetic decrease might be some greater planktonic, bacterial, or detrital densities in that zone of rapid thermal transition. Another or combined possibility, since the thermocline may separate anaerobic and aerobic water, is a redox zone of dissolution and precipitation of ferric hydroxide. Mortimer (1941) noted a turbid layer at the upper level of the hypolimnion and did attribute it to a zone of iron oxidation.

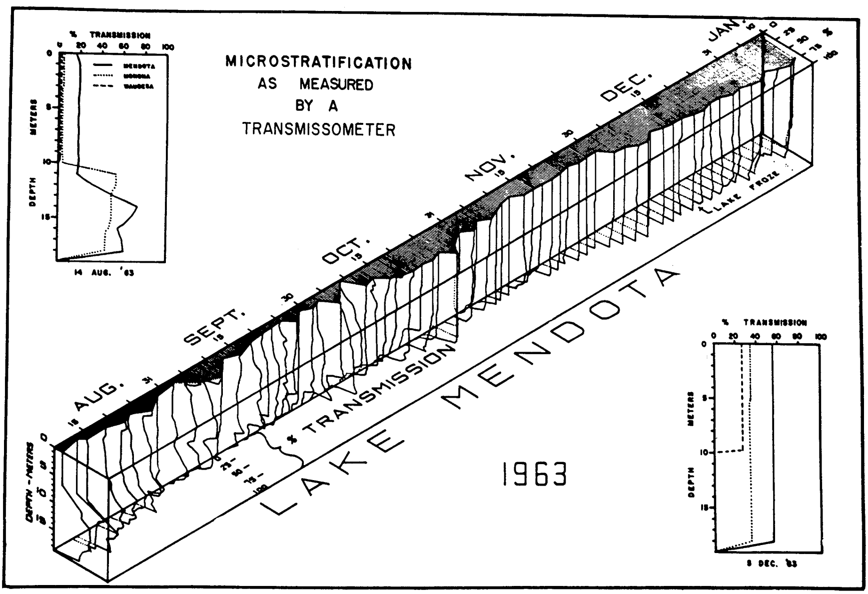

FIGURE 16. Microstratification in Lake Mendota as measured by a transmissometer (one meter light path) in 1963. Separate inserts in the upper left and lower right corners provide some comparison of Lakes Mendota, Monona, and Waubesa.

In 1938 and 1963 the water immediately over the mud-water interface was more turbid. The turbid water near the mud-water interface may reflect boundary layer disturbances from oscillations of standing waves as well as possible density or turbidity currents along the slopes (Hutchinson, 1941).

The general pattern of light transmission for the latter half of 1963 in Lake Mendota, as indicated by the transmissometer, was roughly inverse to that of the thermal profile. That is, the clarity of the water improved in the colder lower waters in summer and throughout the lake as the lake cooled during autumn. The Secchi disk transparency increased during the fall of the previous year (1962) as well. The relationship between cold water and better transmission may have been merely fortuitous for those lakes on those years because algal blooms do occur during autumn and under ice as well (Sawyer, 1947).

Changes in the development and disappearance of layers in a lake can be noted by the changes in transmission of light with time and depth. For example, the clarity of the lower water on 4 August and the clearer, more uniform condition on 25 December are readily apparent (Fig. 16 and 17).

On 26 September (Fig. 17) there was a turbid layer at one to one and one-half meters that was overlain with unusually clear water in the first half meter. The clear water at the surface may have allowed or created light inhibition of a certain algal community there while augmenting prolific algal activity at one to one and one-half meters.

Another unexpected feature was recorded on 8–9 October 1963. On these dates, a turbid and coffee-colored layer extended from the surface to about two meters (Fig. 17). This unusually dark water was most common in the southeastern portion of Lake Mendota near the University of Wisconsin. However, the discoloration extended quite some distance across the lake as well. Therefore, it is not likely that it was something "simply washed in" from rain. More probably the dark water was an intensive surface algal bloom although its specific composition was not determined at that time. The turbid layer of 8–9 October disappeared by 10 October.

The general significance of these findings and those of others (Whitney, 1938; Sauberer, 1962; Mahringer, 1963; Stewart et al. 1966; and Pinsak, 1967) is that the transmissometer can be used to trace or monitor the development or disposition of these layers. Furthermore rapid changes in Secchi disk and photometer values are understood and interpreted more readily when it is realized that such changes may reflect a microstratified zone or narrow layer as well as a general change in water clarity from the quantity and size of algae or inert suspensoids.

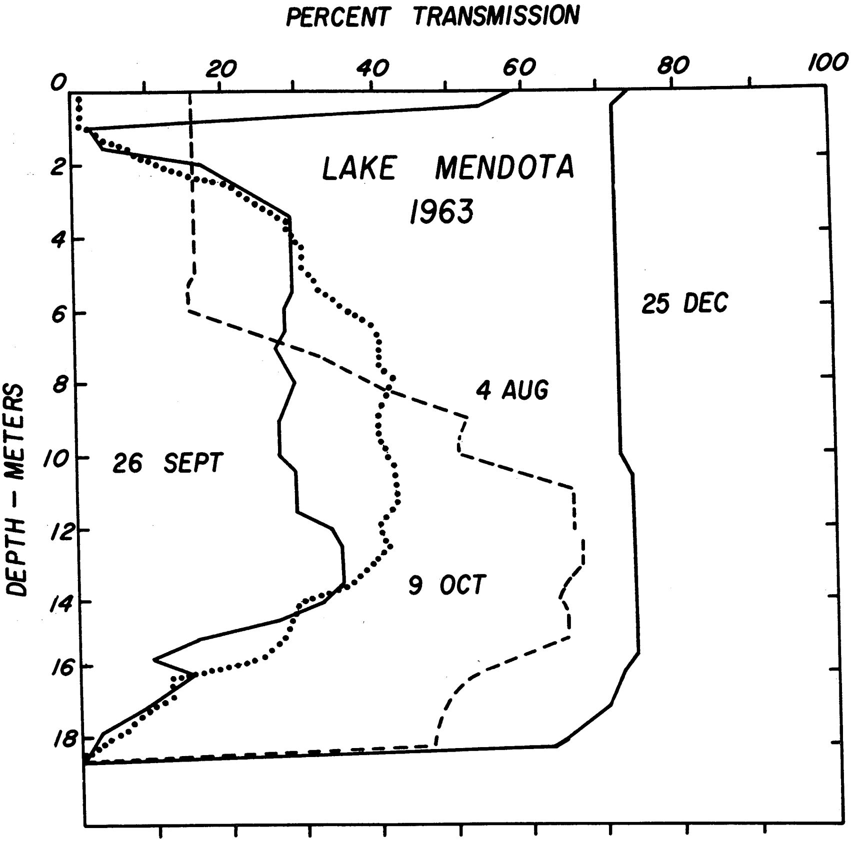

FIGURE 17. Microstratification in Lake Mendota as measured by a transmissometer (one meter path length) on four dates in 1963.

Had Secchi disks and submarine photometer readings been taken in Lake Mendota on 26 Sept 1963 or 8–9 Oct 1963, their results alone may have been puzzling to the investigator and might have given a skewed general picture of the clarity of the water.

IV. *General Significance*

Lake Mendota is a dimitic eutrophic lake in the north temperate zone. By the beginning of the year, the lake is normally frozen. The ice gains in thickness rapidly from the time of freezing through January. During February and early March, the rate of gain in ice-thickness decreases. In the latter part of March and early April there is a precipitous decrease in ice-thickness until the ice disappears.

The mean temperature of the water column under the ice rises gradually through the winter owing to absorption of solar radiation and heat flow from the mud. The concentrations of dissolved oxygen in the lower waters declines during periods of ice-cover.

When the ice departs, dramatic changes occur in the lake. The inverse thermal stratification of winter ceases and a relatively short period of homoiothermy follows. There is rapid heating of the entire water column during vernal circulation.

An interesting feature observed in all three lakes is indicated by the rapid rise in the content of dissolved oxygen at all levels within a few days after the ice melts. The total column of water has values of dissolved oxygen that are higher than at any other time of the year. On the basis of greater solubilities at lower temperatures one would expect theoretically that the highest values of oxygen would occur in the last few days just prior to freezing. This sudden increase in oxygen reflects increased photosynthetic activity of phytoplankton.

As vernal circulation continues, rapid increases in density differences between the developing epilimnion and the hypolimnion establish limits on the depth of mixing. Lakes Mendota and Monona are relatively stable, thermally, during late June and July and August. Lake Waubesa, although primarily a dimictic lake as are Lakes Mendota and Monona, has a shorter period of summer stratification and may be subject to aperiodic turnovers. The total quantity of dissolved oxygen in the lower waters of all three lakes generally decreases rapidly after the onset of stratification.

There is usually a period during the partial autumnal overturn during which the temperatures of Lakes Mendota and Monona remain relatively unchanged. Lake Waubesa shows this to a lesser degree because of its more rapid response time to climatological influences. The physical response of Lake Monona to climatological variables is intermediate to that of Mendota and Waubesa.

At this point in the annual cycle of the lakes, it usually happens that a cold northerly wind cools the remaining epilimnion further, overcomes the remaining density differences, and permits complete mixing. The oxygen deficit in the hypolimnion is repaid quite rapidly and an extended period of complete circulation usually follows. With decreasing water temperatures and increasing oxygen content, the lake proceeds toward the day or days that it freezes. Birge (1908) described appropriately the periods of autumnal and vernal circulation as the "inspiration" periods during a respiratory process.

The day each lake freezes, usually during December, as the day each lake opens in the spring is "critical" in the sense that physical and chemical conditions change dramatically following this event.

Lake Waubesa is in a state of almost perpetual algal "bloom" and demonstrates the most rapid variability of any of the three lakes during their annual cycles. The algal conditions generally are reflected in the descending clarity of the lakes from Mendota to Monona to Waubesa.

V. *Summary and Conclusions*

These studies on some physical (temperature, light, and ice) and chemical (oxygen) variables in the Madison lakes provide detailed data on the annual cycles in Lake Mendota and the relatively little studied Lakes Monona and Waubesa.

The patterns of physical change within the Madison lakes are dictated primarily by morphometric and cyclic climatological influences. Prominent among the climatological influences are the temperature of the air, wind velocities and directions, and solar radiation. Even a cursory examination of these variables illustrates the huge changes that they can impress upon the lakes. The lakes respond to these cyclic external changes but do so through an integrating process.

These more recent data of Lake Mendota, especially when compared to those of Birge and co-workers several decades ago, are for the most part surprisingly similar. The thermal structure, oxygen profiles, and light readings of the lakes resemble those recorded by earlier investigators of the Madison lakes and do not in themselves indicate a significant change in the lakes.

The role of the thermal discharge into Lake Monona from the Madison, Gas and Electric Company may have an increasing effect as the population of Madison grows. This will be most obvious visually in the earlier disappearance of ice.

Owing to the useful information transmissometers provide concerning microstratification of organisms, turbid layers, and possible chemical and thermal stratification, it is unfortunate these instruments are not utilized more widely.

Owing to the vast scientific, recreational, aesthetic, and economic importance of the Madison lakes, it is advisable, as suggested (Sawyer, 1947; Stewart and Rohlich, 1967), to devote a small fraction of the research efforts and funds of a laboratory to a program of systematic surveillance for physical, chemical, and biological variables. These efforts would provide basic limnological data, vital for good management considerations, as well as knowledge of trends or changes in the lakes which may affect the direction of future research.

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THE ALGAE OF THE WINNEBAGO POOL AND SOME TRIBUTARY WATERS[1,2]

William E. Sloey and *John L. Blum*

INTRODUCTION

The Winnebago Pool (Lakes Winnebago, Poygan, Winneconne and Butte des Morts) is one of the more important water resources in Wisconsin. Frequent algal blooms interfere with domestic, industrial and recreational use, but there have been no comprehensive reports on the algae. Smith (1920, 1924) mentioned the relative abundance of some species present in Lake Winnebago in his taxonomic treatise on the Phytoplankton of the Inland Lakes of Wisconsin; and Marsh (1903) made a study comparing the zooplankton and phytoplankton of Lake Winnebago to those of Green Lake. Recently, Leuschow *et al.*, (1970) studied the major groups of net plankton in Lake Winnebago during the open water period. They compared Winnebago to eleven other lakes for trophic level, and found it to be the most eutrophic of the lakes studied.

During a two and one-half year period from 1966 to 1968, the senior author made a physical, chemical and biological study of the Winnebago Pool with particular attention to Lake Butte des Morts. The physico-chemical limnology, C-14 primary productivity, phytoplankton standing crops and community structures were reported previously (Sloey, 1970). This report is limited to the population dynamics of the predominant phytoplankton organisms. A partial species list of the algae of the Pool, of the upper Fox and lower Wolf Rivers and of some tributaries is also included.

METHODS

Sampling

Water samples for phytoplankton counts were collected at five selected stations (Figure 1) at the surface and 0.2 m above the bottom with a horizontal sampler (Howmiller and Sloey, 1969). Aliquots of 2–10 ml, the amount depending on plankton density, were

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[2] The authors would like to thank Dr. Ruth Patrick of the Philadelphia Academy of Natural Sciences, Philadelphia for her kind assistance in confirming some of the diatom species identifications and for the time spent in her laboratories by Dr. Sloey during the summer of 1967.

delivered with a 10 ml Mohr pipette having a 4 mm bore onto 25 mm diameter HA Millipore filters and filtered. The rapid Millipore filter counting technique of McNabb (1960) was employed and all counting was done at 1000 X. Two slides were prepared from each of the surface and bottom water samples. The mean of the four counts (2 each, surface and bottom) was determined for

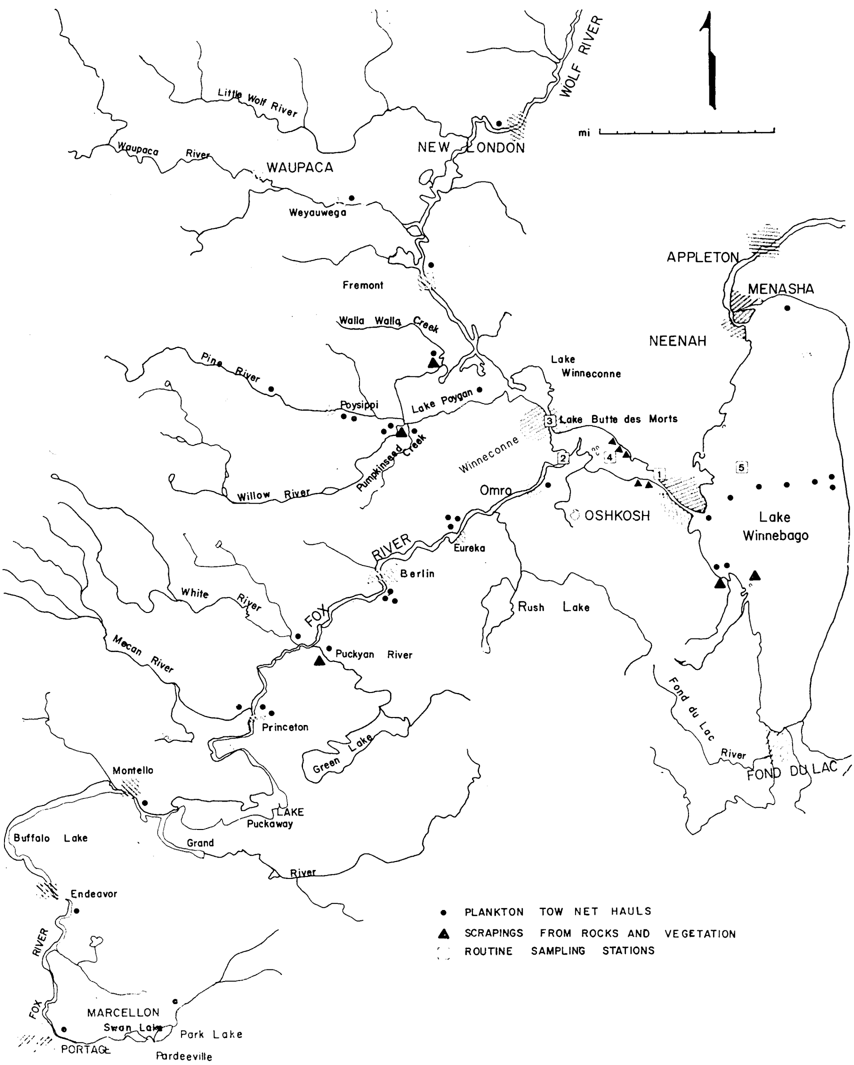

FIGURE 1. A map of the Winnebago Pool and a portion of the associated watershed showing sampling sites. Location: east-central Wisconsin.

each species or group of algae. This was done in the hope of correcting to some extent for variation within samples as well as between samples (from surface and bottom, respectively) and so as to limit the samples to a number that could be handled.

On the days of plankton sampling, a tow net haul was also made at each station to obtain large numbers of organisms for species identification. During the summer of 1966, a qualitative study of the benthic algae was made outside the limits of the numbered stations by scraping submerged rocks, vegetation and navigational buoys, and several plankton sampling transects were made of representative portions of the Pool and of the Upper Fox and Wolf Rivers and their tributaries.

Within 24 hours of sampling, water mounts were prepared from the tow hauls and the scrapings made; all the Chlorophyta, flagellates, and Cyanophyta that could be found in 3–6 transects of the slide were identified. The more uncommon species were recorded on photomicrographs. Some of this material was then cleaned in H_2SO_4 and dichromate, or simply ashed (Patrick and Reimer, 1966) and mounted in Hyrax for detailed study of the diatoms. The remainder of the sample was preserved with 5% formalin and filed, along with the Hyrax mounts, at the Wisconsin State University, Oshkosh. The location of a voucher specimen for each species of diatom was recorded on a 3x5 card and filed with the slides and photomicrographs.

Frequency of sampling

Plankton samples were taken at weekly intervals during the summer of 1966, intermittently during the winter of 1966–67, biweekly during the ice-free periods of 1967 and 1968, and monthly during the winter of 1967–68.

References used for the identification of diatoms were: Hustedt, 1930_a, 1930_b; and Patrick and Reimer, 1966. Those consulted for other groups were: Prescott, 1962; Smith, 1920 and 1924; Tiffany and Britton, 1952. Above the generic level, the nomenclature and taxonomic treatments are those of Prescott (1962).

Determination of cell volumes

Two slides of Millipore filter mounts were selected from each month's set of samples. Using the basic forms of cube, sphere, cylinder and disc, the volume of at least ten units of each species was determined from each slide. A "unit" was specified as a natural aggregate of cells (e.g., filament of *Melosira*, colony of *Asterionella* or a clump of *Microcystis*). Volumes were expressed as $\mu^3 \times 10^6$ ml^{-1}.

Determination of generation times

In a population of cells, each dividing vegetatively into two daughter cells, a logarithmic or exponential growth pattern is assumed. This growth rate can be expressed in terms of the time required for the population to double. Fogg (1965) described this doubling time as a "generation time" on the assumption that predation, disease and losses by flushing and settling are insignificant in cultures and in most planktonic situations. Under optimal conditions the generation time decreases. Making a similar assumption for the phytoplankton of the Winnebago Pool, we calculated generation times (G) for the predominant algae according to the formula of Fogg as follows:

$$G = \frac{0.301\ t}{\log\ (N/N_0)}$$

where:

t = time
N = number of cells at the end of the time period
N_0 = number of cells at the beginning of the time period

In this report, as in the recent literature, "generation time" is used to designate apparent generation time. Obviously, patchiness of phytoplankton populations, dilution from runoff and other factors may affect a natural population. It will be necessary to confirm field observations with laboratory cultures before the term "generation time" can be literally applied to ecological studies.

RESULTS

Occurrence and periodicities of individual species in the Pool

A total of 106 algal taxa were encountered in the Pool during this study. One can assume that each of these formed part of a population which varied with time, probably in response to favorable and unfavorable conditions.

The bloom-forming blue-greens

ANABAENA spp.—The genus *Anabaena* is represented in Lake Butte des Morts by five species, *A. circinalis* (Kütz.) Rabh., *A. lemmermanni* P. Richter, *A. limnetica* G. M. Smith, *A. planktonica* Bruhn., and *A. spiroides* Klebahn. The first two forms *(A. planktonica* and *A. spiroides)* were more common in late summer and fall. *A. limnetica* appeared intermittently throughout the summer and seemed to be most frequent after rainy periods. These forms are difficult to separate unless akinetes are present; thus, routine counts were made at the generic level.

Temperature may be the key factor determining the presence of *Anabaena*. In no case did significant populations occur below 18 C, and declines commenced when temperatures dropped below this value. While populations fluctuated considerably, especially during the summer of 1966, the minimum generation times (N = no. of filaments) ranged from <1.0 during the first week in August 1966 to 23 days in late July 1967. On the basis of biweekly sampling intervals, it appeared that generation times averaged between 2 and 5 days. In spite of lower temperatures in 1967, the population maxima during that year were nearly twice as great as during 1966 or 1968. The highest numbers recorded were 1,925 filaments ml^{-1} at station 4 on 28 July 1967 and 2,950 at station 3 on 22 August (Figure 2).

APHANIZOMENON FLOS-AQUAE *(L.) Ralfs.*—This species occurs with *Anabaena* and appears to have similar seasonal trends. The similarity was particularly striking during 1967 (Figure 2), except that *Aphanizomenon* had a brief surge in October and early November. A surface film of colonies was noted on 1 November at 4 C; by 6 November the temperature had dropped to 2 C and no filaments could be found. Populations during 1968 were much lower than in 1966 or 1967. Maximum values reached only 365 colonies per ml at station 2 on 22 August (1.46 million μ^3 per ml), Lake Winnebago had 827 per ml on the same date. The earliest seasonal appearance was 24 May 1968 (29 per ml) at station 3 when the bottom and surface temperatures were 15.3–15.8 C, respectively. Apparent generation times (N = no. of colonies) averaged between 2 and 5 days and ranged from <1.0 to 29 days during periods of population growth.

MICROCYSTIS AERUGINOSA *Kütz. emend. Elenkin 1924*
Syns: *M. aeruginosa* var. *major*
M. flos-aquae (Wittr.) Kirchner
(see Prescott, p. 456–7)

Microcystis appeared in the plankton with the two previous genera at warm temperatures. Sizable populations appeared very suddenly. For example, the population increased from 0 to 96 colonies ml^{-1} between 10 and 24 May 1968. Once present, populations tended to remain fairly constant throughout the summer (not shown). Since few definite growth periods were detected, few generation times could be determined. It is estimated that this period is 2–6 days inasmuch as the shortest period was 1.82 days (N = no. of colonies) in early August 1966 and the longest was 6.19 days in early July 1966.

The time of lowest temperature (15.0, 15.6 C, bottom and surface, respectively) was on 10 May 1968 at station 2. Unlike *Aph-*

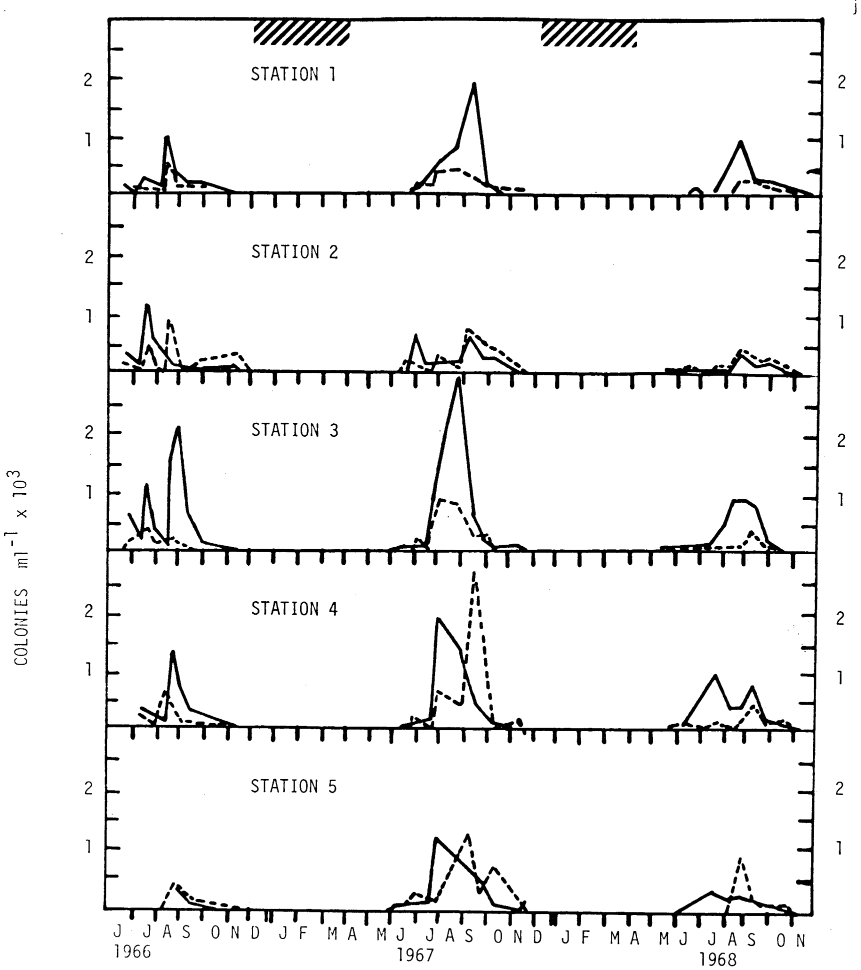

FIGURE 2. Periodicity of *Anabaena spp.* (——) and *Aphanizomenon flos-aquae* (- - -) in the Winnebago Pool, 1966–1968.

anizomenon, populations were larger in 1968 than in 1967. The greatest number was 404 colonies ml^{-1} ($10.6 \times 10^6\ \mu^3$ ml^{-1}) on 22 August 1968 at station 1.

OSCILLATORIA AGARDHII *Gomont.*—This species did not appear to be of major biological significance in the Pool, but its appearance as a minor bloom in the low light regime under the ice during February and March was very striking. The highest number found was 80 filaments per ml on 27 March 1967 at station 3. This was just prior to the spring ice breakup.

The planktonic pennate diatoms (Araphidineae)

ASTERIONELLA FORMOSA *Hass. var.* FORMOSA.—*Asterionella formosa* populations fluctuated very rapidly in Lake Butte des Morts. The species appeared primarily in late fall (October to December) and in late spring (May to July, Figure 3). Populations in the upper Fox River (station 2) and in Lake Winnebago were considerably smaller than at the other stations. Particularly large populations occurred in the Wolf River in November 1966 and at stations 1 and 4 in May and June 1968. During 1967, large populations failed to materialize at any of the stations in either spring or fall. The maximum values recorded were 6,000 cells per ml on 6 June at station 4 and 5,300 cells per ml at station 1 on 24 May 1968. The latter value represented 34.5% of the total phytoplankton volume, the largest percentage found. Fall populations frequently persisted under the ice. In fact, there were only very small populations in Lake Winnebago during 1966 and 1967, but 390 cells per ml appeared under the ice in February 1968. Growth periods of the populations occurred during September to December and March to June. Apparent generation times ranged from 3.06 days in early May, 1968 to 40.5 days in December, 1966 and averaged about 10 days. The average number of cells per colony increased from 4 to 5.4 during early June; this immediately followed a population maximum and a generation time minimum.

SYNEDRA *spp.*—The genus *Synedra* is represented in the Winnebago Pool by at least six species and/or varieties. Like *Anabaena*, these forms are difficult to separate during routine counting on the Millipore filters and thus were also counted at the genus level.

The following entities were present:

Synedra acus Kütz. var. *acus*. Fairly common during the spring bloom.

S. delicatissima var. *angustissima* Grun. Important in the plankton from April until June.

S. pulchella Ralfs. ex. Kütz. var. *pulchella*. An autochthonous epilithic and epipelic form which occasionally appeared in the plankton.

S. ulna (Nitz.) Ehr. var. *ulna*. In spring and fall plankton.

S. ulna var. *amphirhynchus* (Ehr.) Grun. Fairly common in the spring and late fall plankton.

S. ulna var. *longissima* (Wm. Smith) Brun. Occurred only in the fall in small numbers.

Members of the genus *Synedra* were primarily spring and fall forms, but considered together, one or more species were present on almost every sampling date (Figure 3). The smallest and most erratic populations were seen in Lake Winnebago. By far the greatest number occurred at station 2 on 24 May 1968 (5,700 cells per ml), when *Synedra delicatissima* var. *angustissima* represented 12.2% of the total phytoplankton volume. Generation times (N = no. of cells) at the genus level ranged from 1.93 days in early August 1966 when populations were low to 27.5 days in April 1967 when populations were high.

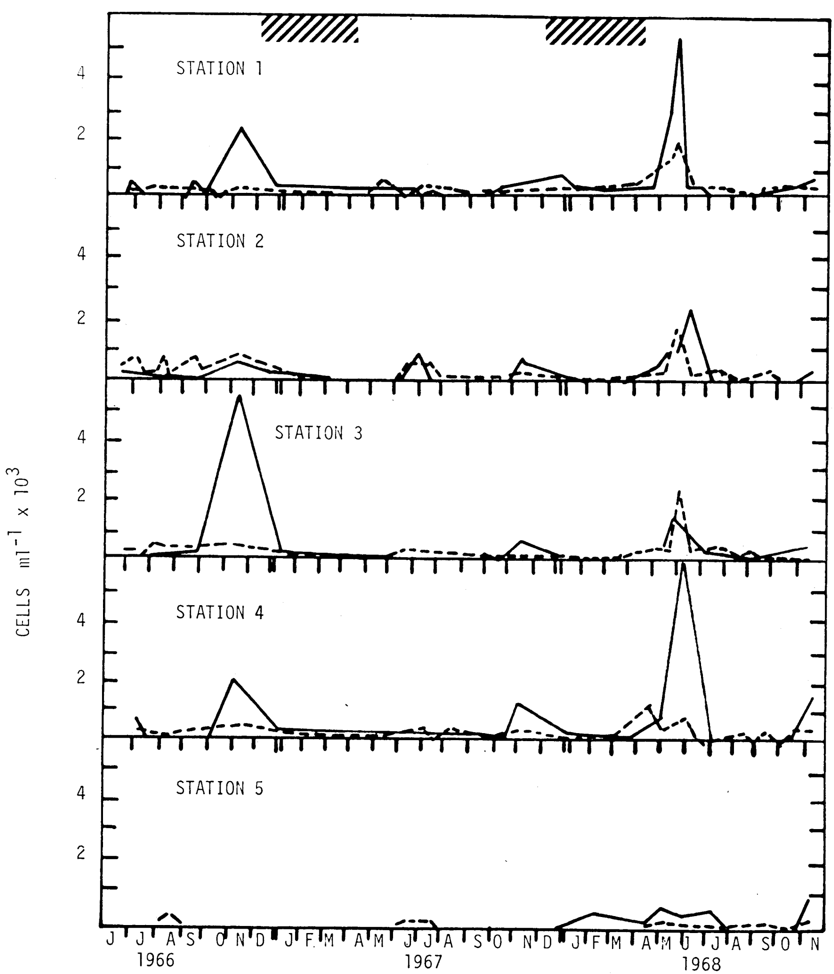

FIGURE 3. Periodicity of *Asterionella formosa* (——) and *Synedra spp.* (- - -) in the Winnebago Pool, 1966–1968.

The centric diatoms

STEPHANODISCUS HANTZSCHII *Grun.*—This nannoplankter was the dominant form during the period of ice cover and immediately thereafter. The species was present in higher numbers during the summer of 1968 than during 1966 or 1967 (Figure 4). The largest number of cells recorded was 14,030 per ml on 29 December 1967 when it comprised some 96.5% of the number and 75.3% of the volume of the phytoplankton. Minima occurred during the July–September maxima of *Melosira spp., S. niagarae* and the blue-greens. Generation times (N = no. of cells) during the growth periods ranged from 1.55 days in June 1966 to 57.1 days in December 1967. Generation times during spring and fall increases averaged 9 days.

While midwinter declines in the populations occurred at every station, there is no question but that this very light and hyaline species persisted better in the relatively stable conditions under the ice than any other diatom observed. There was an eight-fold apparent increase under the ice in 1968 at station 2 (Figure 4).

STEPHANODISCUS NIAGARAE *Ehr.*—*Stephanodiscus niagarae* was primarily a late summer–fall form. By far the greatest populations occurred during October and November 1966 (Figure 4). On 8 November of that year, 686 cells ml^{-1} were present at station 2 (22.6×10^6 μ^3 ml^{-1}). This species was seldom found in the plankton during the more stable ice-cover period. It is probable that *S. niagarae* is also relatively heavy; this could account for its settling out from the plankton under the ice but other factors may be responsible. Generation times (N = no. of cells) were quite long, averaging 16.0 days for 21 positive growth periods. Growth rates were more consistent over long periods of time for this species than for any of the others reported here. During the period of 1 July to 24 October 1968, generation times varied only from 10.1 to 15.7 days at station 1.

MELOSIRA AMBIGUA *(Grun.) O. Müll.*—*Melosira ambigua* was a co-dominant plankter (along with *M. granulata*) from June until October. This species must be considered "persistent" (Bozniak and Kennedy, 1968) since it was present at almost every station on every sampling date (Figure 5). During the summer period, phenomenally high values were recorded. The Fox River at station 2 had populations as high as 98,700 cells per ml on 28 July 1967 and 93,600 per ml on 19 July 1968. The latter value represented 62.64 million μ^3 ml^{-1} and 73.5% of the total phytoplankton volume. Maxima, which occurred as one or more peaks between June and September, were normally 3 to 5 times higher in the upper Fox River (station 2) than in the Wolf (station 3). Minima

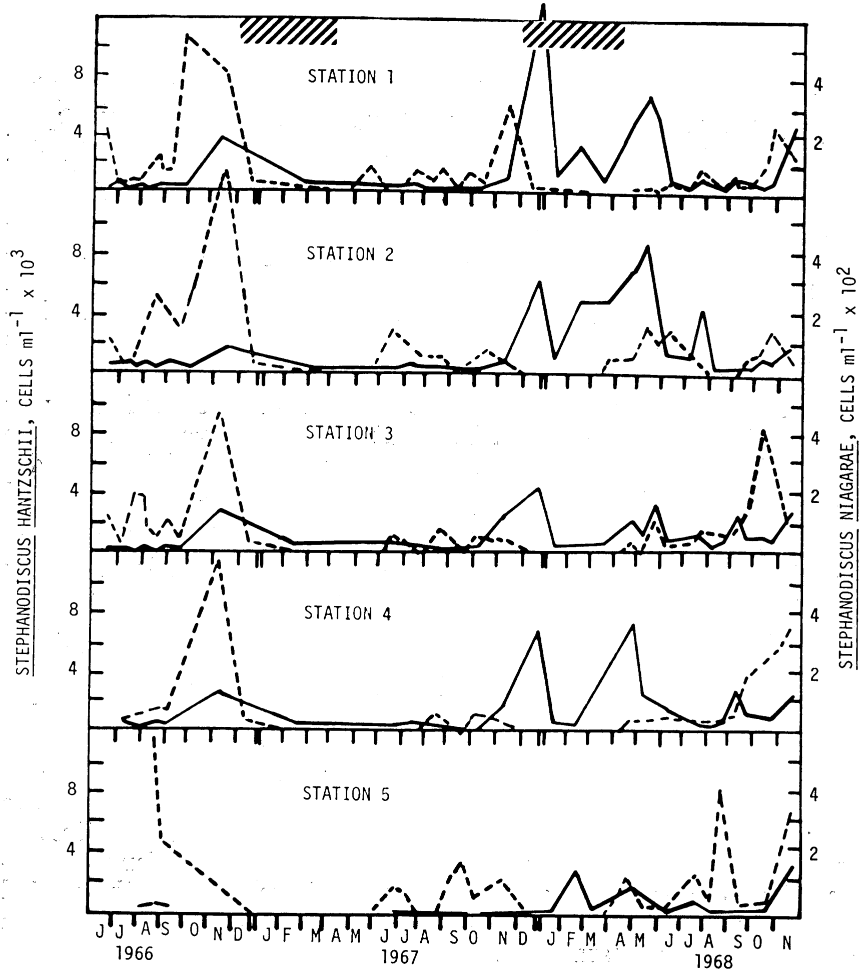

FIGURE 4. Periodicity of *Stephanodiscus Hantzschii* (——) and *S. niagarae* (- - -) in the Winnebago Pool, 1966–1968.

occurred under the ice, but the species never completely disappeared from the plankton. Certainly if any organism could be said to be "typical" of Lake Butte des Morts or the Winnebago pool, it would be *Melosira ambigua.* Exponential phases of population growth occurred between April and July, and a secondary growth phase appeared in early fall when water temperatures started to decline. Cell division rates appeared therefore to be related to water temperatures. Optimum growth rates occurred between 10 and 13 C in early May when the mean generation time (N = no.

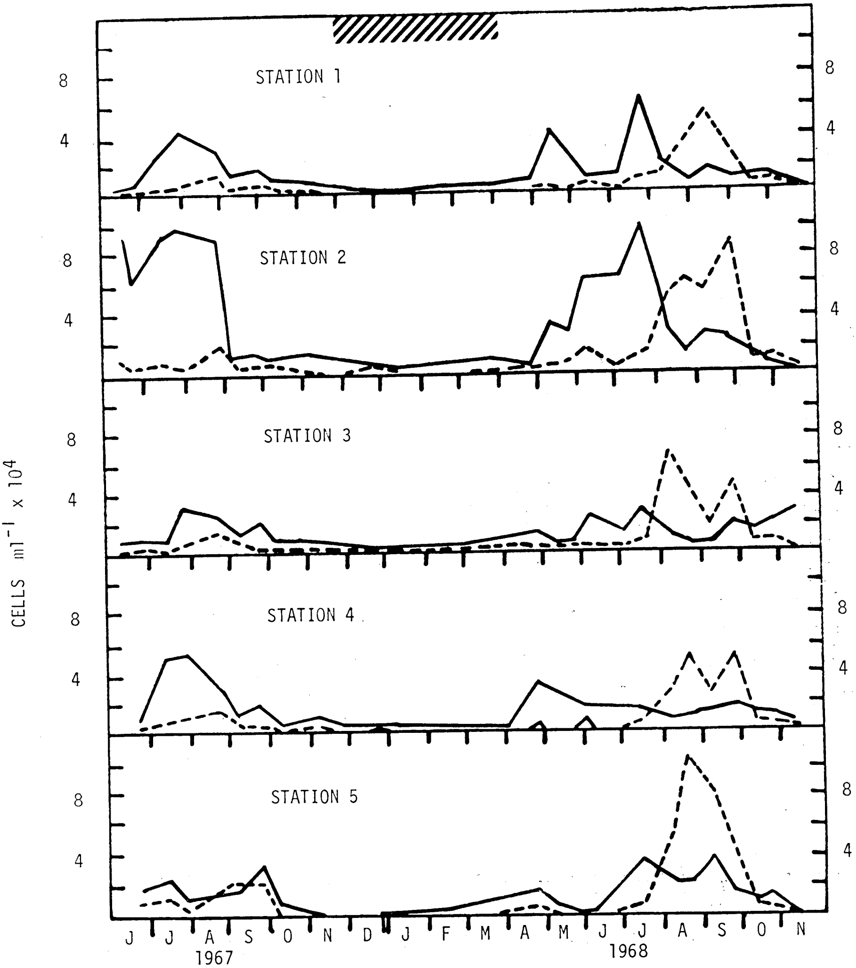

FIGURE 5. Periodicity of *Melosira ambigua* (——) and *M. granulata* (- - -) in the Winnebago Pool, 1967–1968.

of cells) was only 5.37 days. The autumn population growth rate was somewhat slower, with a minimum mean generation time of 9.74 days during September at water temperatures of 19.6 to 20.9 C. Midsummer and late fall growth rates were even slower. Populations decreased throughout October and November (except for station 3).

The number of cells per filament ranged from 6.1 in January to 28.6 in mid-July.

MELOSIRA GRANULATA *(Ehr.) Ralfs.—Melosira granulata* was a co-dominant with *M. ambigua* from June until October when the two species usually represented more than 70% of the total phytoplankton volume and values as high as 95% were recorded. Together, they dominated the phytoplankton throughout the Winnebago pool and as far upstream in the Fox River as Endeavor, some 75 miles above station 2 (see below). Maxima of *M. granulata* were not reached until late August or September, well after the initial maxima of *M. ambigua,* and at water temperatures above 20 C. The highest numbers recorded were 115,500 and 83,211 cells ml^{-1} in Lake Winnebago on 22 August and 5 September 1968, respectively (Figure 5). At station 2 there were 65,000 cells per ml ($57.08 \times 10^6 \mu^3 ml^{-1}$) on 22 August. Populations decreased during late autumn and reached winter levels well before ice formation.

Generation times (N = no. of cells) for *M. granulata* followed a pattern similar to that for *M. ambigua.* Population growth did not commence, however, until after ice-out at the end of March, and minimum doubling times occurred between late May and early July, rather than April.

The number of cells per filament increased from 2.5 in February to 32 on 22 August. The longest filaments occurred after maximum growth rate periods, but at approximately the same time as the population maxima. By 13 November the mean filament length had decreased to only 5 cells.

Melosira binderana Kütz. *M. binderana* was an occasional plankter in Lake Winnebago in spring but was not found in Lake Butte des Morts.

M. italica (Ehr.) Kütz., subsp. *subarctica* O. Müll., (status alpha). *M. italica* was found only in a few later winter collections. It was also found in the upper Fox and Wolf Rivers.

M. granulata, var. *angustissima* O. Müll. This variety was not found in any sample before 10 May and was present only sporadically until September. The number suddenly increased to a peak in October with a maximum number of 1,347 filaments and 26,900 cells per ml on 24 October 1968. Filament lengths also increased from about 8 or 10 to 20 cells during October. By 13 November populations had dropped to only about 100 filaments ml^{-1}. Inasmuch as this narrow "variety" appears after the period of auxospore formation of the nominate variety (15–30 July) one must question if this not a separate species. To determine this, culture studies are needed.

M. varians C. A. Ag. Occasionally occurs in the plankton, but is considered a littoral form (Hustedt, 1930_a, p. 86) and is quite common in rock scrapings and to a lesser extent in scrapings from macrophytes.

Other algae found in the Winnebago pool

The other algae, those of lesser importance in the phytoplankton, and the benthic forms, are listed below according to their general taxonomic affinities.

Bacillariophyceae

Achnanthes lanceolata (Bréb. in Kütz.) Grun. in Cl. and Grun. Observed occasionally in the plankton during late winter and early spring.

Amphipleura pellucida Kütz., var. *pellucida*.

Amphiprora ornata Bailey.

Caloneis ventricosa (Ehr.) Meist., var. *truncatula* (Grun.) Meist.

Cocconeis pediculus Ehr., var. *pediculus*. Very common epilithic and periphytic form in lakes Butte des Morts and Winnebago.

C. placentula Ehr., var. *lineata* (Ehr.) V. H. Common epiphyte, occasionally found in plankton.

Cyclotella Kützingiana Thwaites. Rare, mostly in the Wolf River (station 3).

C. Meneghiniana Kütz. Uncommon.

Cymatopleura elliptica (Bréb.) W. Smith.

C. solea (Bréb.) W. Smith. Common, but never numerous.

Cymbella parva (W. Smith) Cleve.

C. prostrata (Berkeley) Cleve. Common epilithic and epiphytic form.

C. tumida (Bréb.) Van Heurck. Occasional plankter.

Diatoma tenue Ag., var. *elongatum* Lyngb. Occasional in spring plankton.

D. vulgare Bory., var., *vulgare*. Common epilithic and epiphytic form that occasionaly occurs in the plankton.

Epithemia turgida (Ehr.) Kütz., var. *capitata* Fricke.

Eunotia parallela Ehr., var. *parallela*.

Fragilaria capucina Desmazières. Common in spring and fall plankton.

F. construens (Ehr.) Grun., var. *construens*. Occasional plankter.

F. crotonensis Kitton, var. *crotonensis*. Common plankter, especially in spring and early summer.

F. vaucheriae (Kütz.) Peters, var. *vaucheriae*.

Gomphonema sp. Very common epilithic and epiphytic form. Specimens are similar to Hustedt's *G. tergestinum* (1930_a, p. 378) but striae are much coarser (7-8/10 μ).

Gyrosigma attenuatum (Kütz.) Rabh., var. *attenuatum*. Occasional cold water planktont.

G. sciotense (Sulliv. & Warmley) Cl., var. *sciotense.* Occasional spring and fall planktont.

G. spencerii (Queck.) Griff & Henfr., var. *spencerii.*

Meridion circulare (Grev.) Ag., var. *constrictum* (Ralfs) V. H. Occasionally occurs in the plankton in winter and early spring.

Navicula cuspidata (Kütz.) Kütz., var. *major* Meist.

N. exigua Greg. ex Grun., var. *capitata* Patr. Found only in one sample in March. Patrick lists this as a soft water form.

N. gastrum (Ehr.) Kütz., var. *gastrum.*

N. lateropunctata Wallace, Var. *lateropunctata.*

N. meniscultus Schumann, var. *upsaliensis* (Grun.) Grun.

N. pupula Kütz., var. *rectangularis* (Greg.) Grun.

N. salinarum Grun., var. *intermedia* (Grun.) Cl. Common epilithic form.

N. scutelloides W. Smith ex. Greg., var. *scutellodies.* Common, but never numerous in the plankton.

N. viridula (Kütz.) Kütz. emend. V.H., var. *viridula.*

Neidium productum (Wm. Smith) Pfitzer.

Nitzschia acuta Hantzsch.

N. amphibia Grun.

N. filiformis (Wm. Smith) Hust.

N. gracilis Hantzsch.

N. palea (Kütz.) Wm. Smith.

N. sigmoidea (Ehr.) Wm. Smith. Fairly common in spring and fall plankton.

N. spectabilis (Ehr.) Ralfs.

Opephora martyi Herib., var. *martyi.* Fairly common in late winter and spring plankton.

Pinnularia brébissonii (Kütz.) Rabh., var. *brébissonii.*

P. gentilis (Donk.) Cl., var. *gentilis.*

P. major (Kütz.) Rabh., var. *transversa* (A.S.) Cl. striae slightly fewer (6–7/10 μ) than Patrick's description (8–9/10 μ).

P. streptoraphe Cl., var. *streptoraphe.*

Rhoicosphenia curvata (Kütz.) Grun. ex. Rabh., var. *curvata.* Very common benthic form.

Stephanodiscus tenuis Hustedt. Fairly common in late winter and spring plankton.

Surirella tenera Gregory, var. *nervosa.* Most common in June.

Surirella, sp. 1. This species is similar to *S. linearis* (Hustedt, 1930_a; p. 434), but specimens are larger with wider canals.

Surirella, sp. 2. Similar to *S. capronii* (Hustedt, 1930_a, p. 440), but lack the well developed central costae.

Synedra acus Kütz., var. *acus.*

Tabellaria fenestrata (Lyngb.) Kütz., var. *fenestrata.* Rare in Lake Butte des Morts, occurring only in the spring.

Chlorophyceae

Asterococcus limneticus G. M. Smith. Rare summer form.

Cladophora glomerata (L.) Kütz. Extensive growth on rocks, posts, etc., wherever these is wave action. Frequently attached to macrophytes in protected bays. Usually encrusted with periphytic diatoms.

Chlamydomonas globosa Snow. Found only on a few occasions in the Fox River (station 2) in the summer.

Closterium aciculare T. West, var. *subpronum* W. and G. S. West.

C. moniliferum (Bory) Ehrenberg. Associated with macrophytes in bays and marshes.

Dictyosphaerium pulchellum Wood. Rare, in summer plankton.

Dimorphococcus lunatus A. Braun.

Pediastrum boryanum (Turpin) Meneghini. Appears mostly in the fall.

P. duplex Meyen, var. *gracillinum* W. and G. S. West.

P. duplex, var. *cohaerens* Bohlin.

P. simplex (Meyen) Lemmermann, var. *duodenarium* (Bailey) Ragh. Common in fall plankton.

Scenedesmus quadricauda, var. *Westii*.

S. quadricauda (Turp.) Bréb., var. *longispina* (Chod.) G. M. Smith.

Selenastrum Bibrainum Reinsch.

Staurastrum longiradium W. & G. S. West. Common, but not numerous in plankton during summer and fall.

Tetraedron limneticum Borge. Occasionally appears in plankton from August until October.

Chrysophyceae

Dinobryon divergens Imhof. Found only in Wolf River in early summer.

Dinophyceae

Ceratium hirundinella (O. F. Muehl.) Jorgensen. Present in most samples throughout the year, but never found in bloom proportions.

Myxophyceae

Aphanocapsa delicatissima W. and G. S. West. Occurred only in the plankton at station 3 during November (water temperature during one collection, 2.2 C).

Chroococcus limenticus Lemmermann, var. *subsalsus* Lemmermann. Rare, during mid-summer.

C. limneticus, var. *elegans* G. M. Smith. Occasional, during early summer.

Coelosphaerium naegelianum Unger. A very common bloom former in early summer.

Gloeotrichia echinulata (J. F. Smith) P. Richter. Common in Lake Winnebago in June; rare in Lake Butte des Morts as planktont.

G. natans (Hedwig) Rabenhorst. Common epiphyte in marsh areas during late summer.

Merismopedia punctata Meyen.

The algae of the streams tributary to the Winnebago Pool

The Upper Fox River

The upper Fox River near the headwaters at Marcellon is a clear, shallow stream with many aquatic macrophytes. The plankton is represented primarily by tychoplankters and benthic escapes such as *Cymatopleura solea, Melosira varians, Cosmarium moniliferum, Cocconeis placentula, Navicula spp., Cymbella tumida, Phormidium sp., Synedra ulna* var. *spathulifera* (Grun.) V. H., *Stauroneis sp., Diatoma vulgare, Meridion circulare, Cyclotella Meneghiniana,* and *Perionella planktonica.* No "nuisance" blue–greens were found, and only a few individuals of planktonic diatom species such as *Melosira ambigua,* and *Fragilaria capucina.*

At Portage, below Park and Swan Lakes, some of the "nuisance" blue–greens such as *Microcystis flos-aquae, Anabaena spiroides* and *A. circinalis* were evident, along with considerable numbers of planktonic diatoms such as *Melosira ambigua* and *M. granulata* and *Stephanodiscus niagarae.* The plankton was, however, still represented primarily by tychoplankters and benthic escapes including the same species of *Cocconeis, Cyclotella, Diatoma,* and *Cymbella* as was found at Marcellon. *Achnanthes hungarica* (Grun), var. *hungarica, M. varians, Synedra delicatissima,* and *Nitzschia sp.* were also present.

At Endeavor, the Fox River was already turbid and the plankton was dominated by *Melosira ambigua* and *M. granulata* (about 75% of the diatoms) along with *M. italica, Anabaena spiroides, A. planktonica, Ceratium hirundinella,* and *Eudorina sp.* Many of the benthic forms were still present, but their contribution to the total plankton was considerably reduced.

From Montello downstream, the plankton was typical of that found in the Winnebago Pool. The predominant forms were *Aphanizomenon, Anabaena spiroides, Microcystis aeruginosa, Pediastrum sp. Stephanodiscus niagarae* and especially *Melosira ambigua* and *granulata.* From Berlin downstream, *Selenastrum bibraineum* Reinsch, *Eudorina sp., Chlamydomonas sp.* and *Scenedesmus quadricauda* were also present in small numbers.

The Mecan River

The Mecan River at Montello is a marginal trout stream having water slightly discolored from humic acids. The plankton was sparse and composed primarily of *Pediastrum sp., Closterium sp., Navicula spp., Phormidium sp.* and a few filaments of *Melosira granulata.*

The White River

The White as sampled at County Highway D, seven miles east of Princeton is a clear water trout stream. The plankton was composed primarily of benthic escapes and organic debris along with a few filaments of *Melosira granulata* and *Microcystis aeruginasa.*

The Puckyan River

The Puckyan River as sampled from County Highway A east of Princeton is a shallow stream having warm water and many submerged aquatic plants. Skeins of *Spirogyra sp.* streamed from the vegetation and the plankton was primarily epiphytes and benthic escapes, but a few euglenoids and *Chlamydomonas sp.* were present. Epiphytes included *Navicula spp., Cocconeis placentula, Rhoicosphenia curvata, Cymatopleura sp.* and *Cymbella sp.*

The Wolf River

The Wolf River at New London has a composite plankton composed primarily of euplankters such as *Melosira ambigua,* and *M. granulata* with lesser numbers of *M. italica, Fragilaria leptostauron, F. capucina, Synedra acus, Navicula scutelloides, Cymbella tumida,* and *Surirella caproni* Bréb. No blue–greens were present, but considerable numbers of benthic forms such as *Navicula cryptocephala* Kütz. var. *cryptocephala, M. varians, Nitzschia sigmoidea, N. cuspidata,* and *Achnanthes lanceolata* were present.

At Fremont, the Wolf River had a plankton composed almost entirely of euplankters. These were dominated by *Melosira granulata* (including the variety *angustissima*) and *M. ambigua.* On 24 July 1966 no blue–greens were present. Other forms present included *Pediastrum duplex* var. *gracillimum, Synedra sp., M. italica, Chroococcus elegans, Pediastrum boryanum, Stephanodiscus niagarae, M. varians, Surirella sp.* and *Cocconeis pediculus.*

The Waupaca River

The Waupaca River below the reservoir at Weyauwega is a warm-water stream containing mostly *Melosira ambigua* and *Oscillatoria tenuis,* with some *M. granulata.* Other forms present included *Actinastrum sp., Nitzschi sp., Synedra acus, Meridion* *circulare, Diatoma vulgare, Cyclotella glomerata, Fragilaria leptostauron, Melosia varians, Gyrosigma sp., Opephora martyi, Navicula cryptocephala, Cymbella tumida,* and *Synedra delicatissima,* var. *angustissima.*

The Walla Walla Creek

The Walla Walla Creek at County Highway EE north of Lake Poygan is a small stream containing much floating plant debris. The plankton was composed almost entirely of epiphytes and benthic escapes, but a few filaments of *Melosira ambigua* and *M. granulata* were present. Also present were *Amphora ovalis, Navicula scutilloides, N. cryptocephala, Fragilaria leptostauron, Opephora martyi, Cymbella tumida, Meridion circulare* var. *constrictum, Navicula accommada Hust.* var. *accommada, Cymatopleura solea, Cyclotella meneghiniana, Diatoma vulgare, Nitzschia spp.* and *Synedra ulna* var. *amphirhynchus* (Ehr.) Grun.

The Pine River

The Pine River (1 mile east of Waushara County Highway W on 26th Street) near Saxville is a clear trout stream. The seston is composed primarily of organic debris and benthic escapes. These include *Gomphonema constrictum* Ehr. var. *capitata* (Ehr.) Cleve, *Fragilaria pinnata* Ehrenberg, *Melosira varians, Diatoma vulgare, Navicula spp.,* and *Cocconeis placentula* var. *lineata.*

Below the reservoir at Poysippi, the Pine contains primarily the gigantic *Oscillatoria princeps* Vaucher. About 25% of the diatoms were *Melosira ambigua* and *M. granulata.* Also present were *Amphora ovalis, Navicula gastrum* var. *gastrum, Cocconeis placentula* var. *lineata, Achnanthes saxonica* Krasske var. *saxonica, A. lanceolata,* and *Synedra ulna* var. *contracta.*

The Willow River

The Willow River at County Highway D near Borth is a sluggish stream containing many macrophytes and a wide variety of Chlorophytes and diatoms. These included *Scenedesmus bijuga* (Turpin) Lagerheim, *S. quadricauda, Anabaena planktonica* Brun., *Cosmarium botrytis* (Bory) Meneghini, *Gloeotrichia natans* (Hedwig) Rabenhorst, *Oocystis elliptica* W. West, *Merismopedia convoluta* de Brébisson in Kütz, *Synedra ulna* var. contracta *S. socia* Wallace var. *socia, Pinnularia sp., Cyclotella Meneghiniana, Cymbella cuspidata* Kütz., *C. sp., Cocconeis placentula* var. *lineata, Hantzschia sp.,* and *Nitzschi spectabilis* (Ehr.) Ralfs.

At County Highway Q above the Auroraville millpond, the Willow is a fast flowing trout stream and contains mostly detritus and benthic escapes such as *Melosira varians, Nitzschia spp.* and *Neidium productum* (Wm. Smith) Pfitzer.

The Pumpkinseed Creek

The Pumpkinseed Creek at County Highway D near Borth is also a sluggish, warm-water stream. The plankton is predominated by *Synedra pulchella* Ralfs ex. Kütz. var. *pulchella* and *S. acus*. Also present were *Eunotia curvata* (Kütz.) Lagerst. var. *curvata*, *Eudorina elegans* Ehrenberg, *Gomphonema constrictum* Ehr. var. *capitata* Ehr. Cleve., *Scenedesmus quadricauda* var. *longispina*, *Staurastrum longiradium*, *Rhoicosphenia curvata* and *Melosira varians*.

SUMMARY

General Observations

During this study, 106 taxonomic entities of algae were encountered in the Winnebago Pool and additional forms were found in the upper Fox and Wolf Rivers and their tributaries. Total standing crops of phytoplankton were very high (volumes ranged to $110 \times 10^6 \mu^3 ml^{-1}$; Sloey, 1970).

Lake Butte des Morts and the Winnebago Pool exhibit phytoplankton typical of shallow, eutrophic lakes and large rivers (Rawson, 1961, Fritsch, 1931, Eddy, 1934, and Hustedt, 1930_a, 1930_b). Plankton similar to that in the Pool predominated in the upper Fox as far upstream as Endeavor and in the Wolf as far upstream as New London. The Pool, then, as concerns its phytoplankton populations, represents little more than a widened expanse of these rivers.

In general, the upper Fox contained higher populations of most species than the Wolf or the lakes of the Pool. Lake Butte des Morts contained higher populations than Winneconne–Poygan (represented by station 3 at town of Winneconne), and higher populations of all predominant forms, except *Melosira granulata,* than Lake Winnebago.

Throughout the year, except for brief periods during blooms of blue-greens, the centric diatoms *Melosira ambigua* and *M. granulata* and *Stephanodiscus niagarae* and *S. Hantzschii* dominated the plankton. *M. ambigua* was most abundant during early summer, *M. granulata* during late summer, *S. niagarae* during autumn and *S. Hantzschii* during winter. In late autumn and early spring, the araphids, *Synedra spp.* and *Asterionella formosa* reached maximum numbers. When water temperatures exceeded 15 C, the "nuisance" blue-greens, *Anabaena spp.*, *Aphanizomenon flos-aqua* and *Microcystis aeruginosa* were evident and at times dominated the plankton.

Generation Time as a Measure of Growth Conditions

Minimum generation times for a number of algae were determined. These ranged from 1–3 days for bloom forming blue-greens

TABLE 1. A COMPARISON OF GENERATION TIMES OF PHYTOPLANKTON IN THE WINNEBAGO POOL WITH THOSE REPORTED BY OTHER AUTHORS*

AUTHOR	SLOEY AND BLUM	HOLLAND	FOGG	VERDUIN
Water	Winnebago Pool	Green Bay, L. Michigan	Culture	Lake Erie
Asterionella	10 (3.06–40.5)	13 (6.5–19)	9.6 (20 C)	7
Melosira granulata	25 (Aug.–Sept.) (2.9–59.1)	19 (Aug.–Oct.)		
Melosira ambigua	5–13.2 (April–May) (5–55.7)	14 (April–May)		
Stephanodiscus niagarae	10.6 (April–May)	34 (Aug.–Sept.)		23 (April)
Anabaena	2–5 (0.78–23.8)		10.6 (25 C)	2.5 (20 C)

*References Cites: Holland, R., 1969; Fogg, G. E., 1965, and Verduin, J., 1952.

such as *Anabaena* and *Microcystis* to 16 days for *Stephanodiscus niagarae*. The generation times reported here are reasonably consistent with those from the literature (see Table 1).

A shortened generation time of a population apparently reflects favorable growth conditions. In this study no species continued to increase without interruption until population maximum. In each case numerous dips were observed which probably resulted from sampling error, basin flushing or other (generally unknown) external causes. However, the rate of each recovery after a dip undoubtedly reflected the optimality of the environmental conditions for that organism. Nutrient levels were lowest when total plankton counts were highest and basin flushing affected standing crops (Sloey, 1970). Correlations of generation times to seasons and particularly to water temperature were obvious, but other positive correlations between populations or generation times of any species and water chemistry (i.e., nitrate, phosphate, etc.) were not observed. Water temperature is a result of seasonal weather patterns and daylength; as such it might mask photoperiod responses of the flora and it functions indirectly by altering metabolic rates, nutrient availability and flotation.

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KINETICS OF ORTHOPHOSPHATE UPTAKE BY PHYTOPLANKTON POPULATIONS IN LAKE WINNEBAGO

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ABSTRACT

The growth of natural phytoplankton populations of Lake Winnebago was investigated with regard to orthophosphate limitation. An ascorbic acid-antimony modification of a standard molybdenum blue colorimetric test for orthophosphate showed a concentration of 94.0 $\mu g \cdot liter^{-1}$ in late November, 1970. This concentration steadily decreased through the winter months to a minimum of 29.0 $\mu g \cdot liter^{-1}$ in early February, 1971. With the removal of ice cover and increased allochthanous addition of phosphate associated with the spring thaw, the orthophosphate concentration increased to 109.0 $\mu g \cdot liter^{-1}$ in early April.

A standard acetone extraction procedure showed that chlorophyll concentrations followed a similar trend in seasonal variation. The 2.2 $mg \cdot m^{-3}$ concentration found in the January 9, 1971 sample decreased to a minimum of 0.4 $mg \cdot m^{-3}$ for the January 24 sample. The chlorophyll concentration gradually increased to 20.8 $mg \cdot m^{-3}$ by early April.

Primary productivity measured by a standard ^{14}C technique, increase in biovolume determined by the Model B Coulter Counter, and chlorophyll production were used to study the kinetics of orthophosphate uptake in enrichment experiments where varied amounts of orthophosphate, ranging from 20 to 200 $\mu g \cdot liter^{-1}$, were added to samples of Lake Winnebago water.

The resulting changes in the rates of these parameters suggest that uptake followed the Michaelis–Menten equation, modified for nutrient limitation theory, for enriched samples collected on February 2 and February 20, 1971. This model may also apply to the November and April populations; however, a limitation in experimental design prohibited the calculation of V_{max} and K_t.

Orthophosphate was determined to be a limiting factor for productivity in Lake Winnebago over the winter months.

I. *Introduction and Background*

Eutrophication refers specifically to the natural or artificial addition of nutrients to aquatic ecosystems. This term has been more broadly interpreted to include the physical, chemical, and biological implications of nutrient enrichment. When these effects are undesirable the process is a form of pollution. One of the effects of increasing importance in aquatic biological research is the role of nutrients in relation to the productivity of the system. Because of the accompanying degradation of water quality for recreational and industrial use, much concern has been given to the increase in biological productivity that results from the addition of nutrients to the aquatic system. While the process is natural and a function of the age of the particular system, man's industrial, agricultural, and domestic activities may effectively increase the natural rate of eutrophication. In order to determine how to best minimize the effects of man's activities on the rate of eutrophication, the role of nutrients in relation to productivity must be determined. This not only necessitates the elaboration of effects of individual nutrients upon the system, but also includes the determination of the synergistic relationships among the various plant nutrients. For example, iron has been found necessary in some systems to enhance the availability of other major nutrients, such as nitrate and phosphate (Schelske, 1962). The particular nutrient(s) that determines the trophic nature of a system varies greatly from lake to lake and from fresh water to marine environments.

Ryther found nitrate to be the limiting factor in primary productivity in Great South Bay off Long Island, New York (1971). Schelske determined that iron was the limiting nutrient in several Michigan marl lakes (1962). Micronutrients such as sulfur, potassium, magnesium, calcium, boron, zinc, copper, cobalt, sodium, and chloride are also essential nutrients for growth (Lee, 1970). Molybdenum and manganese have been shown to limit productivity in Castle Lake, California (Goldman, 1965). Provasoli (1969) has shown that certain organic compounds, such as vitamin B_{12}, thiamine, and biotin are necessary requirements for several marine phytoplankters. However, the nutrient most often implicated as the limiting factor in biological production is phosphorous (Wentz and Lee, 1969).

Considering its importance as a vital structural component of DNA, RNA, and protein, as well as its functional significance in intermediary metabolism; the common occurrence of phosphate as a limiting factor of productivity is logical from a theoretical viewpoint. In addition phosphate usually occurs in minute concentrations compared to other nutrients in lakes (Tucker, 1957).

The purpose of this study was to investigate the influence of phosphorous on the realization of productivity potential in Lake Winnebago by comparing the uptake of phosphate enrichments by natural phytoplankton assemblages as the natural available phosphate concentrations in the lake varied over a six month period. While previous research of this nature has employed the direct measurement of nutrient uptake by means of radioactively labelled nutrient sources, such as $^{32}PO_4$ and $^{15}NO_3$ (Dugdale, 1967; MacIsaac and Dugdale, 1969), this project emphasized a more indirect approach. The rate of phosphate uptake was measured in terms of three biological parameters. Increases in chlorophyll concentration, population size in terms of biovolume, and primary production were monitored as a function of phosphate concentration by enriching samples of Lake Winnebago water with orthophosphate. The use of these parameters lends more biological meaning to the determined uptake kinetics. One might follow not only how the nutrient is taken up, but also how the nutrient is utilized by the plankton.

II. *General Lake Information*

Lake Winnebago is a large, shallow, fresh water lake located in northeastern Wisconsin, with over 137,000 acres of surface area and a maximum depth of 21 feet (Lueschow, Helm, Winter, and Karl, 1970). The western shore is extensively developed. The four largest cities on the lake, Fond du Lac, Oshkosh, Neenah, and Menasha, are located on this shore. The remaining shoreline is under private ownership, agricultural cultivation, or recreational use, in the form of county and state parks. Lake Winnebago, typically characterized by frequent plankton "blooms", high nutrient content, and low Secchi disc readings (annual mean of 2.3 meters) has been classified as one of the more eutrophic lakes in Wisconsin (Lueschow, Helm, Winter, and Karl, 1970).

This lake is also important as the source of the lower Fox River, which is its major outlet. This river ultimately flows into Green Bay.

III. *Methods and Procedures*

A. *Sampling*

Twelve nineteen liter samples of Lake Winnebago water were collected biweekly over a period beginning in early November, 1970 and ending in early April, 1971. The samples were collected by means of a battery operated pump from a depth that ranged from 3 to 4 meters through surgical tubing to a Nalgene polypropylene carboy. A piece of #11 plankton net (0.145 mm) placed over the mouth of the carboy prevented the introduction of zooplankton to the sample.

During the period of ice cover, samples were collected approximately one quarter mile offshore from Sportsman's Park, which is located on the northern shore several miles southeast of Appleton at fire lane #8. All other samples were collected near High Cliff State Park, nearly two miles away from Sportman's Park.

B. *Phosphate*

Usually 24, but no later than 48 hours after collection, 250 mls. of the sample were Millipore filtered (.45μ). One hundred mls. were used for an orthophosphate determination.

Because of the amount of controversy concerning the preservation (Lee, 1969), storage (Hassenteufel *et al.*, 1963; Strickland and Parsons, 1965; and Lee, 1969), and measurement of orthophosphate in lake water; the polypropylene carboy was chosen for sample storage. Similarly, all phosphate enrichment experiments were performed in Nalgene polypropylene bottles to minimize loss of phosphate by container absorption.

Due to the nature of the experiments, no preservatives were added to the samples. The samples were stored at 15 C until tested. Workers generally agree that refrigeration is the most preferred method of sample preservation (Schelske, personal communication).

Glass distilled water blanks, standard orthophosphate solutions, and samples were all treated with a colorimetric test developed by Murphy and Riley (1962), which uses ascorbic acid-antimony as the reducing agent. This method is reported to have a low temperature coefficient, stable color, and no salt error according to Strickland and Parsons, as cited by Lee (1969). A Bausch and Lomb Spectronic 20 equipped with red phototube and filter measured absorbance of blanks, standards, and samples at 830 μ.

A one thousand milligrams per liter solution was made by adding 2.007 grams of $Na_3PO_4 \cdot 12H_2O$ to 500 mls. of glass distilled water. This stock solution was the phosphate source for the enrichment experiments and the phosphate test standard solutions.

On the same day that the initial phosphate tests were performed, the enrichment experiments were begun. Subsamples were transferred from the carboy so as to completely fill 1.98 liter Nalgene polybottles, which had been previously autoclaved at 120 p.s.i. for twenty minutes. Care was taken to thoroughly mix the carboy sample in order to ensure the homogeneity of the five subsamples in the experiment. Predetermined amounts of phosphate were added to four of the subsamples. The fifth bottle, which contained the phosphate present in the lake at the sample date, served as the control. The samples were incubated for five days on individual magnetic stirrers under constant temperature (15 C) and incident white light (1000 ft. candles) saturation, which appears to be the only light requirement for enrichment experiments of this nature (MacIssac, 1969).

C. *Particle-size distributions*

The Model B Coulter Counter proved to be a fast, efficient device for obtaining the distribution and abundance of phytoplankton in the initial and nutrient enriched Lake Winnebago samples. Size distributions were taken both at the beginning and at the end of the experiments with a 100 μ aperture. The initial size distribution represented the current population of phytoplankton in the lake. The final distributions represented population growth due to phosphate enrichment. The difference in biovolume divided by the duration of the experiment in hours expresses a rate of biovolume increase (cubic microns per ml. per hr.) as a function of phosphate concentration.

The amount of detritus collected in several of the samples was measured by means of the Coulter Counter to determine its significance in the enrichment experiments (Sheldon and Parsons, 1967). The one per cent NaCl electrolyte solution produced a maximum of only one to two per cent error in sample counts at the most sensitive machine settings.

D. *Chlorophyll*

In this study changes in chlorophyll concentration were used to determine increases in phytoplankton populations as a function of phosphate enrichment. Four replicate samples were taken from the original Lake Winnebago sample at the beginning of the experiment. Similarly, chlorophyll was extracted in quadruplicates from the control and experimental bottles at the end of the experiments. The chlorophyll concentration was determined by a standard trichromatic acetone extraction procedure (Strickland and Parsons, 1965). The extracted volume ranged from 100 to 250 mls., depending upon the phytoplankton population density present in the initial Lake Winnebago sample; however, the volume remained internally consistent for any experiment the author performed.

A Bausch and Lomb Spectronic 20 measured absorbance at 630, 645, and 665 μ. The optical densities for all samples were punched onto computer cards and fed into an IBM 1620 data processing system. The duration of the experiment (in hours) and a dilution factor were also included in the input of the CHLOREG program, which calculates the concentrations of chlorophyll a and b using the revised coefficients of Parsons and Strickland (1963). Because concentrations for chlorophyll$_c$ were often less than zero, which is attributed to a fault of the trichromatic test (Strickland and Parsons, 1965), chlorophyll$_c$ was deleted from the experimental design.

Having calculated the concentrations of chlorophyll a and b in all samples, the CHLOREG program calculated the rate of chlorophyll production in the control and enriched bottles which is expressed as mg Chlorophyll · m^{-3} · hr^{-1}. Finally, all possible comparisons were made between the five populations to test whether the production rates were significantly different from one another. A contrast test, instead of the standard t test, was used to calculate significant differences between chlorophyll production rates at the .05 level (Dixon and Massey, 1969).

E. *Primary Productivity*

On the final day of the experiment, the rate of carbon fixation was measured for each of the populations in the enrichment experiment by the standard ^{14}C method (Vollenweider, 1969). A standard phenolphthalein-methyl orange test was used to measure total alkalinity as ppm $CaCO_3$ (Standard Methods, 1965). This value was corrected to total available carbon-12 by a factor determined by the pH of the sample (Bachman, 1959). A Corning pH meter was used to measure endpoints in the sample titrations for alkalinity, as well as to measure sample pH.

The source of available ^{14}C was labelled $NaHCO_3$ purchased from New England Nuclear in ampoules containing one microcurie in one ml. of sterile water (2.22 x 10^6 dpm). In all experiments, the available ^{14}C was one microcurie.

Ten ml. aliquots were filtered (.45 μ) at two hour intervals over a six hour incubation from the light and dark bottles. This volume was used to minimize loss of activity during period of filtration (Arthur and Rigler, 1967).

The filters were dried in a vacuum at 35 C overnight. After drying, the filters and 10 mls. of a scintillation cocktail consisting of 5.0 grams of PPO (2,5 diphenyloxazole) dissolved in 1000 mls. of reagent grade toluene were placed in glass scintillation vials and loaded onto a Beckman LS-230 Liquid Scintillation System.

The efficiency of counting this primary fluor system ranged from an initial 87% to 92% in later experiments. The efficiency was determined by making a set of standards with $NaHCO_3$ (4.422 x 10^5 dpm per ml.) in toluene as the ^{14}C source (Packard Instrument Company). Also, known amounts of ^{14}C ($NaHCO_3$) were added to several vials which were recounted to calculate efficiency. Counting efficiency was determined for each experiment for calculation of carbon fixation. An isotope correction factor of 1.06 was used.

The carbon fixation rates were calculated by means of a least squares analysis program available on a RAX IBM 360/44 computer. The program calculated slope (photosynthetic rate), y-intercept, and correlation coefficient (r). In all cases, the value of r was .90 or greater for the rate calculation.

IV. *Results*

A. *Seasonal Phosphate and Chlorophyll Concentrations*

The variation of phosphate and chlorophyll concentrations in Lake Winnebago over the period of study as illustrated in Figure 1 demonstrates a somewhat parallel trend. While the measured decrease in phosphate and chlorophyll occurs almost simultaneously through the month of January, the increase in chlorophyll appears to follow that of phosphate by about a one week interval through the month of April. An increase in orthophosphate during one week is followed by a similar rise in chlorophyll the following week. This seems to substantiate two essential points in the enrichment study. First, the soluble inorganic phosphate measured by the test appears to be a legitimate form of phosphorous that is utilized by the phytoplankton. Second, this form of phosphorous is a limiting factor for population growth in Lake Winnebago, at least from January to late March or early April. Hilsenhoff (1967) found phosphorous to fluctuate greatly over a four year study of Lake Winnebago, 1961–1964, but reports that phosphorous concentrations were lowest in the winter and highest in the summer. He reports an annual mean of 2.0 $\mu g \cdot liter^{-1}$ for a station near the sampling site for this study. Soluble phosphate levels determined by Sloey (1970) for a station in Lake Winnebago two miles east of Oshkosh were lowest in late October and November. The values range from 20.0 to 30.0 $\mu g \cdot liter^{-1}$. However, he reports no values for January or February.

The fivefold increase in the phosphate concentration from January to April probably reflects the large amount of phosphorous that enters the lake by agricultural and urban runoff during the spring thaw. Phosphate concentrations as great as 1000 $\mu g \cdot liter^{-1}$ have been measured in samples of surface runoff (Biggar and Corey, 1969).

B. *Seasonal Variation in Phytoplankton*

The size distributions of the Lake Winnebago samples indicate an interesting succession over the course of the study. The sample collected November 24, 1970 exhibits two predominant populations at 9.4 and 29.9 micron diameters (Figure 2). Figure 3 depicts the tremendous decrease in the abundance of phytoplankton by January 9, 1971. The shift in peak location indicates an apparent change in the species composition by January 24. The 3.0 micron diameter particle clearly dominates the community, while a sizeable decrease has occurred at all other particle diameters. It must be pointed out that this peak may be due to detritus or background noise at the upper limit of machine sensitivity for the 100 μ aperture. The February 2 sample displays the lowest abundance of phytoplankton

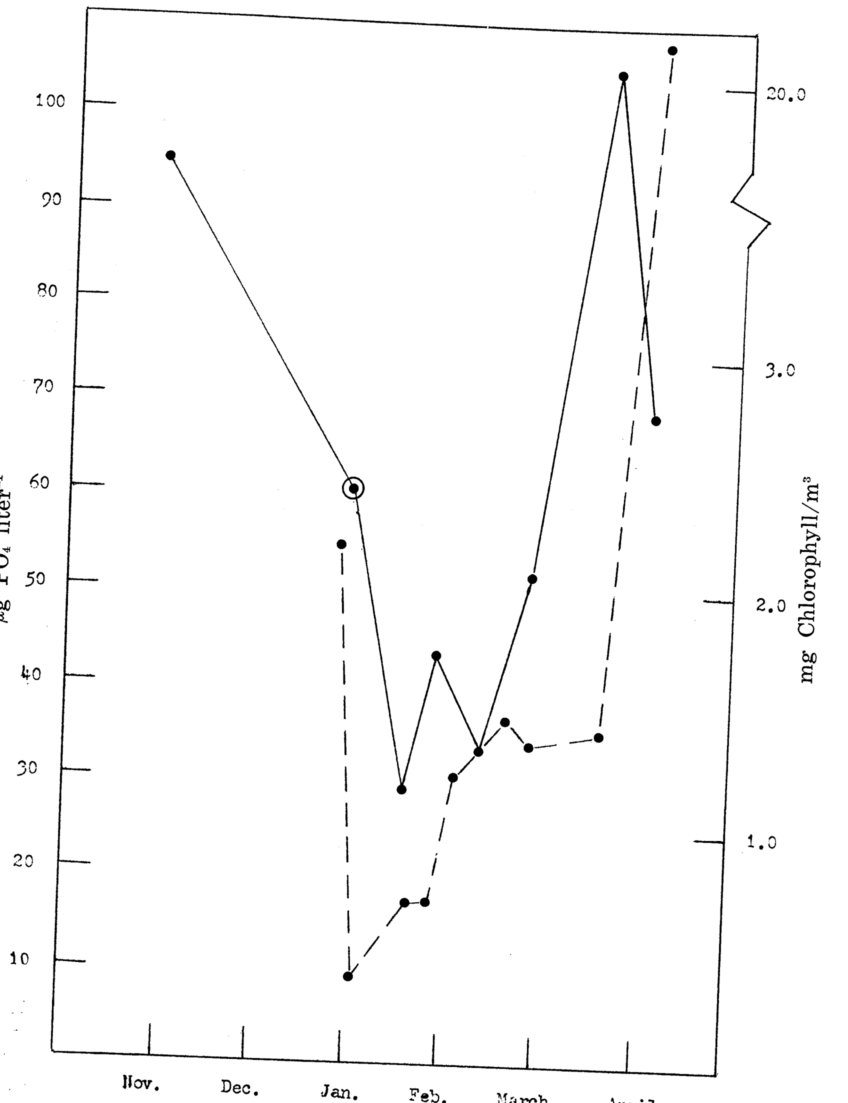

FIGURE 1. Seasonal variation of phosphate (ortho) and chlorophyll$_{(a+b)}$ concentrations in Lake Winnebago from November, 1970 to April, 1971. Sample depth is approximately 3 meters. Solid line = $\mu g \cdot liter^{-1}$ PO_4. (Encircled point is from Lueschow, Helm, Winter, and Karl, 1970). Dashed line = mg Chlorophyll$_{(a+b)}$ $\cdot$ m^{-3}.

of all samples collected. (Figure 4). It is interesting to note that the lowest phosphate concentration was determined for this sample (Figure 1), though light must have also been limiting under the

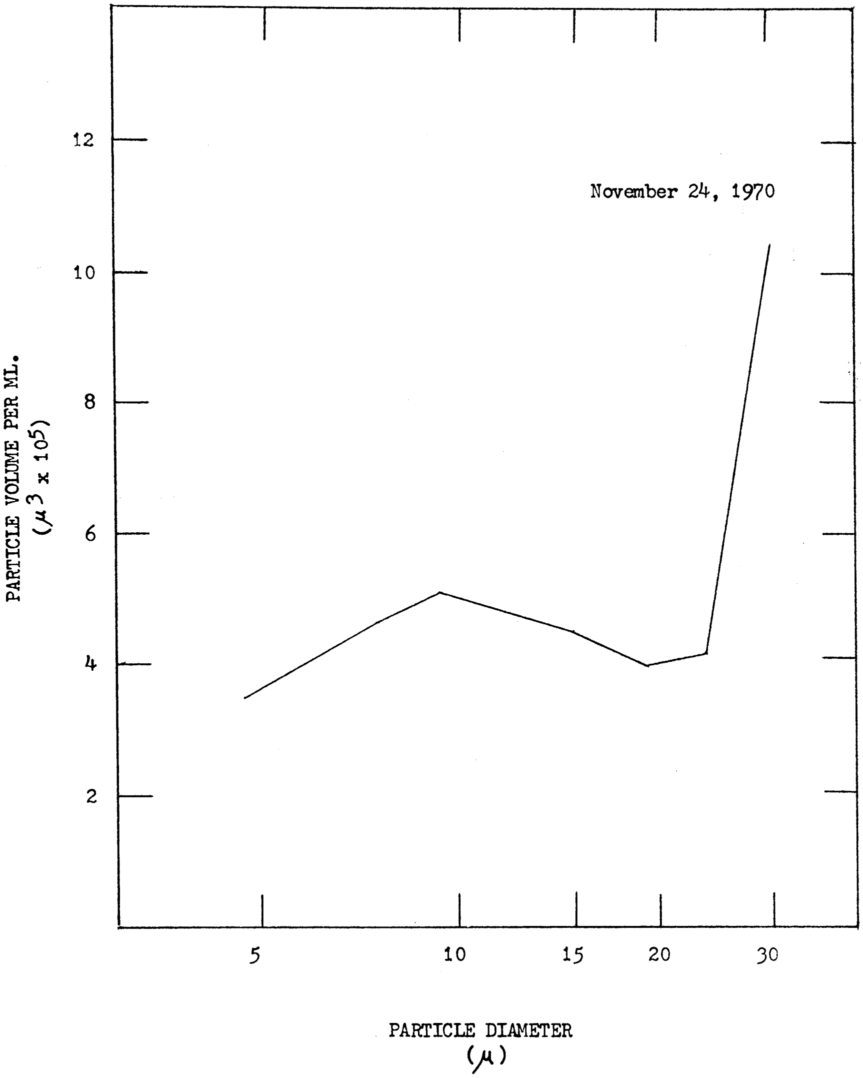

FIGURE 2. Size distribution determined by Coulter Counter (100 μ aperture) for a L. Winnebago sample collected November 24, 1970.

thick cover of ice and snow present at this date. By February 12, the size distribution indicates the emergence of a population that can maintain and reproduce itself under these severe environmental conditions (Figure 4-b). This phytoplankter at a diameter of 9.4 microns has convincingly established itself as the dominant

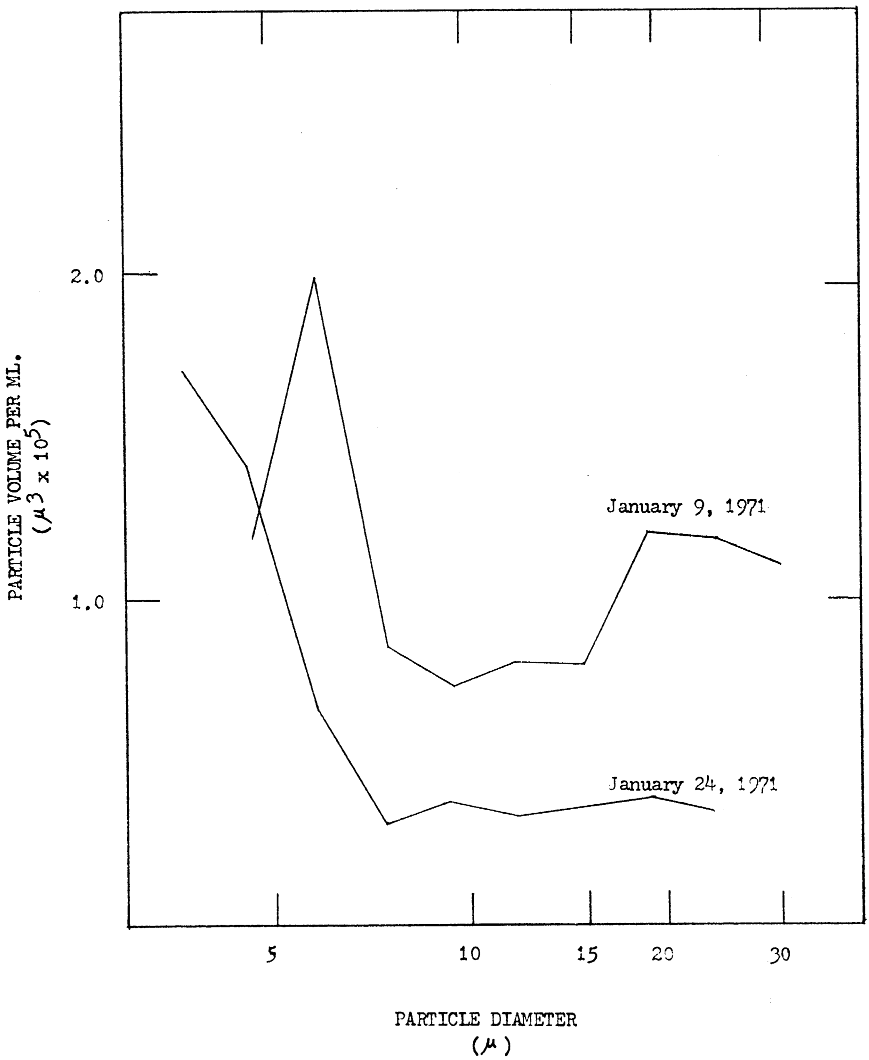

FIGURE 3. Size distribution determined by Coulter Counter for L. Winnebago samples collected January 9 and January 24, 1971 (100 μ aperture).

species of the winter population by February 20 (Figure 4-c). Qualitative observations with a Zeiss inverted plankton scope revealed a species of *Asterionella* to be the most abundant form in this sample. The distribution of the March 1 sample reflects a substantial change in the community structure with regard to the

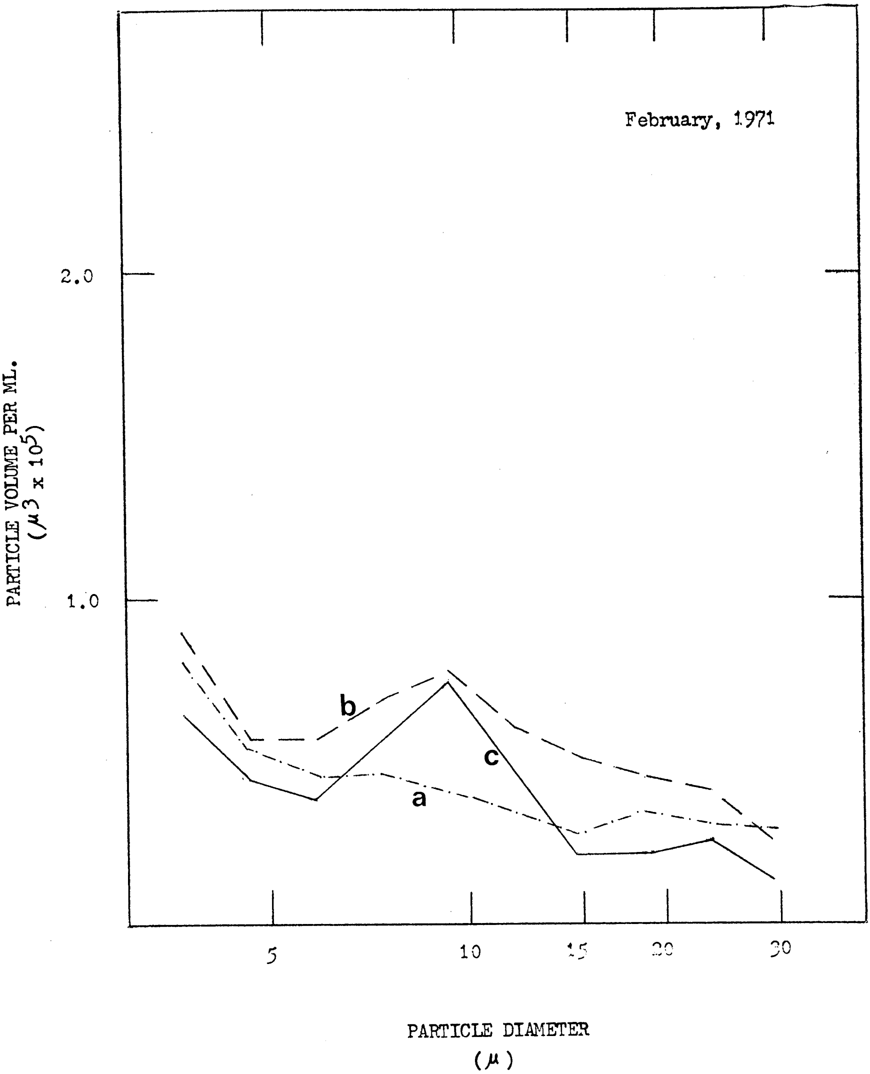

FIGURE 4. Size distributions for L. Winnebago samples (a) collected on February 2, (b) collected February 12, and (c) collected on February 20, 1971 as determined by the Coulter Counter (100 μ aperture).

previous sample (Figure 5-a). The appearance of two new peaks may illustrate the growth of new populations as the physical and chemical parameters of the lake change with the spring thaw. Figure 1 shows that the phosphate concentration has substantially increased by this time. The evident blending and reduction of these

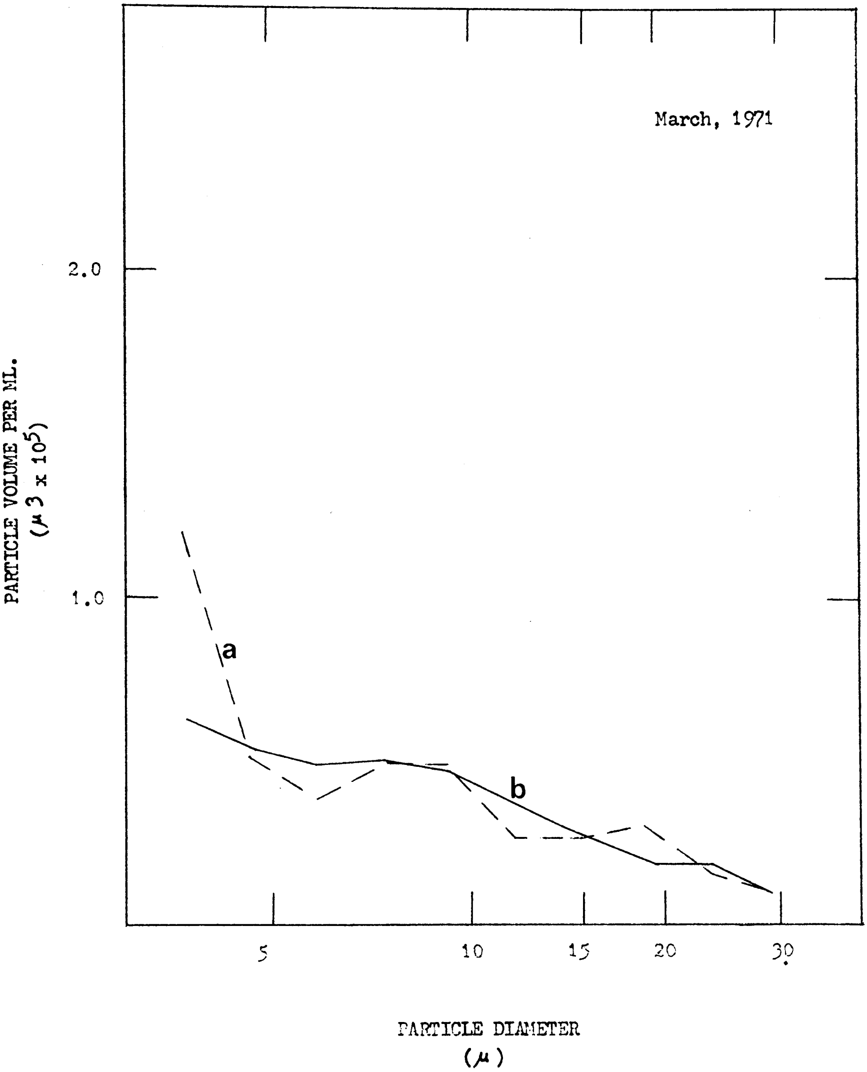

FIGURE 5. Size distribution for L. Winnebago samples collected (a) on March 1, and (b) on March 13, 1971 (100 μ aperture).

peaks (Figure 5-b) by March 13 might suggest that they were transient species with a very narrow tolerance range for the nutrient conditions in the lake during March. This is a common occurrence as community structure may change significantly in natural phytoplankton assemblages within a week's time (Schelske, Callender, and Stoermer, 1969).

The final distribution (Figure 6) emphasizes the increase in biovolume in the sample collected on April 2, 1971. By this time, phosphorous had reached the highest concentration measured during this study (Figure 1).

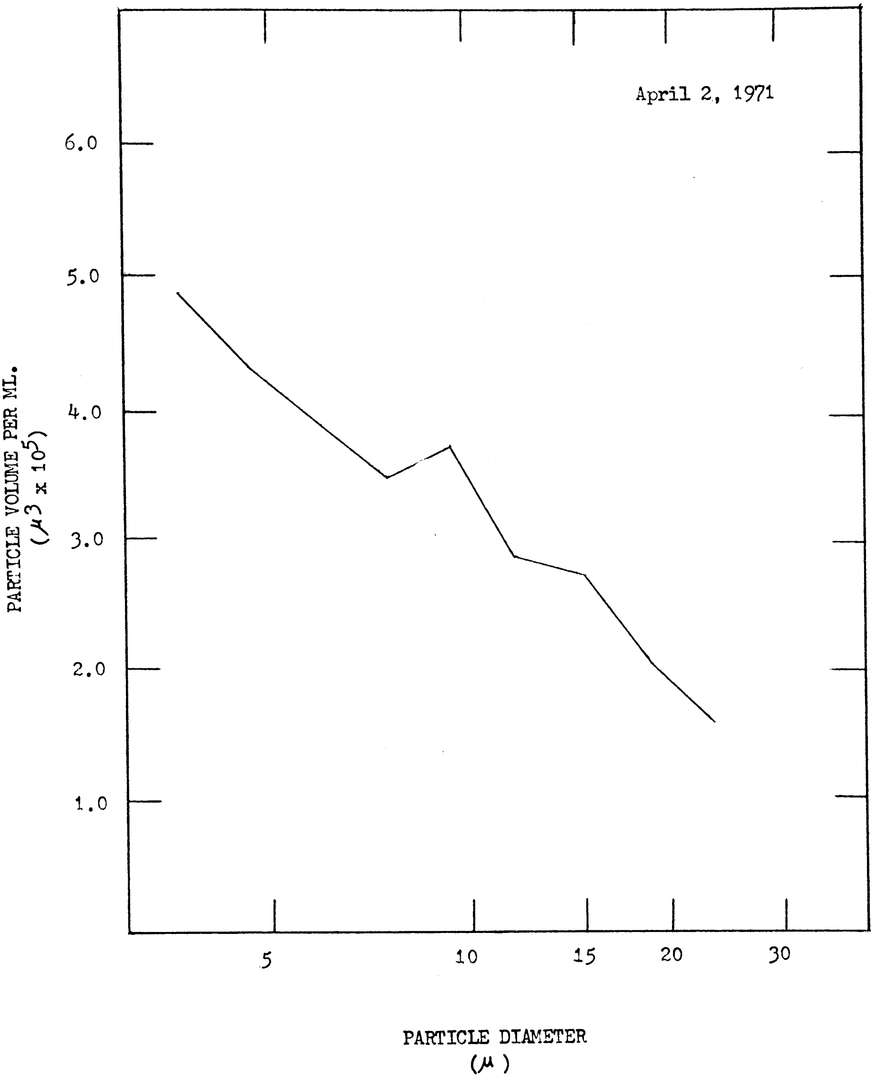

FIGURE 6. Size distribution for L. Winnebago sample collected on April 2, 1971 (100 μ aperture).

C. *Phosphate Uptake Kinetics*

The enrichment experiments performed with the samples collected on February 2 and February 20, 1971 yielded rates of biovolume increase, primary production, and chlorophyll production relative to orthophosphate concentration that approximated the model proposed by Dugdale (1967) and MacIsaac and Dugdale (1969) for the kinetics of nutrient uptake by phytoplankton. This model is derived from the Michaelis–Menten equation for the effect of substrate concentration on the rate of an enzyme catalyzed reaction as expressed by:

$$v = \frac{V_{max} S}{K_m + S} \qquad (1)$$

where,

v = rate of catalyzed reaction
V_{max} = maximum rate of reaction
S = substrate concentration
K_m = substration concentration at which $\frac{1}{2}V_{max}$ is calculated (Lehninger, 1970).

This equation describes the curve in Figure 7-a. Two modifications of the Michaelis–Menten equation have been derived in order to more accurately calculate V_{max} and K_m. By taking the reciprocal of both sides of (1) and simplifying, a linear function results:

$$\frac{1}{v} = \frac{K_m}{V_{max}} \cdot \frac{1}{S} + \frac{1}{V_{max}} \qquad (2)$$

This is the Lineweaver–Burk equation, which is graphically represented in Figure 7-b.

The Eadie–Hofstee modification is derived by multiplying both sides of (2) by $V_{max}(v)$ and rearranging to yield:

$$v = \frac{-V_{max}}{K_m} \cdot \frac{V}{S} + V_{max} \qquad (3)$$

which is illustrated in Figure 7-c. These modifications will be of importance in the application of the Michaelis–Menten model to the measured uptake kinetics of phosphate in this study.

The units of variables in the Michaelis–Menten model are slightly different in application to the study of nutrient uptake. In this paper,

v = uptake velocity measured as rate of
increase in biovolume, cubic microns $\cdot$ ml^{-1} $\cdot$ hr^{-1}
primary productivity, mg Carbon $\cdot$ m^{-3} $\cdot$ hr^{-1}
chlorophyll production, mg Chlor. $\cdot$ m^{-3} $\cdot$ hr^{-1}
V_{max} = maximum value of above rates
S = μg $\cdot$ $liter^{-1}$ orthophosphate
K_m = concentration of o-PO_4 where $\frac{1}{2}V_{max}$ is realized.

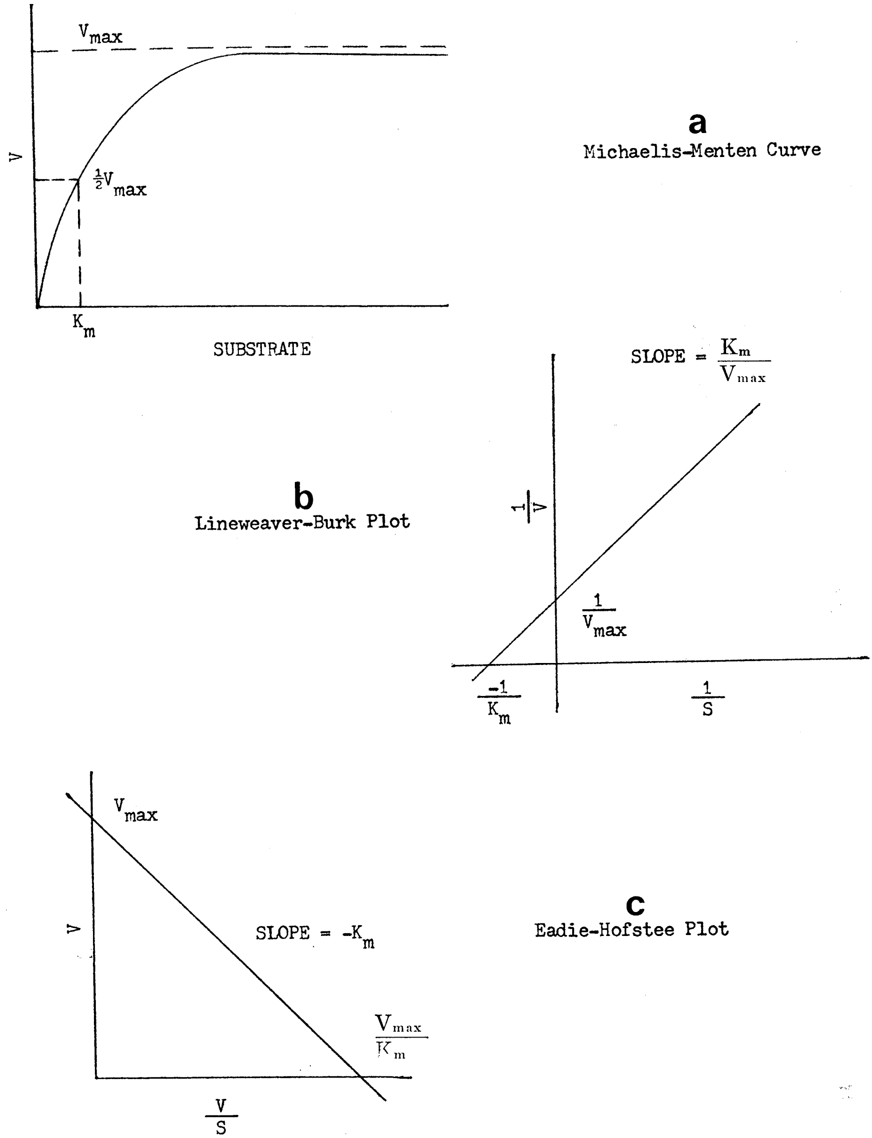

FIGURE 7–a. Michaelis–Menten curve. V_{max} = maximum reaction rate. K_m = substrate concentration where reaction rate is one half of maximum velocity. 7–b. The Lineweaver–Burk linear modification of the Michaelis–Menten curve. 7–c. The Eadie–Hofstee linear modification of the Michaelis–Menten curve. (Lehninger, 1970).

Rather than use the designation K_m, K_t or "transport constant" will be used to emphasize that a mathematical and not a biochemical equivalence of the Michaelis–Menten model is being used. This follows the notation developed by Wright and Hobbie, as cited by Dugdale (1967). However, if one considers an enzyme mediated mechanism for nutrient uptake, a biochemical equivalence may be inferred from this particular application of the model. From this brief description of the model, one can analyze the rates of biovolume increase, primary production, and chlorophyll synthesis as a function of increasing phosphate concentrations in the Lake Winnebago samples collected during the month of February.

In order to compare the increase in biovolume of the enriched samples to that of the control for any given experiment, size distributions were taken at both the beginning and end of the experiment. This is necessary because the control sample contains the concentration of orthophosphate innate to Lake Winnebago at the time of sample collection. When incubated under conditions of light saturation and 15 C, the population utilizes the available phosphate supply. Figure 8 shows a typical growth pattern of a control sample that has been incubated under the described conditions. The measured rate of increase could then be plotted as a function of the orthophosphate present in the Lake Winnebago sample and compared with the rates of biovolume increase of the enriched samples.

Clearly not all of the measured biovolume of any given size distribution consists of living algal cells. Sheldon and Parsons (1967) have determined a method for calculating the amount of detritus in a sample that takes advantage of the assumption that the growth rate of detritus is zero. The total volume of the initial size distribution for a January 9, 1971 sample was 11.2×10^5 $\mu^3 \cdot ml^{-1}$. The amount of detritus measured in this sample was 5.72×10^5 $\mu^3 \cdot ml^{-1}$, which is 51% of the initial total volume. However, at the end of the enrichment experiment, the measured biovolume was 320×10^5 $\mu^3 \cdot ml^{-1}$. Assuming a growth rate of zero, the previously measured amount of detritus is only 1.5% of the total biovolume. This seems to indicate that in the enrichment experiments the amount of detritus in the final analysis of samples does not contribute any significant source of error in calculating rates of increase. The same technique revealed a detritus level of 1.8×10^6 $\mu^3 \cdot ml^{-1}$ in the April 2, 1971 sample. However, this is still only 51% of the initial biovolume of the sample, 3.5×10^6 $\mu^3 \cdot ml^{-1}$. This might tend to indicate that the amount of detritus present in Lake Winnebago is directly proportional to the phytoplankton population size. However, much more data is needed to validate this hypothesis.

The use of biovolume to study the kinetics of phosphate uptake provides evidence that there is no appreciable change in species

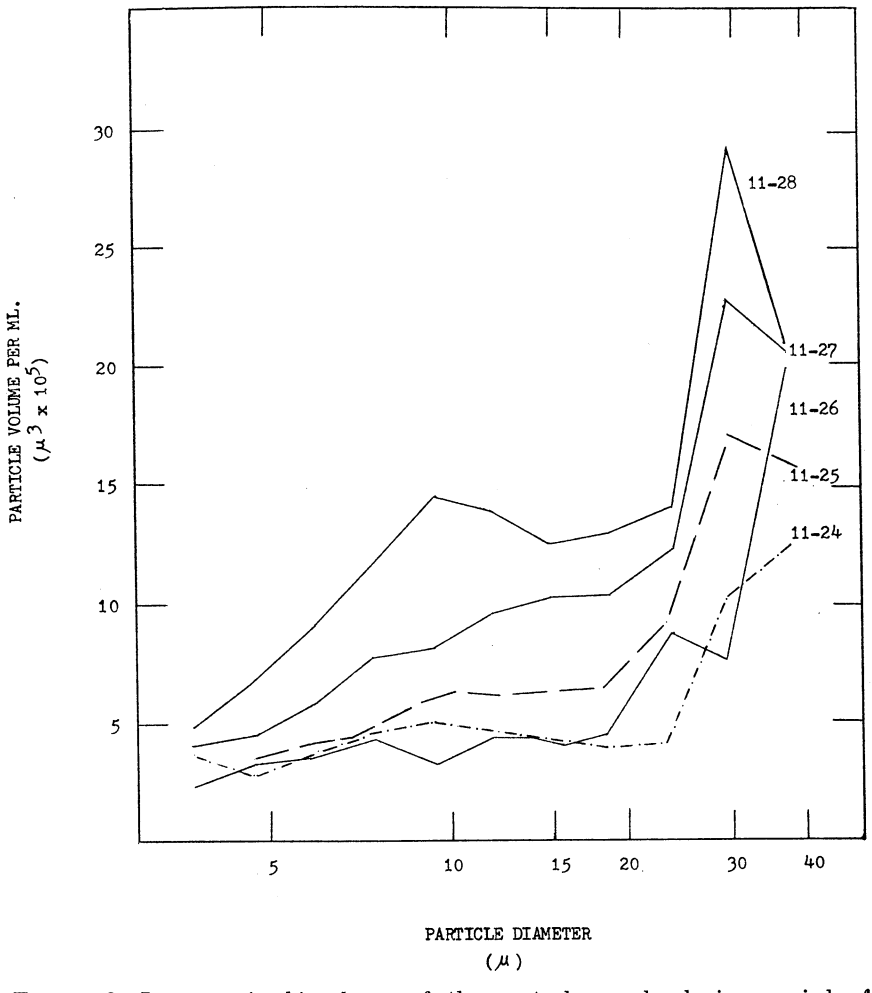

FIGURE 8. Increase in biovolume of the control sample during period of incubation determined by Coulter Counter (100 μ aperture). Sample collected Nov. 24, 1970.

composition in the samples as a result of enrichment. Figure 9 illustrates this. The sample, collected February 2, 1971, was enriched to phosphate concentrations ranging from 50 $\mu g \cdot liter^{-1}$ to 200 $\mu g \cdot liter^{-1}$. The shape of the distribution remained very similar during the period of incubation.

The use of biovolume increase as a function of phosphate enrichment provided meaningful data for application to Michaelis–Menten kinetics in only one experiment. This was an enrichment experi-

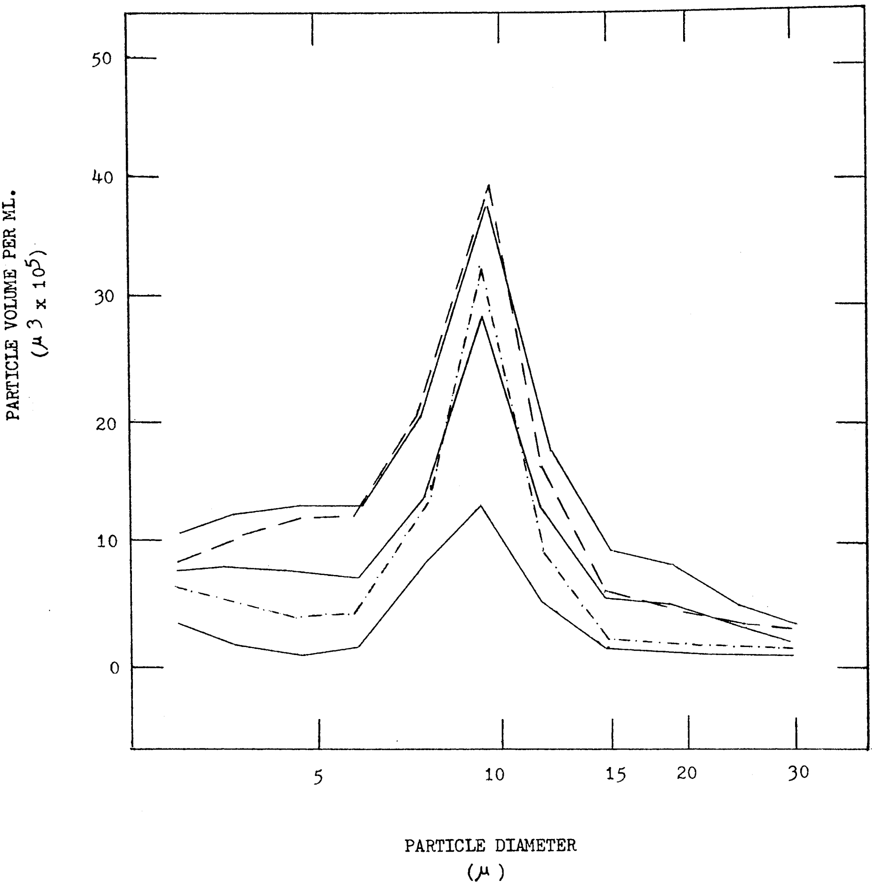

FIGURE 9. Increase in biovolume at various particle diameters as a function of orthophosphate enrichment. Lowest solid line = control. Dashed line = 50 ppb o-PO_4 addition. Middle solid line = 100 ppb o-PO_4 addition. Upper solid line = 150 ppb o-PO_4 addition. Dash–dot line = 200 ppb o-PO_4 addition.

ment performed with a sample collected on February 20, 1971. Figure 10 illustrates the increase in biovolume ($\mu^3 \cdot ml^{-1} \cdot hr^{-1}$) for particles arbitrarily categorized into three size ranges according to particle diameter. The curve for the circled dots shows that the greatest increase in growth rate as a function of phosphate addition occurred for particles in the size range of 5.9 to 14.9 microns. This is interesting in view of the initial size distribution of this sample (Figure 4-c). The growth rates of the smaller cells (3.0–4.7 μ), though considerably lower, also suggest an approximation to Michaelis–Menten kinetics. The growth rates for the larger

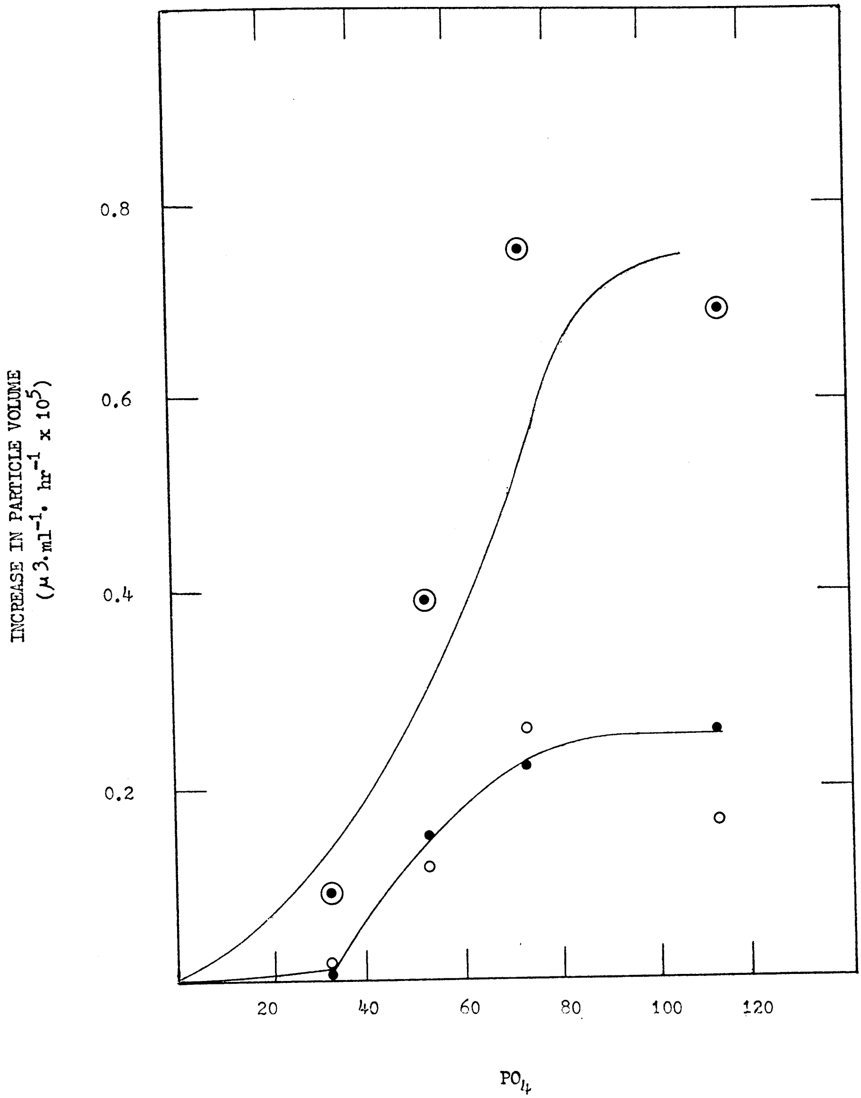

FIGURE 10. Rate of biovolume increase as a function of increasing o-PO_4 concentration for different diameter particles. Circled dots = 5.9 — 14.9 μ diameter. Solid dots = 3.0 — 4.7 μ diameter. Open circles = 18.8 — 29.9 μ diameter. From enrichment experiment with February 20, 1971 sample.

particles (18.8–29.9 μ) appear to approximate the curve for the smaller particle growth rates. If one assumes that at zero phosphate there is no increase in biovolume, the data suggests a lag period in population growth as a function of phosphate enrichment. The validity and significance of this assumption will be discussed later.

Figure 11 illustrates the rates of carbon fixation and production of chlorophyll a and b as a function of increasing phosphate concentrations in an enrichment experiment with a sample collected February 2, 1971. The data seems to demonstrate that phosphate is being taken up in a Michaelis–Menten relationship. To determine the validity of fitting the data to this particular curve, the data was subjected to the Lineweaver–Burk and Eadie–Hofstee modifica-

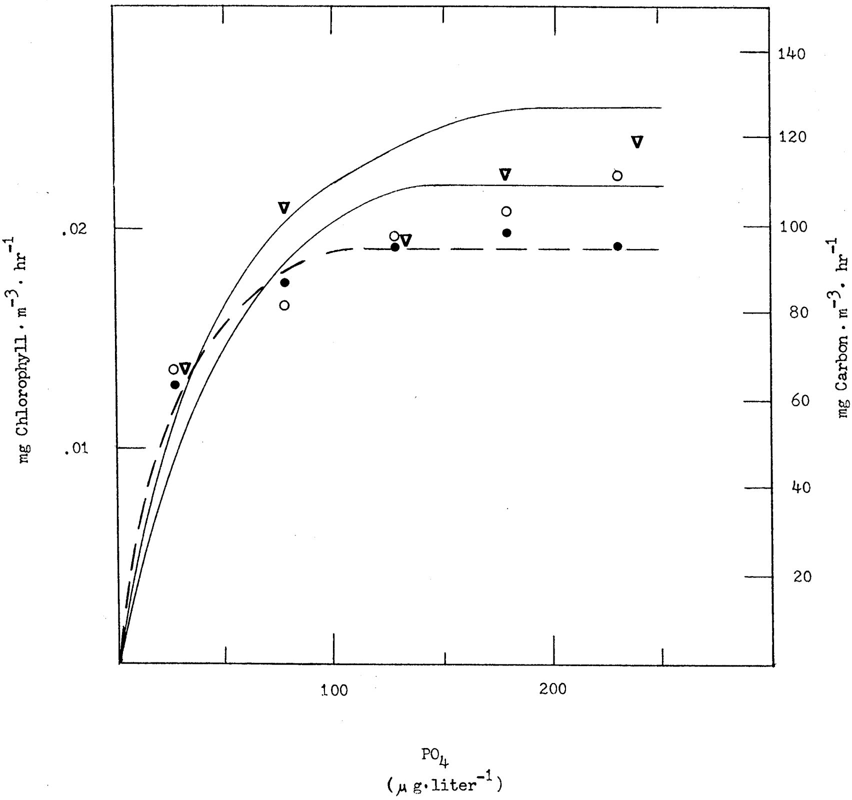

FIGURE 11. Rates of carbon fixation and production of chlorophyll a and b as a function of increasing concentrations of orthophosphate. L. Winnebago sample collected February 2, 1971. Δ = mg Carbon · m^{-3} · hr^{-1}. Solid dots = $chlorophyll_a$. Open circles = $chlorophyll_b$.

tions. The values of V_{max}, K_t, and a linear regression correlation coefficient could then be calculated. These values are presented in Table 1. As might be expected, the values calculated by both modifications were highly comparable for any given sample as seen in Table 1. For convenience only the Lineweaver–Burk modifications are illustrated in this paper. Figure 12 is the application of this modification to the data presented in Figure 11. The values of r for primary production, $chlorophyll_a$, and $chlorophyll_b$ production, are respectively, .97, .99, and .97. These values suggest the fit of the data to the Michaelis–Menten curve is valid. All lines were determined by least squares analysis on the RAX IBM 360/44. The contrast test mentioned earlier shows that rates of chlorophyll produc-

TABLE 1. COMPARISON OF V_{max} AND K_t CALCULATED BY LINEWEAVER-BURK AND EADIE-HOFSTEE MODIFICATIONS OF MICHAELIS-MENTEN EQUATION

a

Sample Date	V_{max} mg Carbon·m^{-3}·hr^{-1}		K_t μg·$liter^{-1}$ PO_4	
	Lne.-Bk.	Ead.-Hof.	Lne.-Bk.	Ead.-Hof.
Feb. 2	129.9	127.7	25.7	24.5
Feb. 20	25.6	24.4	16.2	10.9

b

Sample Date	V_{max} mg $Chlor._a$·m^{-3}·hr^{-1}		K_t μg·$liter^{-1}$ PO_4	
	Lne.-Bk.	Ead.-Hof.	Lne.-Bk.	Ead.-Hof.
Feb. 2	.022	.021	19.7	19.2
Feb. 20	.007	.007	39.4	49.3

c

Sample Date	V_{max} mg $Chlor._b$·m^{-3}·hr^{-1}		K_t μg·$liter^{-1}$ PO_4	
	Lne.-Bk.	Ead.-Hof.	Lne.-Bk.	Ead.-Hof.
Feb. 2	.023	.023	22.5	23.6
Feb. 20	.024	.022	195.0	172.5

a = primary production rates

b = rates of $chlorophyll_a$ synthesis

c = rates of $chlorophyll_b$ synthesis

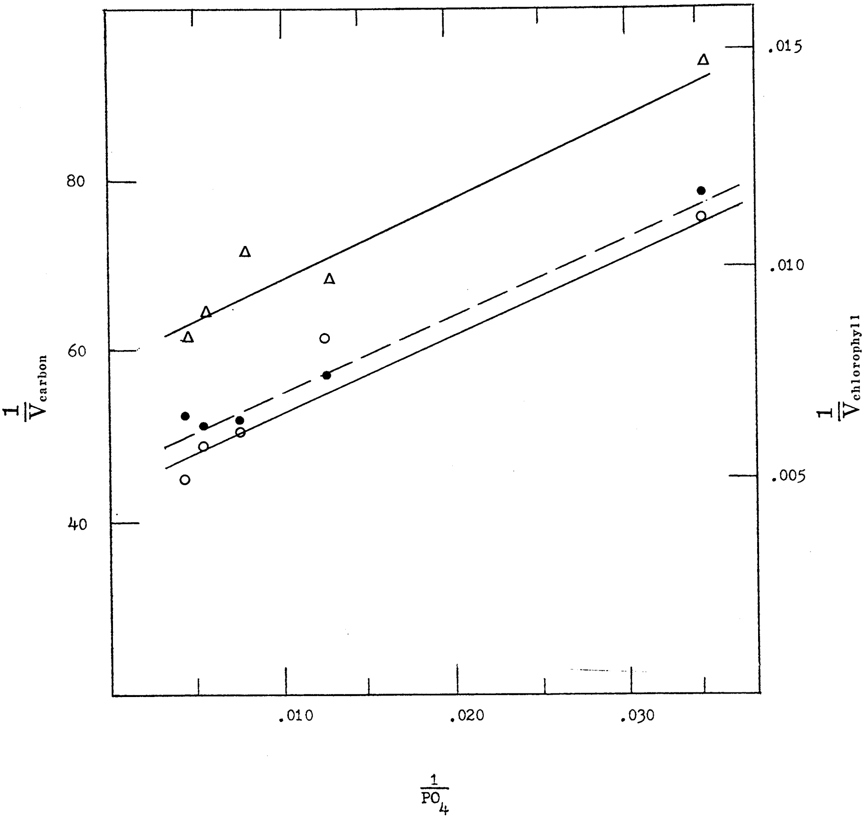

FIGURE 12. Application of the Lineweaver–Burk modification to the data presented in Fig. 11. For carbon fixation (triangles), V_{max} = 129.9 mg Carbon · m^{-3} · hr^{-1}. K_t = 25.7 μg · $liter^{-1}$ o-PO_4, r = .97. For $chlorophyll_a$, V_{max} = .022 mg chlor. · m^{-3} · hr^{-1}. K_t = 19.7 μg · $liter^{-1}$ o-PO_4, r = .99 (solid dots). For $chlorophyll_b$ (open circles), V_{max} = .023 mg chlor. · m^{-3} · hr^{-1}. K_t = 22.5 μg · $liter^{-1}$ o-PO_4, r = .97.

tion at the steep part of the curve are significantly different from those points along the plateau of the curve; however, as expected, the rates along the plateau are not significantly different from one another (P=.05).

The rates of carbon fixation and chlorophyll synthesis determined from the enrichment of a sample collected February 20, 1971 again demonstrate Michaelis–Menten phosphate uptake as illustrated in Figure 13. The values of V_{max} and K_t for both primary production and chlorophyll synthesis rates are presented in Table 1. At this time there is no obvious reason for the differences in V_{max} and K_t calculated at these two dates for these parameters.

However, the values of V_{max} for production of $chlorophyll_b$ are quite comparable, .023 and .024 mg Chlor. · m^{-3} · hr^{-1}, as calculated by the Lineweaver–Burk modification. To determine the fit of these rates to the Michaelis–Menten curve, the data was again subjected to least squares analysis. The value of r = .51 for carbon fixation rate as a function of phosphate enrichment. In the deter-

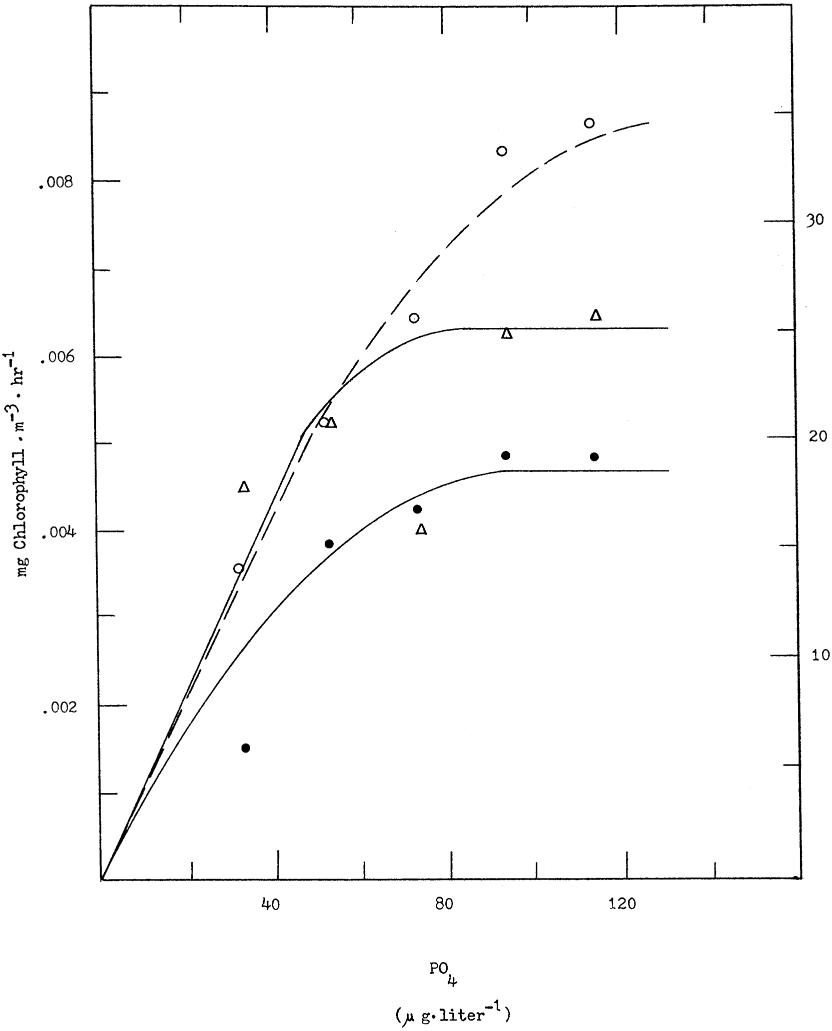

FIGURE 13. Rates of carbon fixation and chlorophyll a and b production as a function of increasing concentrations of orthophosphate. L. Winnebago sample collected February 20, 1971. Δ = mg Carbon · m^{-3} · hr^{-1}. Solid dots = $chlorophyll_a$. Open circles = $chlorophyll_b$.

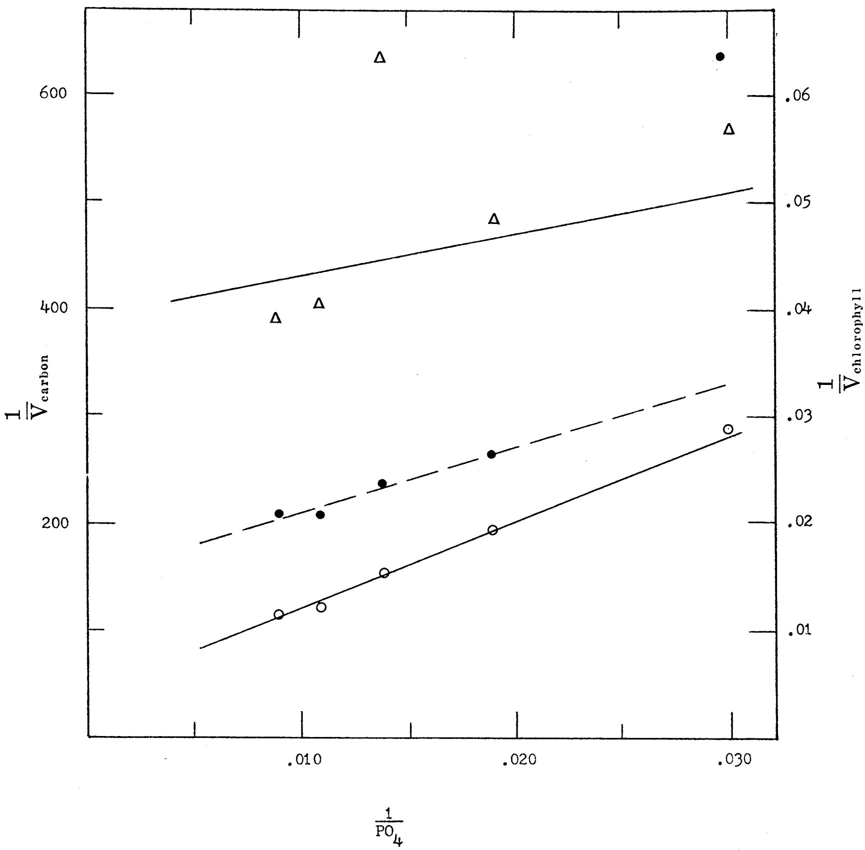

FIGURE 14. Application of the Lineweaver–Burk modification to the data presented in Fig. 13. For carbon fixation, (triangles), $V_{max} = 25.6$ mg Carbon · m^{-3} · hr^{1-}. $K_t = 16.2$ μg · $liter^{-1}$, r = .51. For $chlorophyll_a$ omitting point at $\frac{1}{PO_4} = .029$ (solid dots), $V_{max} = .007$ mg chlor. · m^{-3} · hr^{-1}. $K_t = 39.4$ μg · $liter^{-1}$, r = .98. For $chlorophyll_b$ (open circles), $V_{max} = .024$ mg chlor. · m^{-3} · hr^{-1}. $K_t = 195.0$ μg · $liter^{-1}$ o-PO_4, r = .99.

mination of r for the rate of $chlorophyll_a$ synthesis as a function of phosphate addition, the value of $\frac{1}{V}$ for the point at $\frac{1}{PO_4}$ was omitted because of its extreme variation from the other points which otherwise suggest a strong linear correlation, r = .98. For the rate of $chlorophyll_b$ production, r = .99. Again the Michaelis–Menten relationship seems valid as a model for phosphate uptake.

Rates of primary productivity in enrichment experiments performed with samples collected in November, 1970 indicated that orthophosphate was not a limiting factor for growth. The rate of carbon fixation for the control in an experiment with a November 18 sample was 17.8 mg Carbon · m^{-3} · hr^{-1}. In a 50 μg · $liter^{-1}$ phosphate enriched sample for this experiment, the rate was only 14.0 mg Carbon · m^{-3} · hr^{-1}. A t-test for small sample sizes (Hoel, 1967) showed that these rates are not statistically different at the .05 level of predictability. The addition of 1.0 and 2.0 mg · $liter^{-1}$ equivalents of orthophosphate to a sample collected on November 9, 1970 yielded similar results. The rate of productivity in the control sample was 46.0 mg Carbon · m^{-3} · hr^{-1}. The rates for the enriched samples were 30.7 and 28.8 mg Carbon · m^{-3} · hr^{-1}, respectively. Because these rates are not sample means, the significance of the decrease cannot be tested. However, the data shows that there was no increase in productivity with the addition of phosphate.

Similarly, productivity rates for a sample collected on April 2, 1971 indicated that phosphate was not limiting in the spring. The rate of productivity for the control was 154 mg Carbon · m^{-3} · hr^{-1}, while the rate for the most highly enriched sample of the series was only 158 mg Carbon · m^{-3} · hr^{-1}. These rates are not significantly different at the .05 level. The rates of productivity for a sample collected April 18 and enriched with 20, 40, and 60 μg · $liter^{-1}$ orthophosphate are 21.3 mg Carbon · m^{-3} · hr^{-1} for the control and 21.5, 28.3, and 28.5 mg Carbon · m^{-3} · hr^{-1} for the enriched samples. The significance of the increase is questionable, however the values are not means so they cannot be tested. Phosphate is probably no longer limiting; however, this statement is made with some reservation due to the absence of statistical verification.

No chlorophyll production rates were measured during late autumn when orthophosphate was present in high concentrations. However, the rate of chlorophyll synthesis was found to decrease somewhat with increasing additions of phosphate to a Lake Winnebago sample collected April 2, 1971, when orthophosphate was measured as 105.0 μg · $liter^{-1}$ (Figure 15). Such inhibition also occurred in the enrichment of a sample collected on April 18, 1971. This seasonal pattern of nutrient uptake as measured by increased chlorophyll synthesis rate seems to parallel that of carbon fixation.

V. *Discussion*

The results of the enrichment experiments indicate that the use of biological parameters to indirectly measure the kinetics of phosphate uptake is a valid approach to nutrient limitation theory and its relation to natural phytoplankton populations. Primary productivity and chlorophyll production seem particularly suited for this

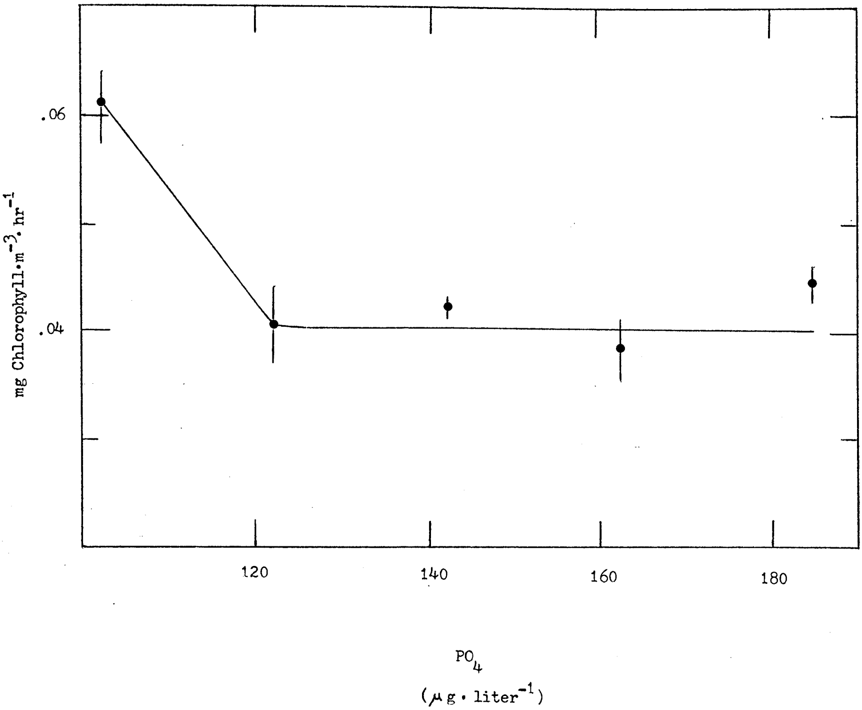

FIGURE 15. Mean chlorophyll$_{(a+b)}$ production rates as a function of increasing orthophosphate concentrations in an enrichment experiment with a sample collected April 2, 1971.

type of study. However, care must be taken in the use of these parameters.

Results obtained by means of the ^{14}C technique for measuring carbon fixation are subject to uncertainty in interpretation. The addition of phosphate may influence the photosynthetic apparatus specifically. In other words, a certain concentration of the nutrient may specifically alter the physiological efficiency of photosynthesis just as other metabolic processes are regulated by pH, temperature, or other similar environmental factors. Once the nutrient is depleted beyond the critical concentration, the productivity of the system will return to its level measured prior to enrichment. The effect of enrichment is short lived. However, this type of error is normally associated with the effect of micronutrients, according to Fogg in 1965, cited by Dugdale (1967).

Because phosphate can increase productivity as these enrichment experiments illustrate, any compound that displays a rapid synthesis in response to slight increases in the level of productivity would be a sensitive parameter for potentially measuring the utilization of phosphorous in the system. Chlorophyll is such a compound (Margalef, 1968). This sensitivity in relation to phosphate enrichment as shown in Figures 11 and 13 support the use of this parameter for measuring phosphate uptake quite well. It must be remembered, however, that the interpretation of this induced chlorophyll increase in relation to growth includes not only increased cell numbers, but also the synthesis of maximum chlorophyll content per cell prior to division.

The use of biovolume increase as a growth parameter must also be carefully interpreted. Increase in cell numbers or biovolume results from phosphate induced productivity only after the cellular content of chlorophyll and carbon have been maximized. This may explain the lag in the increase in growth rate as illustrated in Figure 10. When intermediary metabolism in the cell has achieved its optimum level or maximum efficiency, any remaining potential energy from the phosphate induced increase in productivity may be channeled into increasing the population size, as measured by increased biovolume. This makes the use of biovolume increase to estimate uptake kinetics less sensitive than the measurement of chlorophyll synthesis or the direct measurement of primary productivity by the ^{14}C method.

Regardless of the approach taken to elucidate the kinetics of nutrient uptake, there is one limitation to the experimental design when dealing with natural populations. This limitation is equally applicable to this study or to the direct measurement of uptake by the use of labelled nutrients as performed by Dugdale (1967) and MacIsaac and Dugdale (1969). In both studies, a lower limit to the amount of possible enrichment is determined by the concentration of the nutrient in the sample when collected. As enrichment implies addition, no calculation of uptake could be measured for concentrations of the nutrient below that already present in the sample. If the rate of nutrient uptake by the plankton was already at the plateau of a Michaelis–Menten curve, further additions of the nutrient would fail to yield the necessary information to calculate values of V_{max} or K_t. Uptake rates of enriched samples in this case would simply approximate the plateau or show inhibition. MacIsaac and Dugdale (1969) found this to be true in their study of nitrate uptake kinetics by marine phytoplankton. The plateau approximations and inhibition measured at high phosphate concentrations in the fall and spring by both chlorophyll production and primary production indicate a similar situation may exist for populations in Lake Winnebago in regard to phosphate uptake. The kinetics in the fall and spring populations may be still

Michaelis–Menten in nature; however, the values of V_{max} and K_t cannot be determined with the particular experimental design. In this study, Michaelis–Menten kinetics were best described by all parameters in February when the phosphate concentrations were at or near their lowest recorded values (Figure 1).

An alternate design might involve culturing different algal species in low nutrient mediums. These species might then be subjected to enrichments to determine their particular values of V_{max} and K_t for various nutrients. Unfortunately, it is difficult to extrapolate results obtained in the laboratory to the behavior of the organisms in a dynamic ecosystem. Values of V_{max} and K_t calculated under these conditions may be entirely different from those values for a species in its natural environment. Furthermore, Hamilton (1969), working with species of algae collected from Cayuga Lake in New York in controlled culture mediums, found the effects of phosphate enrichment (5.0 $\mu g \cdot liter^{-1}$ KH_2PO_4) unclear as determined by productivity measurements with ^{14}C. In some cases, this small concentration was even found to limit productivity. Certainly more work needs to be done in this area of research.

The ecological significance of the Michaelis–Menten model for nutrient uptake provides insight into the dynamics of nutrient limitation. While the application of the model to natural populations assumes that a single species of phytoplankton or a group of species with similar uptake kinetics dominates the population, this is usually not the case in most systems. Dugdale (1967) has calculated values of V_{max} for several species of algae and found them to range from .268 $\cdot$ hr^{-1} for *Skeletonema costatum* (Grev.) to .034 $\cdot$ hr^{-1} for *Rhizoselenia alata* Bright. These values are for nitrate uptake. Eppley (1969) has determined K_t values for seventeen oceanic and neritic species for nitrate and ammonium uptake. His results range from 8.6 μ moles $\cdot$ $liter^{-1}$ to 0.1 μ moles $\cdot$ $liter^{-1}$. Unfortunately, the use of biological parameters does not allow the author to compare uptake rates or K_t values with those of Eppley and Dugdale. Furthermore, this study only involved phosphate. Nitrate kinetics were not investigated.

Returning to Dugdale's work, if the species with the lowest value of V_{max}, *R. alata,* also exhibits a lower K_t value than *S. costatum,* then *R. alata* would be able to maintain itself in lower nitrate concentrations than *S. costatum. Skeletonema* would utilize nitrate faster and consequently approach concentrations where it could no longer compete with *R. alata.* This effect would be greatly amplified in time if the nitrate concentration was being depleted by other species of plankton as well. In general, species with lower values of V_{max} and K_t would successively dominate the algal community as the concentration of the limiting nutrient decreased through time. These species would be evolutionarily selected for where competition for low available nutrient concentrations existed (i.e. the Sargasso Sea, Dugdale, 1967). The values of V_{max} and K_t found in this study represent only one predominant species of phytoplankton, most likely a species of *Asterionella*. Therefore, no comparisons can be made at this time with other Lake Winnebago species to test the significance of V_{max} and K_t in relation to phytoplankton succession. However, it is interesting to note that the data illustrated in Figure 15 indicates a greater probable value of V_{max} for the April 2, 1971 population than those that were calculated for the February experiments in terms of chorophyll synthesis rates. The measured phosphate concentration more than doubled during this time period (Figure 1). More data is needed to pursue this aspect of succession in the Lake Winnebago phytoplankton populations. The important concept that emerges from the above data in terms of Michaelis–Menten kinetics is that nutrient limitation is a dynamic process. Not only the available nutrient concentration for a given element determines limitation, but the rate in which this nutrient is utilized by the different species in the community, as well as the rate in which the nutrient is supplied to the system are equally important in describing limiting conditions.

Furthermore, the Michaelis–Menten model as applied to nutrient limitation theory may provide valuable insight into the predictability of dynamic interactions between phytoplankton and nutrients in aquatic systems. If V_{max} and K_t values were determined for many species in relation to the different macro and micronutrients, a systems analysis approach with the analog computer might be of great importance in determining the effects of varying nutrient compositions on the productivity, species diversity, and abundance of phytoplankton in both oligotrophic and eutrophic systems. This predictive power would be of invaluable assistance in proper planning for the location of cities, industry, and waste treatment plants, as well as in calculating the permissible amount of nutrient loading for any system over time in order to minimize the effect of urban, industrial, and agricultural activities on the natural rate of eutrophication. Parker (1968) has been successful in integrating some field investigations with laboratory information to calculate the effect of increasing organic phosphate pollution of Kootenay Lake, British Columbia, on populations of phytoplankton. By means of a digital computer and a program based upon biological constants that approached reality for such parameters as nutrient concentration, photoperiod, and temperature, Parker was quite successful in predicting the occurrence of algae "blooms" as a result of the inflow of phosphate from a fertilizer plant located on the Kootenay River, which flows into the lake.

Smith (1969) has used the Michaelis–Menten expression to follow the effect of increased nutrient supply on a phytoplankton, zooplankton, predator food chain. He also investigated the situation in which a secondary predator was added to the simulation. In the first situation, Smith's model shows the effect of nutrient increase to be reflected in an increase in the population of the phytoplankton. Interestingly, there is also an increase in the density of the predator population. In the second situation, which includes the secondary predator, the system responds quite differently. The increase in nutrient concentration remains mostly in free form, while there is a small increase in the zooplankton and secondary predator populations. While such models are very simple in their ecological approach, they are a vital step in the direction of understanding the structural and functional dynamics of the trophic nature of the aquatic ecosystem. Smith's model indicates the subtle effects that one trophic level has upon another in relation to nutrient enrichment. Clearly, much more work of this nature, especially a further elucidation of nutrient limitation dynamics in the form of Michaelis–Menten theory, is vital in man's understanding of the process of eutrophication.

Another interesting aspect of the nutrient enrichment study described in this paper pertains specifically to Lake Winnebago. While the measured value of soluble phosphorous has increased manifold from the 2.0 $\mu g \cdot liter^{-1}$ annual mean reported by Hilsenhoff for the 1961–1964 period to the 29.0 to 105.0 $\mu g \cdot liter^{-1}$ range of concentrations determined over the course of this study, the enrichment experiments performed in February, 1971 demonstrated rather substantially that soluble phosphorous can still be a productivity limiting factor in this aquatic system. Lake Winnebago appears to have not yet reached a state of year round phosphorous saturation. Any concerned effort to effectively limit the allochthanous input of phosphorous into this system would be of significance in reversing the culturally induced acceleration of the eutrophication processes. Strict regulation of urban, industrial, and agricultural phosphorous loading would be proportionally repaid by an increase in water quality with its associated biological, chemical, and cultural implications.

Acknowledgement

Appreciation must be expressed to Mr. Peter Becker for his invaluable assistance in the design of the CHLOREG program.

The data for the calculation of chlorophyll synthesis rates for the April 2, 1971 sample as illustrated in Figure 15 was provided by the members of the Experimental Ecology class at Lawrence University.

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A RECORD OF THE FRESHWATER NEMERTEAN, *PROSTOMA RUBRUM*, IN WISCONSIN

Robert F. Browning

Prostoma rubrum is the only freshwater species of the acoelomate phylum, Nemertea (Rhynchocoela), which is known to occur in North America. Although Coe (1943) implies they are widely distributed throughout the United States, the only actual sites of occurrence he mentions are some freshwater ponds in the Woods Hole area. Poluhowich (1968) reviewed various aspects of the biology of *P. rubrum* in an attempt to stimulate new collections of this worm and extend the distribution records. In his review he provides references to their occurrence in the Chicago area and in Pennsylvania. He also reported that he collected numerous specimens from a small brook in Stratford, Connecticut. In a recent letter to me, he indicated that he had received word of a few additional reports in response to his publication but not enough to substantiate Coe's claim of nation-wide distribution. The present report appears to be the first record of *P. rubrum* in Wisconsin.

A population of *P. rubrum* was discovered in Silver Creek, in the city of Ripon (Fond du Lac County) from samples brought into the laboratory from a class field trip in early September 1970. The first specimen was isolated by two students, Joan Strewler and Kathleen Spence, and from its general morphology, I tentatively identified it as *P. rubrum*. The identification was confirmed later by observing the involvement of its probocsis in feeding and the deposition of eggs in peculiar mucous tubes secreted by sexually mature worms.

Using the collection method devised by Polohouwich (1968), I isolated as many as 35–40 specimens from a liter of substrate on several occasions during the Fall of 1970. The most productive substrate consisted of a mixture of mud detritus, and filamentous algae. In mid-February only two specimens were obtained from substrate samples obtained under snow and ice cover. In early April I found no specimens but this was probably due to the extended period of high water associated with the spring thaw. Although the high water undoubtedly flushed a great deal of the preferred substrate downstream, it is likely that many of the worms migrated deeper in the stream bed. I have not investigated this possibility fully at the present time.

The first specimens were taken approximately 100 yards downstream from the spillway of Gothic Mill Pond, an impoundment in a city park. A student, Mydin Shariff, made a preliminary semiquantitative study of their distribution in Silver Creek which suggested that the population was confined to that portion of the stream from the pond overflow, downstream to the vicinity of the sewage treatment plant, a distance of a little over one mile. This work will be repeated quantitatively this summer and fall to pinpoint the linear distribution of this species in Silver Creek. Such a study may answer some very interesting questions concerning the physical and biotic factors involved in the dispersal of this species. According to Coe (1943), "The species presumably was carried to the western states with cultivated water plants."

Thus far, attempts to establish laboratory cultures have been unsuccessful although I have maintained individual specimens for up to two months by feeding them a small length of tubifex worm each week.

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A RECORD OF *CRASPEDACUSTA SOWERBYI* IN WISCONSIN[1]

Richard P. Howmiller and *G. M. Ludwig*

ABSTRACT

The freshwater jellyfish, *Craspedacusta sowerbyi,* is reported for the first time from Wisconsin. Large numbers of medusae occurred in a small artificial pond in late summer of 1969 and 1970. This appears to be the northernmost locality for the species in the Mississippi drainage.

The known North American distribution of the freshwater jellyfish, *Craspedacusta sowerbyi* Lankester, is broad but appears to be centered in the northeastern quarter of the United States. There seem to be no previous records of this species as far north in the Mississippi drainage as Wisconsin (Pennak 1957, Lytle 1960, Bushnell and Porter 1967). As pointed out by Pennak (1957) the lack of reported occurrences in this region are remarkable because of the considerable limnological knowledge of Wisconsin and Minnesota.

A medusa brought to the Milwaukee Public Museum for identification directed our attention to a population of *C. sowerbyi* in a small pond on Skillet Creek Farm (N ½ Sec 15, T 11 N, R 6 E) near Baraboo, Sauk County, Wisconsin. The pond is approximately 50 m in diameter, dug in glacial till and fed by water from Skillet Creek. Dug six years ago, the pond still appears "new" with a bottom of sand and gravel and no colonization by aquatic macrophytes. Medusae of *C. sowerbyi* have been noticed by the owner in the fall of 1969 and 1970. When we visited the pond on September 13, 1970, large medusae (1.0–1.5 cm) were abundant; we captured more than 50 with small hand nets in an hour. Some medusae swam to the surface of the water and floated downward again. Others lay, pulsing slowly, on the bottom in patches of filamentous algae *(Spirogyra)* and detritus. Crayfish, amphipods, ostracods, chironomid larvae, mayfly nymphs and the gastropods, *Campeloma* and *Ferrissia,* were common in the algae and detritus. Polyps of *C. sowerbyi* were not observed.

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[1] Contribution No. 43, Center for Great Lakes Studies, University of Wisconsin–Milwaukee, Milwaukee, Wisconsin 53201

Surface water temperature at mid-day on September 13, 1970, was 18 C. Medusae were common in the pond during the previous two or three weeks, according to the property owner.

Many other records of *C. sowerbyi*, perhaps a majority, are from artificial ponds or impoundments (Pennak 1957; Lytle 1960, Bushnell and Porter 1967). It has been suggested that long range dispersal may have occurred in conjunction with shipments of aquatic plans (Bushnell and Porter 1967). The owner of Skillet Creek Farm stated that no aquatic plants and no animals other than locally obtained bass, bluegills and crappies had been introduced to the pond. *Craspedacusta* must have been introduced by some agent other than man. Perhaps wood ducks, which frequent the pond, carried in *Craspedacusta* polyps among their wet feathers.

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PEDOLOGY OF THE TWO CREEKS SECTION, MANITOWOC COUNTY, WISCONSIN

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INTRODUCTION

The Two Creeks Forest Bed of eastern Wisconsin is a well known marker of the interval of deglaciation between the Cary and Valders glacial advances. Frye and Willman (1960) have classified this interval as the Two Creekan, a substage of the Wisconsinian that occurred from about 12,500 to 11,000 radiocarbon years ago. According to their classification, the Two Creekan followed a much longer, earlier substage, the Woodfordian, and preceded the Valderan, or youngest substage, recently described by Black (1966).

The Two Creeks horizon, near the village of Two Creeks, Wisconsin, consists of a thin paleosol, in which long-dead trees and other plants are rooted, and the overlying, broken over remains of the Two Creeks forest. Both are buried beneath younger drift. At the surface a modern soil has been formed. While the age of the buried horizon, its paleobiological nature and geologic history have been the subject of considerable study, little has been written about the site from a pedological point of view. The present paper is a report of such a study.

LOCATION OF SITE

The original Two Creeks site, first reported by Goldthwaite (1907), was located along the west shore of Lake Michigan in Manitowoc County, Wisconsin (Sec. 11, T21N, R24E). Other exposures in the same general area were subsequently studied by Wilson (1932), (1936), Thwaites (1943), Thwaites and Bertrand (1957), Horn (1960), West (1961), and Hole (1967). Similar horizons have also been reported in the Fox River Valley by Lawson (1902) and in the Duck Creek Ridges by Piette (1963), and Janke (1962).

The section described in this study was found in the near vertical bluffs overlooking Lake Michigan just south of the Manitowoc–Kewaunee County line (NE½, Sec. 2, T21N, R24E). This exposure was 2–3 kilometers north of the one described by Goldthwaite in 1907 and that studied by Wilson in 1936.

METHOD OF STUDY

Field studies were made of a 4.8 meter vertical section extending from the top of the bluff to a talud at its base. This section, which included both the modern soil and the Two Creeks paleosol, was subdivided into soil horizons or sedimentary strata on the basis of morphologic and/or stratigraphic features (Fig. 1).

In the laboratory, gravel, mainly 15 to 20 mm in diameter, was separated from air-dried bulk samples with a No. 10 U. S. Standard sieve. Gravel content was expressed as percent by weight of each bulk sample. The particle-size distribution of the <2 mm fractions was determined by the method outlined by Day (1956); a hydrometer was used to determine the percentage of silt and clay. Carbonates were not removed prior to analysis. Organic matter in the surface horizon (Ap) of the modern soil was destroyed by treatment with 30% H_2O_2.

Percent calcium carbonate equivalent was determined by treating 1 gram samples with an excess of 1*N* HCl and then back titrating with 1*N* NaOH. Milliequivalents of acid neutralized were expressed as a percentage of the me that would be neutralized by 1 g of pure $CaCO_3$. Reductant soluble iron was determined according to the method of Aquilera and Jackson (1953).

Organic carbon content of the peaty surface horizon of the buried paleosol was determined by the method described by Walkley and Black (Jackson, 1958); total nitrogen by the Kjeldahl method (Jackson, 1958). Solubility in sodium pyrophosphate ($Na_4P_2O_7$), as a measure of the degree of decomposition of organic matter, was measured by placing a sample on a spot plate and thoroughly wetting it in a saturated solution of $Na_4P_2O_7$; a strip of filter paper was then inserted and the resultant color of the filter paper determined. pH readings were made on soil pastes, with a glass electrode, after the soil had been saturated with distilled water and then allowed to equilibrate for a ½ hour. Samples were ashed at 600°C for 4 hours in a muffle furnace to determine ash content.

Results and Discussion

The soil developed on the modern surface at the study site was formed in reddish brown, clay loam glacial till of Valderan age, and thin loamy coverings likely of glacio-fluvial or glacio-lacustrine origin (Fig. 2). This soil had been cultivated at one time, before erosion of the headland had caused the bluff to retreat inland to a point where cultivation of the site was no longer possible.

The pedon described was tentatively identified as a dark surface variant of Hortonville loam, a Glossic Hapludalf. Its description was as follows:

Ap	0–25 cm	Black (10YR 2/1—moist) and grayish brown (10YR 5/2—dry) loam; moderate, medium granular structure; friable moist; neutral to alkaline; abrupt boundary.

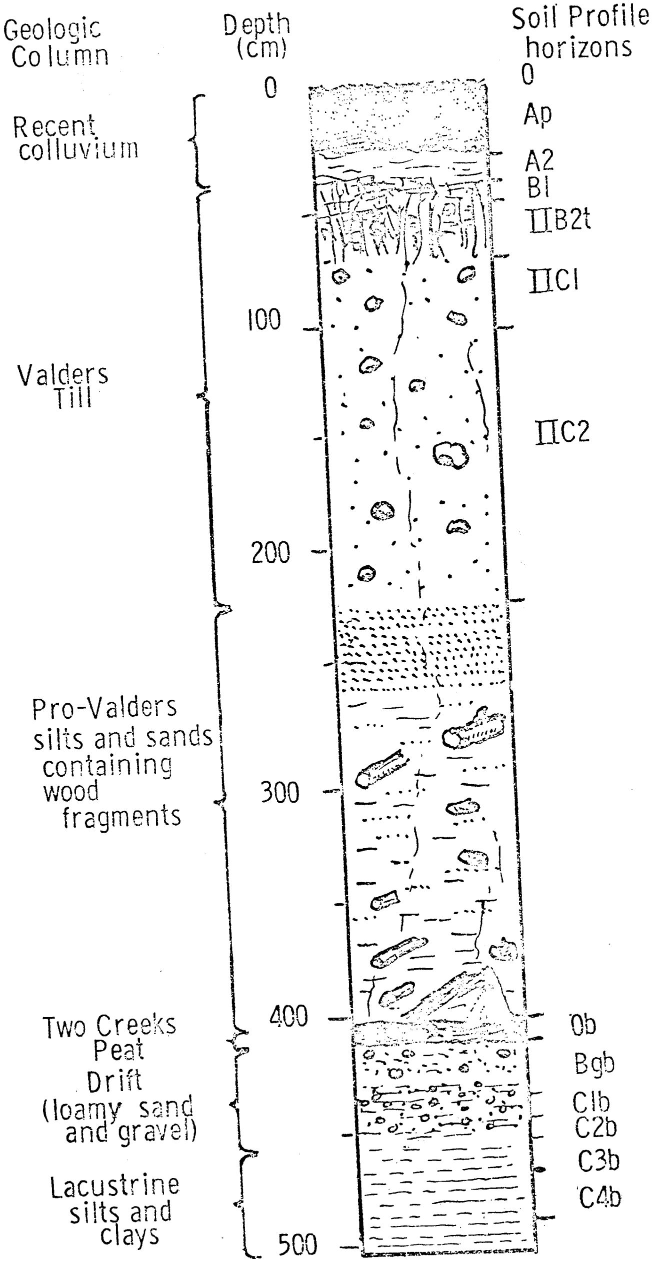

FIGURE 1. Sketch of section studied showing stratigraphic and morphologic features.

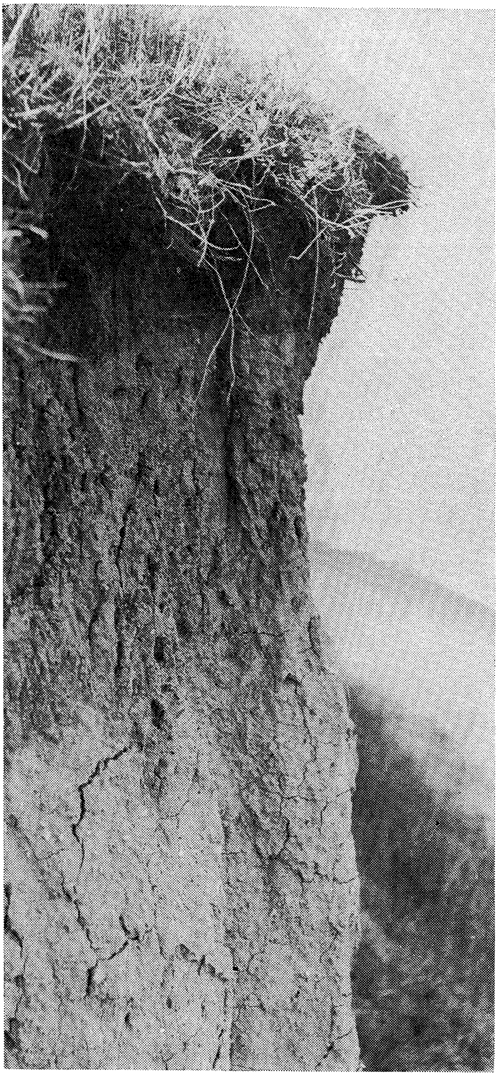

FIGURE 2. Modern soil in bluff overlooking Lake Michigan at Two Creeks site. Note dark surface horizon, structured Bt horizon, and underlying Valders till.

A2 25–36 cm Brown (10YR 5/3—moist) and pinkish gray (7.5YR 6/2—dry) fine sandy loam; weak, medium platy structure; plates break into weak, medium subangular blocky aggregates;

		patchy, yellowish-brown (10YR 5/3—dry) stains on ped surfaces; friable moist; a few pebbles; alkaline; clear boundary.
B1	36–46 cm	Brown (7.5YR 5/4—moist) and light brown (7.5YR 6/4—dry) silt loam; moderate, fine to medium, subangular blocky structure; pinkish gray (7.5YR 7/2) coatings on ped faces; slightly sticky wet, hard dry; alkaline; clear boundary.
IIB2t	46–71 cm	Reddish-brown (5YR 5/3–4/3—moist) clay loam; moderate, coarse prismatic structure; prisms break into strong, medium angular blocky peds; clay coatings on both vertical and horizontal faces; sticky wet, hard dry; a few pebbles; alkaline; clear boundary.
IIC1	71–102 cm	Reddish-brown (5YR 5/3—moist) loam to clay loam; moderate, coarse prismatic structure; prisms break into moderate, medium, angular blocky peds; sticky wet, hard dry; a few, mainly dolomitic, pebbles and cobbles; calcareous matrix; gradual boundary.
IIC2	102–224 cm	Reddish-brown (5YR 5/3—moist) clay loam; coarse prismatic structure; prisms break into coarse blocky peds; light brownish-gray (2.5Y 6/2—moist) coatings on vertical faces of prisms. These coatings effervesce strongly in dilute acid; ped interiors effervesce moderately; a few, mainly dolomitic, pebbles and cobbles; abrupt boundary with underlying pro-Valderan mud flows.

As can be seen by its description, this soil was characterized by a thick, dark colored, surface (Ap) horizon. Surface horizons of this nature are not common to well or moderately well drained soils of the Two Creeks area, as typical A1 horizons are thin, and underlain by light colored eluvial layers. A likely explanation is that adjacent, cultivated slopes had eroded during the post settlement era, causing the accumulation of 18–20 cm of colluvium at the study site. Tillage operations, concurrent with this period of colluvial deposition, would have mixed these sediments with the original A1 horizon, forming the thick, uniformly dark colored and loamy, mollic-like epipedon described. Field observations support this hypothesis as the study site was slightly concave in surface configuration, with adjacent, cultivated, slopes.

Below the Ap horizon, A2 and B1 horizons were formed in thin, sandy loam and silt loam strata, respectively. The low clay content and numerous uncoated soil grains in the gray A2 horizon indicate that both illimerization (loss of clay) and podzolization (loss of iron) had occurred during soil formation. These observations are supported by laboratory data on clay and iron content (see Tables 1 and 2).

Yellowish-brown stains on peds in the A2 horizon suggest that some secondary translocation of iron had occurred and that a Bir horizon was beginning to form. This observation agrees with those

TABLE 1. MECHANICAL COMPOSITION AND TEXTURAL CLASS OF MODERN SOIL AND UNDERLYING DEPOSITS AT TWO CREEKS SITE.*

HORIZON	DEPTH	GRAVEL†	SAND	SILT	CLAY	TEXTURAL CLASS‡
		>2mm	2–0.05mm	0.05–.002mm	<.002mm	
	cm	%	%	%	%	
Ap	0– 25	0	35	47	18	l
A2	25– 36	trace	60	24	16	fsl
B1	36– 46		Not determined			sil
II B2t	46– 71	trace	31	34	35	cl
II C1	71–102	16	39	36	25	l-cl
II C2	102–224	12	28	35	37	cl
III C3	224–260		Not determined			s
IV C4	260–368	0	15	66	19	sil
IV C5	368–406	0	28	60	12	sil

*C1 and C2 horizons are Valders till; C3, C4 and C5 horizons are pro-Valders deposits.

†Gravel content was determined on bulk sample. Sand, silt and clay on < 2 mm subsample.

‡Standard abbreviations are used as follows: l, loam; fsl, fine sandy loam; sil, silt loam; cl, clay loam; s, sand.

TABLE 2. CONTENT OF FREE IRON OXIDES AND CARBONATES IN MODERN SOIL AT TWO CREEKS SITE.

HORIZON	DEPTH	Fe_2O_3	$CaCO_3$ EQUIVALENT
	cm	%	%
Ap	0– 25	1.52	—
A2	25– 36	0.58	—
B1	36– 46	—	—
II B2	46– 71	1.69	—
II C1	71–102	0.67	40
II C2	102–224	0.89	33

made by Beaver and Lee (1963) which indicated that the Two Creeks site is in a transitional soil zone where Spodosols form in acid, sandy deposits; bisequal soils (Alfic Haplorthods) in loamy sediments underlain by calcareous, loamy to fine textured till at moderate depth; and degraded Alfisols (Glossic Hapludalfs) in moderately fine to fine textured glacial drift having thin loamy surface coverings. In the soil described, the loamy coverings were likely not deep enough for an upper, Spodosol sequum to develop; however, the rusty stains were indicative of juvenile development of a Bir (spodic) horizon. Morphological observations of associated soils along the face of the bluff lent support to this theory. Some of these soils were formed in loamy and sandy coverings, 50 to 75 cm thick over Valders till, and exhibited bisequal profiles characterized by an upper, A2-Bhir sequum over A′2 and Bt horizons. Other soils having very thin surface coverings were monosequal in nature. It should be noted, however, that the latter soils were characterized by a degraded B, or an A and B horizon indicating strong podzolization.

Degradation of the B1 horizon in the soil studied was indicated by the pinkish gray color of ped faces in that layer. This color was indicative of the stripping away of iron coatings from sand and silt grains, as could be observed with an ordinary (10X) hand lens. The lower boundary of the B1 horizon marked a lithologic discontinuity, as the underlying IIB2t horizon contained considerably more clay, as well as a few erratic pebbles and cobbles (Table 1), suggesting that it was formed in Valderan till. Argillans on ped faces in this layer indicated that illuvial clays were present. Structural elements in the IIB2t horizon were extremely well defined. This was likely due in part to exposure and desiccation of the profile, and in part to the moderately high content of expanding layer silicate clay minerals characteristic of red clays in this region (Petersen, Lee, and Chesters, 1966).

Total depth of A and B horizons in the modern soil was 71 cm; the C horizon (unleached Valderan till) extended beyond this to a depth of 224 cm. Laboratory data (Tables 1 and 2) showed this till to be of heavy loam or clay loam texture in which carbonate content ranged from 30 to 40%. Till of this texture is common to the region (Lee, Janke and Beaver, 1962). Vertical faces of prismatic elements in the C2 horizon were covered with brownish-gray coatings; this same phenomenon has been noted by the authors in other red clay deposits in eastern Wisconsin. The physical appearance of these coatings indicated that they were illuvial in origin; their strong effervescence with HCl suggested that they were composed in part of pedogenic calcite.

Below the Valderan till a layer of coarse and medium sand was encountered (Fig. 1 and Table 1). This, and the two silty layers beneath, resembled the pro-Valders fluvial deposits described earlier by Thwaites and Bertrand (1957). Occasional seams of sand were noted in the upper part of the silty layers; several wood fragments were noted in both layers.

The Two Creeks Soil

The Two Creeks paleosol was beneath the pro-Valders deposits at a depth of 406 cm (Fig. 1). It consisted of a thin, compact organic layer and a gleyed subsoil horizon (Fig. 3). Rooted in this soil was a brokenover tree approximately 7 inches in diameter,

FIGURE 3. Two Creeks paleosol beneath light colored, silty, Pro-Valders deposits. The thin, dark colored layer is the Ohb horizon. Note: the tape is in inches.

breast high (Fig. 4). It was lying toward the west–southwest, corresponding to the generally assumed direction of Valders ice flow at this point. Broeker and Farrand (1963) have dated wood from the Two Creeks horizon at 11,850 ± 100 radiocarbon years before present.

The gross morphology of the buried paleosol at this exposure gave it the appearance of a thin, young, hydromorphic soil that would be classified as an Aquent in the new (U. S.) system of soil classification (Soil Survey Staff, 1967). Its description was as follows:

Ohb	8–0 cm	Black (10YR-5YR 2/1) fibrous peat containing recognizable fragments of twigs; coarse platy structure; very compact; brittle dry; slightly acid (pH 6.5); abrupt smooth boundary.
Bgb	0–20 cm	Grayish-brown (2.5Y 5/2) to light brownish gray (2.5Y 6/2) loam; weak platy structure; apedal; friable moist; many pebbles; calcareous; clear wavy boundary.

FIGURE 4. Broken over tree, rooted in the Two Creeks paleosol. This tree points west-southwest, indicating the direction of Valders ice flow at this point.

C1b	20–26 cm	Brown (10YR 5/3) loamy sand; single grain; stratified; calcareous; abrupt boundary.
C2b	26–41 cm	Brown (10YR 5/3) gravelly loamy sand; stratified; loose; iron stains noted; calcareous; abrupt wavy boundary.
IIC3b	41–46 cm	Pale brown (10YR 6/3) silt loam (laminated silts, clays, and fine sands); very friable; calcareous; abrupt boundary.
IIC4b	46–66 cm	Reddish gray (5YR 5/2) silty clay loam (laminated silts and clays); massive, breaking with conchoidal fracture; very hard dry and very firm moist; calcareous. This deposit extended to the level of the modern beach.

As can be seen from its description, the uppermost horizon of the Two Creeks soil consisted of dark colored, fibrous, organic material, many wood fragments, and considerable mineral material; its compact nature suggested that it had been considerably thicker before being compressed by the weight of overlying deposits.

Analyses of this horizon (Table 3) showed that the organic fraction was highly soluble in $Na_4P_2O_7$, indicating a more advanced stage of decomposition than its fibrous nature and relatively wide C:N ratio (33) would suggest. Chesters (1959) studied a sample of material from this horizon and reported that its thermogram "showed many lignin characteristics"; he believed it to be more highly decomposed than a sample of Horicon muck, a well decomposed, contemporary Histosol. On the basis of these analyses the horizon was classified as Oh, despite its fibrous appearance. In the new system of classification (Soil Survey Staff, 1968), an Oh (hemic) horizon is partially decomposed but may be fibrous in appearance.

Other characteristics of this horizon that relate to its genesis were its slightly acid pH and relatively high ash content (Table 3). Free carbonates were not present except as they occurred in the shells of mollusks or other soil fauna. This suggests that carbonate

TABLE 3. CHEMICAL AND PHYSICAL PROPERTIES OF THE SURFACE HORIZON OF THE TWO CREEKS PALEOSOL.

THICKNESS	ORGANIC CARBON	TOTAL NITROGEN	C:N RATIO	SPEC*	pH	ASH
cm	%	%				%
8	15.8	0.48	33	10YR 2/2	6.5	63.1

*Acronym for sodium pyrophosphate extract color (Munsell notation).

laden waters did not move through this horizon, either vertically or laterally, while it was buried.

The high content of ash in the Ohb horizon indicates considerable incorporation of mineral sediments. A partial explanation is that during its terminal stage, the Two Creeks Forest was inundated by waters in front of the advancing Valders ice, and then buried by mud flows. During this period, considerable sand, silt and clay were deposited on the Ohb horizon; some of this sediment likely infiltrated the layer.

Another factor contributing to the high mineral content of the Ohb horizon relates to its environment of formation. Wilson's studies (1932, 1936) of the paleocology of the Two Creeks horizon showed that 3 biologic zones were present, corresponding to 3 periods of development during its genesis. The first period was characterized by aquatic or semi-aquatic mollusks, indicating a wet, early stage at which time muddy runoff waters were likely present. The middle period was characterized by mosses characteristic of moist to dry woodlands. A major part of the Ohb horizon at this site probably developed as the 01 or 02 horizon of an upland forest soil; its high mineral content is likely due in part to the mixing of mineral and organic material frequently seen in such horizons.

Below the Ohb was the Bgb horizon, formed in a loamy deposit containing many pebbles (Table 4). According to Thwaites and Bertrand (1957), the sediments comprising this and underlying layers were deposited in glacial Lake Chicago in front of Cary ice as it melted and retreated northward.

TABLE 4. MECHANICAL COMPOSITION AND TEXTURAL CLASS OF TWO CREEKS SOIL AND UNDERLYING DEPOSITS.

Horizon	Depth	Gravel*	Sand	Silt	Clay	Textural Class†
		>2mm	2–0.05mm	0.05–.002mm	<.002mm	
	cm	%	%	%	%	
Ohb	8– 0		Histic material			peat
Bgb	0–20	10	39	41	20	l
C1b	20–26	trace	82	11	7	ls
II C2b	26–41	70	84	6	10	gr ls
III C3b	41–46	trace	11	77	12	sil
III C4b	46–66	0	5	64	31	sicl

*Gravel content was determined on bulk sample; sand, silt and clay on < 2 mm subsample.

†Standard abbreviations are used as follows: l, loam; ls, loamy sand; gr ls, gravelly loamy sand; sil, silt loam; sicl, silty clay loam.

The Bgb horizon was about 20 cm thick; morphological evidences of pedogenesis included its gray, reduced color, indicative of gleization, and structural development. In comparison to the underlying C1b and C2b horizons, it had a higher content of clay and free iron and a somewhat lower content of carbonates (Tables 4 and 5). The latter likely represents leaching during the relatively brief period that this soil underwent pedogenesis. Free iron content is in part a reflection of original texture, but it may also reflect illuvial accumulation; clay content is likely related to sedimentary history.

The present day morphology of the B horizon suggests that it was formed under water-logged conditions and that it was the subsoil of a hydromorphic soil. This may not have been the case, however, as the process of gleization is not strictly a pedogenic process but occurs quite readily wherever there are reducing conditions, providing a source of energy such as organic matter is available. This can be demonstrated in the laboratory and is frequently observed in young soils, for example in waterlogged layers of recent colluvium. Near Coopers Mill, a few km inland from the Two Creeks site, gravel pit operations exposed logs buried in Valderan outwash. Examination of the sand around many of these logs revealed a peripheral gleyed zone, several inches thick, and obviously developed *in situ* since burial.

Beneath the Bgb horizon were thin layers of loamy sand, gravel, and silt loam, underlain by reddish colored, calcareous, laminated silts and clays which extended to the level of the modern beach. The latter were similar to the Early Lake Chicago deposits described by Thwaites and Bertrand (1957). According to their observations, which were made when higher lake levels caused rapid removal of talus from the base of the bluff, these deposits ranged from 7 to 20 feet in thickness and were underlain by gray, loamy, Cary-age glacial till.

TABLE 5. CONTENT OF FREE IRON OXIDES AND CARBONATES IN THE TWO CREEKS PALEOSOL.

Horizon	Thickness	Fe_2O_3	$CaCO_3$ Equivalent
	cm	%	%
Ohb	8	—	—
Bgb	20	0.51	35.2
C1b	6	0.22	42.0
C2b	15	0.32	37.7

History of the Two Creeks Site

The chronology of events at the Two Creeks site has been described by Thwaites and Bertrand (1957), Wilson (1932), Hough (1958), Murray (1953) and others as follows:

1. When Cary (Woodfordian) glacial ice retreated from eastern Wisconsin, the Lake Michigan basin was flooded by waters of glacial Lake Chicago. This was the Glenwood State (Wilson, 1932, quoting Thwaites, unpublished) during which lake waters were about 60 feet higher than at present or about 640 feet elevation. Sediments, including varved silts and clays, derived in part from reddish brown fine textured clastics siphoned down from the Lake Superior basin (Murray, 1953), (Peterson, Lee and Chesters, 1966), were deposited in glacial Lake Chicago, Green Bay, and the Lake Winnebago lowlands.
2. When Cary ice retreated beyond the Straits of Mackinac, freeing the northern outlet of the lake, water levels in Lake Chicago fell to present levels (580 feet) or lower. Freshly exposed soil material was invaded by aquatic and semi aquatic mollusks, mosses, and other water loving plants, later by trees, primarily black spruce *(Picea mariana)* in moist areas (Wilson, 1932). This, Two Creekan substage estimated by Frye and Willman (1960) to be not over 1500 years in duration, was the period during which the Two Creeks soil formed.
3. The Two Creekan period ended with the advance of Valders ice. Water in front of the glacier rose to the Calumet outlet (about 40 feet above present levels); the Two Creeks Forest was inundated, and pro-Valders lake deposits were deposited on the forest floor. Valders ice then passed over the area burying the Two Creeks soil and overlying deposits beneath red till.
4. When Valders ice retreated, about 7000 years ago (Frye, Willman and Black, 1965), the area in front of the melting ice was again flooded. Sand, silt and clay was deposited locally on uplands. When the Straits of Mackinac were again freed of ice, water levels receded to present day levels. Formation of the modern soil at the Two Creeks site presumably began between 7000 and 5000 years B.P., and has continued until the present day.

Soil Formation

The Two Creeks soil formed from the vegetative remains of plants growing on it, and in sediments presumably deposited in glacial Lake Chicago during retreat of Cary ice. At the site studied the varved silts and clays, described by Thwaites and Bertrand (1957), were overlain by thin layers of sandy and loamy sediments. The modern soil at the Two Creeks site was formed partially in Valders till and partially in loamy post-Valders deposits, the latter likely laid down in front of the melting Valders ice and later reworked in part by wind. The till at this site is of clay loam texture (about 35% clay) and is calcareous (40% calcium carbonate equivalent). The clay fraction of glacial till in this region is comprised mainly of montmorillonite, mica, vermiculite, chlorite and interstratified minerals (Janke, 1962). Loamy cover sediments were likely calcareous when deposited but included only 16–18% clay (Table 1).

Forest vegetation at the Two Creeks site was comprised mainly of black spruce (Wilson, 1932). A log identified as white spruce *(Picea canadensis)* was also found by Wilson, however he believed it to have been derived from a drier site. At his second site, Wilson (1936) also found balsam. Other flora included mosses and lichens. A number of the former were identified by Cheny (1930; 1931) who found them to be existing species that are generally found north of the Two Creeks site under present-day climatic conditions. The organic-rich surface layer of the soil also included pollen spores indicating the presence of grasses *(Gramineae)*, heath plants *(Ericaceae)*, birch *(Betula)* and jackpine *(Pinus banksiana)* in nearby areas during Two Creeks time. Wilson (1932) concluded from the boreal character of the fossil trees and the associated biota that the climate during the Two Creeks interval was probably like that of northern Minnesota today, or somewhat colder. Later studies by Culberson (1955) of fossil mosses supported this conclusion. Zumberge and Potzger (1955), after studies of a nearby area in western Michigan, came to a similar conclusion on the basis of pollen studies and radio-carbon dating, finding evidence that a spruce–fir forest and a cool to cold, moist climate existed in that area about 11,000 years before present. West (1961), on the basis of pollen studies in a Cary end moraine bog (outside the Valderan drift), found that white spruce *(Picea glauca)* reached a maximum during Two Creeks time suggesting that the vegetation at that time had true boreal character. Later, when Valders ice advanced, black spruce became prominent, indicating wetness.

If the climate during Two Creeks time was somewhat cooler than at present, and the Two Creeks Forest consisted of moist to dry woodlands for at least 300 years (Wilson, 1932, 1936; Broeker and Farrand, 1963), the dominant soil forming process during the period the site was covered by forest growth was likely podzolization rather than gleization, with the latter process being dominant prior to growth of the forest, and during and after inundation and burial of the Forest Bed. Following this line of reasoning, the horizon we now call Bgb may very well have been Bir or Bhir, i.e., a spodic-like horizon characterized by an accumulation of illuvial iron, or illuvial iron and humus, at the time of burial. Later, iron in the subsoil horizon could have been reduced to produce the gley-like horizon present today.

Climatic and biotic factors affecting the modern soil at Two Creeks can probably best be inferred from West's (1961) pollen studies. West found that pioneer vegetation, following retreat of glacial ice, consisted of scattered white spruce, weeds and shrubs. These were followed by oak *(Quercus)* and birch *(Betula)* and as a warming trend continued, jack pine, elm *(Ulmus)*, oak and ironwood *(Ostrya)*. Later, white and red pine *(Pinus strobus)* replaced jack pine, and hardwoods such as elm, hickory *(Carya)*, ironwood, walnut *(Juglans)* and basswood *(Tilia)* became prominent. As the climate became warmer and drier, and lake levels dropped to the Lake Chippewa stage during the xerothermic period that ended about 3500 years before present, oak became the dominant tree species. At the same time grasses and forbs (e.g., *Gramineae, Cyperaceae* and *Compositae*) became common, indicating prairie-like vegetation. During a succeeding cooler and moister period, oak was followed by pine and then beech, hemlock *(Tsuga)* and birch. Hemlock then increased in importance up until settlement, when forests were cleared and most of the land cultivated.

The humid cool and humid to subhumid temperate climatic regimes described, in combination with coniferous and deciduous vegetation, would be conducive to soil forming processes such as eluviation and illuviation of clay (illimerization), and of iron and humus (podzolization). Soils in the region having distinct argillic (clay enriched) subsoil horizons are generally believed to have formed under hardwoods such as oak, hickory, maple and basswood, and in some cases prairie, alternating with hardwoods, under humid to subhumid temperate climatic conditions. Forest species such as red and white pine, white spruce, beech, and hemlock, especially the latter, produce litter that is conducive to the formation of podzol soils (Lee, 1955, Wilde, 1958); cool humid climatic conditions are associated with all major podzol (Spodosol) regions.

It appears therefore, that during the early stages of formation, as the forest canopy closed above it, the modern soil accumulated organic matter in and on its surface layer. This was followed by the removal of carbonates from the upper part of the soil by precipitation percolating through the litter layer and into the mineral soil below, slowly leaching out the free carbonates present. Clay was then dispersed in surface layers and translocated to subsoil horizons where it was deposited on ped surfaces, and in pores, as water was withdrawn into the soil matrix by capillary action. This last process, occurring over a long period of time, produced the argillic (Bt) horizon present in this soil today.

Following the xerothermic period about 1500 B. C., and the increase in pine, beech, and hemlock, podzolization likely became the dominant soil forming process in the upper, leached and relatively permeable part of the soil. While podzolization did not proceed very far in the pedon studied, where loamy coverings were relatively thin, it was apparent that in adjacent pedons, where loamy or sandy deposits extended to greater depths, podzolization was much more pronounced.

The thick dark colored surface horizon of the modern soil can best be explained as an anthropic feature brought about by man's cultivation of the land, resulting in erosion of surrounding slopes and deposition of topsoil at the study site.

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LOWER WISCONSIN RIVER VALLEY SOIL RESOURCES AND USE POTENTIALS

G. E. Musolf and *F. D. Hole*

The Wisconsin River flows for 90 miles (145 km) from the glacial end moraine at Prairie du Sac to the confluence with the Mississippi River at Prairie du Chien. This stretch is called the Lower Wisconsin River Valley of which the floor includes 145, 107 acres in area (227^2 mi; 587 km^2). The valley floor consists of floodplain and a sequence of stepped natural terraces, only 10 percent of which, by area, are rock benches, the rest being of glacial outwash. The geomorphic history of these features has been discussed elsewhere (Hole *et al.*, 1952; Musolf, 1970).

The westward to southwestward trend of this valley runs counter to the major flow of people and freight between Chicago and Twin Cities (Figure 1). "Nature-made highway" was the title assigned to the Fox–Wisconsin waterway by Whitbeck in 1915. The idea of improving the Lower Wisconsin River by local dredging and excavation of supplemental side canals was promoted by W. J. Nicodemus in an article in these Transactions in 1874, when a passage for steamboats to carry grain eastward was seen as a real need. Other more rapid means of transportation developed on land before this "improvement" could be accomplished, as was recognized by F. E. Williams (1921) who attributed "the passing of an historic waterway" to the directional trend mentioned above, to the shallowness that even impeded canoe passage, to frozen conditions in winter and to several other factors. The valley is relatively little trafficked even today and retains much of its natural beauty. It is a major "environmental corridor" (Lewis, 1964) which is attracting an increasing number of tourists from the vicinities of the three nearest urban centers (Figure 1). The floor of the Lower Wisconsin River Valley has five features that qualify it as an environmental corridor: water, wetlands, floodplain, sandy soils and escarpments at the edge of the terraces. The valley floor is bracketed by scenic wooded bluffs and ridges, themselves "corridors", although peripheral to the specific emphasis of this study.

It is the purpose of this paper to report on the soil resources of the valley floor as a unit, and to suggest how a zoning ordinance might function on the basis of the detailed soil map in such a way as to avoid unwise land use in this unique area. We may look at the valley from the point of view of a hypothetical Lower Wis-

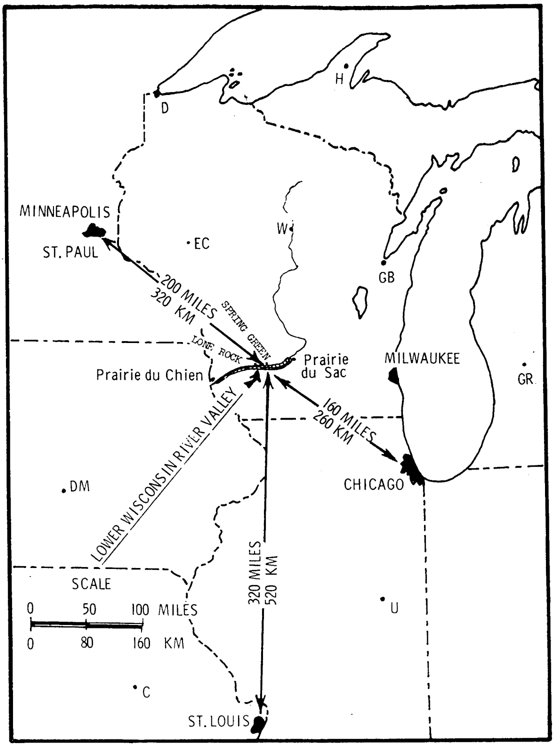

FIGURE 1. Regional location of the Lower Wisconsin River Valley.

consin River Valley planning commission as it might begin with a soil inventory to assess the potentialities of this long, narrow strip of land, water and scenery with respect to agriculture, industry, recreation, wildlife, residences and esthetic enjoyment.

The data for the soil inventory have been collected over many years in the portions of six counties which the valley includes (Figure 2). The soil mapping has been done by soil scientists of the Soil Conservation Service and cooperating soil scientists of the University of Wisconsin. Musolf (1970) assembled the maps for the entire valley and measured on them the acreages of the 356 different soil phases that had been listed previously on a county basis (Robinson and Klingelhoets, 1959; Robinson and Klingelhoets, 1961; Slota and Garvey, 1961; Klingelhoets, 1962). He also arranged the soil map information in a way suitable for incorporation into a zoning ordinance similar to that adopted in Buffalo County, Wisconsin (Buffalo County Zoning Committee, 1965).

Grateful acknowledgement is made to Soil Conservation Service

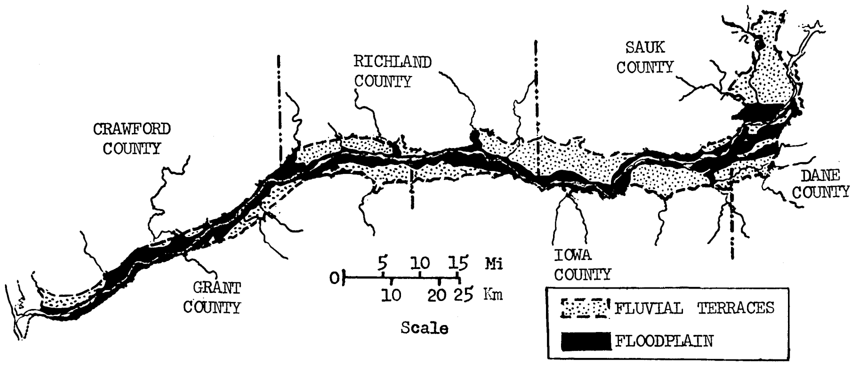

FIGURE 2. Fluvial terraces and floodplain of the Lower Wisconsin River valley.

soil scientists R. W. Slota and C. Glocker for their assistance, as well as to E. H. Hammond who, as Professor of Geography at the University of Wisconsin at Madison, helped to initiate this study. Acknowledgement is also made to the University of Wisconsin Center System Faculty and Curricula Development Committee for financial support of the senior author during this study.

METHODS AND PROCEDURES

Field investigations were carried out by the senior author during the summers of 1962, 1965, and 1968. Natural river terraces and rock benches and land use patterns were mapped. The junior author was a participant in the soil mapping program in Richland and Grant Counties (Hole, *et al.*, 1950; Hole, 1956) and in cooperative soil correlations in Iowa and Dane Counties.

Acreages of soil phases in the valley were determined by the "cut and weigh" method by which an analytical balance was used to determine actual weights of portions of the map. Care was taken to establish controlled conditions for these measurements. Calculation of proportionate areas of the map units on the basis of weight was done with the aid of a desk calculator. Acreages were summarized by towns and counties of the valley, and for the entire valley floor as a whole.

Versatility of the Lower Wisconsin River Valley and its Relation to Multiple Land Use Potential

The versatility of the valley is indicated by the variety of its soils which range from riverwash and peat to active sand dunes and level productive loams, all enclosed by steep bluffs, 300 to 500 feet (100 to 170 m) high. Sixty percent of the soils of the natural terraces, or about 56,000 acres (22,670 hectares) developed under stands of tall prairie, 23 percent under forest and 17 percent under bog and marsh vegetation, as interpreted from soil profile characteristics. The valley walls stand about four and one-half miles (7.2 km) apart near the Cary end moraine at Prairie du Sac and near Lone Rock, and only one-half mile (0.8 km) apart near the confluence of the Wisconsin and Mississippi Rivers (Figure 2). The abundance of groundwater would make possible some industry (within the strict limits of modern environmental quality standards) and irrigated truck cropping, such as is already practiced on sandy and loamy soils. It is possible that sludge from Madison sewage treatment plants might be used to fertilize truck crop fields in the valley in northern Iowa County. The ribbon-like shape of the area, however, precludes development of large-scale commercial canning crop operations, which require roughly equidimensional clusters of numerous 160-acre blocks of level soils irrigable by self-propelled rotating sprinkler systems. The cultivable part of the valley floor is irregularly partitioned and interrupted by sinuous floodplain, railroads and highways, and old dune ridges. The valley offers scenic beauty and opportunities for outdoor recreation, coupled with production of vegetable crops and dairy products on a limited scale. Farmers' roadside stands are familiar sights during the growing season.The village of Spring Green in Sauk County is a cultural center with a legitimate stage theatre that attracts visitors in the summer. State, county and private facilities for boating, camping, and a variety of forms of recreation are important to the economy of the area. The Lower Wisconsin River Valley contains much of scientific interest with respect to geology, geography, botany, zoology, ecology, archaeology and soil science.

The Soil Resources

On the valley floor are nearly one hundred different types of soil and miscellaneous land units. These are subdivided into the 356 soil phases on the basis of slope, degree of erosion and landscape position. The intricate pattern of these soils lies on major geomorphic units (Figure 2) as follows. Floodplain soils account for 35 percent of the area. These include alluvial land and riverwash (81.5%), peat and muck (11.5%) and marsh (7%). Twenty-six acres of cherty alluvial land are the result of recent flood deposits by tributary streams. Terraces, mostly made of glacial outwash, occupy the remaining 65 percent of the area, including six small rock terraces in the lower half of the valley. Escarpments, usually less than 25 feet in height, commonly mark boundaries between flood plain soils and terrace soils, and between terraces of different levels.

Soils information plotted in Figure 3 shows that the valley floor is predominantly level to gently sloping, only slightly to

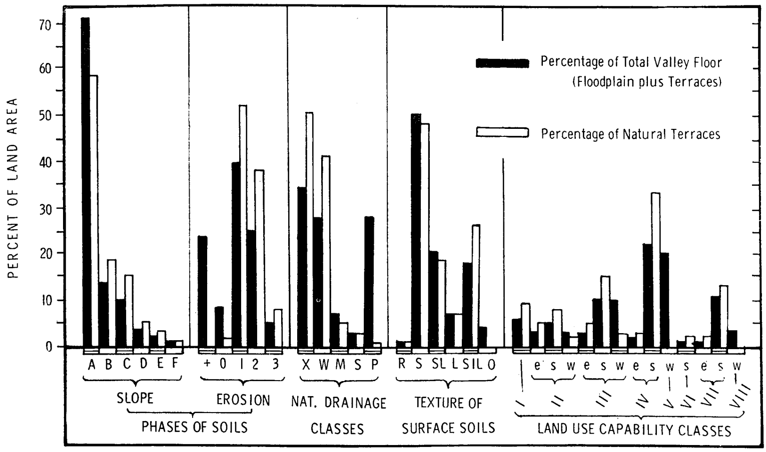

FIGURE 3. Areal extent of soil physical characteristics and land use capability in the Lower Wisconsin River valley.

moderately eroded, naturally excessively drained (drouthy) to well drained, sandy in texture and fourth class in land use capability. Bimodal features of the soils are 1) presence of both excessively and poorly drained soils, and 2) presence of both sandy and silty soils. Figures 4 through 6 illustrate soil ratings on major terrace levels.

The silty soils are derived from loess (and their derivatives) largely deposited during the period 29,000 years before present (Hogan and Beatty, 1963) to the time of post-Cary loess deposition. This later deposition was probably between 14,000 and 6,000 years before present judging by pedogenic analyses by Allan and Hole (1968). The sand of the valley floor was deposited by meltwater from Valderan glacial ice about 9,000 years ago, and wind has redistributed it as dunes and valley fills both southward (as Chelsea sand in Grant County) and northeastward (Plainfield in Richland County) (Hole, 1956; and Hole, *et al.,* 1950). Some of the loams of the terraces appear to be admixtures of the sand and overwash of silt from tributary valleys. The mixing was probably by biotic agents, particularly ants (Baxter and Hole, 1967).

The soils of the natural terraces differ from the valley floor as a whole in being a little more sloping and eroded, sandier, drouthier, and very slightly higher in land use capability, according to the Soil Conservation Service system of rating. An experimental numerical productivity rating of soil used by Musolf (1970) in the Lower Wisconsin River Valley gave the Plainfield loamy sand a rating of 39, the Sparta loamy fine sand 57, the Dakota

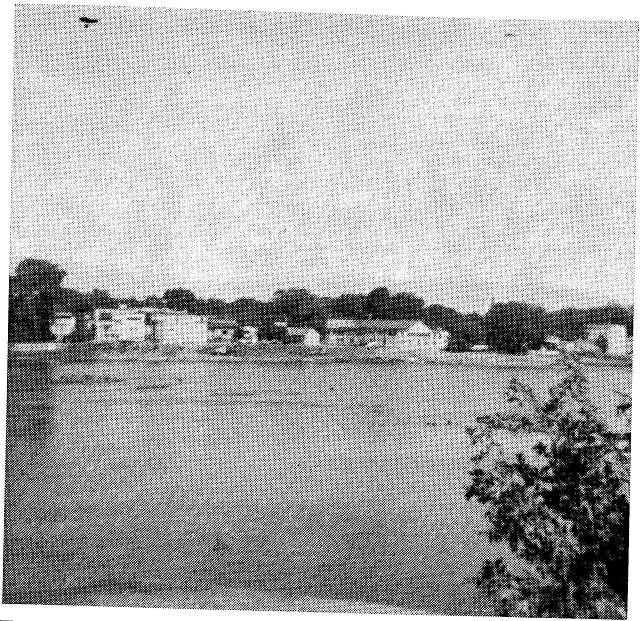

FIGURE 4. Low terrace, Sauk City, Sauk County: *Dakota sandy loam;* S.C.S. land capability—Class III-s; Soil productivity rating—75.

sandy loam 75, the Richwood silt loam 97 (near the maximum possible rating), and all the soils of the valley an average of 61, as compared with a rating of 90 for the upland prairie (Argiudoll) soil landscape of southern Grant County near Cuba City. It is true that with irrigation and fertilization the sands of the valley terraces could be brought up to the equivalent of the Dakota loam in productivity. But the dissection of the soil bodies into narrow strips, already referred to, precludes development of significant crop units. The relatively low natural agricultural productivity of the soils of the valley still dictates an emphasis on multiple land use with special attention to recreational activities and forestry.

Suggested Use of the Detailed Soil Survey for Zoning Purposes in the Lower Wisconsin River Valley

A well designed zoning ordinance makes possible the avoidance of objectionable land uses, such as misplacement of non-farm rural homes on soils incapable of accepting septic system effluent and and construction of hunting and fishing shacks on floodplains (Yanggen *et al.*, 1966). Primary rural land use districts may be set up, as was done in Buffalo County (Buffalo County Zoning Committee, 1965) under six headings: agricultural, residential,

FIGURE 5. Intermediate terrace, 1¾ miles west of Mazomanie, Dane County: *Sparta loamy fine sand;* S.C.S. land capability—Class IV-s; Soil productivity rating—57.

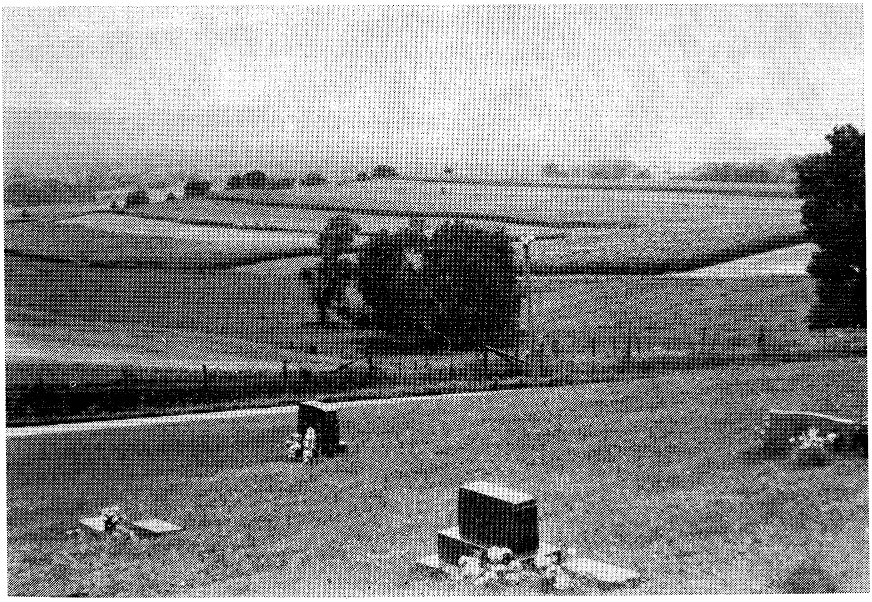

FIGURE 6. High terrace, 1 mile northwest of Wauzeka, Crawford County: *Fayette silt loam, uplands;* S.C.S. land capability—Classes III-e and IV-e; Soil productivity rating—75 and 48.

recreational, commercial, industrial and floodplain. These districts are related rationally to specific parcels of land by using the detailed soil map as the zoning map, with four interpretive overlay maps on it showing four soil districts: steep soils, wet soils, floodplain soils and suitable soils. The suitable soils are further subdivided into sandy soils, medium-textured soils and clayey soils so that lots may be made large enough for adequate on-lot sewage disposal. Musolf (1970) has grouped the soils of the Lower Wisconsin River Valley in this manner and has shown that the area can be zoned under a uniform system. Musolf's overlay grouping (too voluminous for reproduction here) is suitable for use with the Buffalo County Ordinance and detailed soil maps which are published for Crawford, Grant, Iowa and Richland Counties. Incorporation of a detailed official soil map into a zoning scheme makes decisions about use of most parcels of land clear-cut and unclouded by conflict of opinion. Where serious questions are raised, additional field checking by soil scientists can quickly lead to a satisfactory solution. Advantages of the use of the soil survey in zoning outweigh the disadvantages (Yanggen *et al.,* 1966).

SUMMARY

Since the exploratory canoe trip along the Lower Wisconsin River Valley in 1673 by Père Jacques Marquette and Louis Joliet, European and American settlers have replaced the Indian occupants, exploited the forests and prairies and, in succession, practiced wheat, hop, corn–hog, dairy and truck crop farming. Development of the Lower Wisconsin River as a main transportation route never materialized. Erosion control practices, planting of trees in shelterbelts and plantations, and protection of woodlands from grazing have resulted from a growing awareness by the inhabitants of the need for soil and water conservation and from technical assistance provided to land operators by the Soil Conservation Service and the College of Agricultural and Life Sciences working through cooperative Extension. Recreational activities and residential developments have been increasing in the area. Recent elevation of standards for the protection of quality of water and other components of the environment, and an increasing appreciation of the scientific, esthetic and recreational values of this principal environmental corridor of Wisconsin point to the need for a practical land use zoning system in the valley. It is advantageous to base the zoning on the detailed soil maps that are now available, along with interpretive overlay maps and zoning directives that regulate land use according to site characteristics.

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THE PITUITARY GLAND OF THE ALEWIFE IN LAKE MICHIGAN: CYCLICAL CHANGES IN THREE ADENOHYPOPHYSEAL CELL TYPES

Alexander H. H. Li and *Eldon D. Warner*

The population explosion of the alewife (*Alosa pseudoharengus*, Wilson) in the Great Lakes is frequently accompanied by massive spring and early summer mortalities. The possibility of endocrine involvement in this phenomenon was first suggested by Hoar (1952). He found histological evidence of thyroid hyperplasia and exhaustion in alewives in Lake Ontario and postulated thyroid-related osmoregulatory failure as a factor in the die-offs. The lack of more recent endocrine information emphasizes the need for further study of this important regulatory system in relation to alewife physiology and mortality.

Since the pituitary gland plays a key role in a variety of hormonal activities, it is a prime target for investigation. In elucidating pituitary function a logical first step is to identify the specific types of hormone-secreting cells and to study their annual patterns of change. Investigations of this nature have been carried out in many other species of teleost fishes. The earlier literature has been reviewed by Pickford and Atz (1957). Olivereau (1963) described six types of chromophilic cells in the teleost pars distalis on the basis of her own and other work. The tentative functions which she assigned to these cells have largely been supported by subsequent histophysiological studies. The pars intermedia of certain teleosts appears to contain two additional cell types. (Olivereau, 1969) Thus, a total of eight kinds of cells have been identified in the teleost adenohypophysis. Among the more recent studies of cyclical pituitary changes are those of Sokol (1961), Robertson and Wexler (1962 a and b), Sathyanesan (1963), Lagios (1965), Olivereau (1967) and Sage and Bromage (1970).

The present report includes a description of the histology and cytology of the alewife pituitary gland and an account of cyclical variations in three adenohypophyseal cell types, the gonadotrophs, thyrotrophs and corticotrophs.

Supported in part by Sea Grant Project #68–4203 from the National Science Foundation.

Materials and Methods

Alewives were collected by trawl, seine or dip net from several sites in southern Lake Michigan. The collections covered a period from May 21, 1968 to April 27, 1969 with all months represented except September and October. The samples of May through August 1968 were obtained off Saugatuck, Michigan while those of November 1968 through April 1969 were taken along the western shore of the Lake between Waukegan, Illinois and Port Washington, Wisconsin. Adult specimens of both sexes were present in all collections.

Immediately after capture, the fish were placed in Bouin–Hollande fixative for at least three days. After fixation they were air dried and at this time body weight, standard length and sex were recorded and scale samples were taken for age determinations. Prior to further processing they were stored in 70% ethanol. Fifty adult specimens, all apparently healthy when captured, were selected for the pituitary study.

The dorsal portion of the head of each specimen was removed and decalcified in 5% formic acid for five days. After decalcification, extraneous tissue was trimmed away, leaving a cube about 0.5 cm. square per side containing the pituitary gland and associated brain structures. The preparations were dehydrated in ethanol, cleared in xylene and infiltrated and imbedded in paraplast. Serial sagittal sections were cut at six micra. The staining procedures employed were as follows: (1) periodic acid-Schiff reagent (PAS), lead hematoxylin and orange G (modified from MacConaill, 1956, McMannus and Mowry, 1958 and Elftmann, 1959 a and b); (2) aldehyde fuchsin, lead hematoxylin and orange G (modified from Gomori, 1950, MacConaill, 1956 and Elftmann, 1959 a and b; (3) erythrosine, Mallory II and acid alizarine blue (modified from Herlant, 1960).

Pituitary cell types were identified by tinctorial reaction, morphology and location and by reference to other histological and histophysiological studies.

Several criteria were used in evaluating the cyclical secretory activity of gonadotrophs, thyrotrophs and corticotrophs. Nuclear diameters were measured with an ocular micrometer on midsagittal sections of glands from four fish (two males and two females) for each collection date. The mean nuclear diameter of each cell type on a given collection date was based on a total of 40 measurements. The Student–Newman–Keul multiple range test was employed to compare differences among the means for statistical significance. Results are shown graphically in Figure 1. Other criteria of secretory activity were cell size, degree of cytoplasmic granulation and vacuolation, staining intensity and nucleolar prominence.

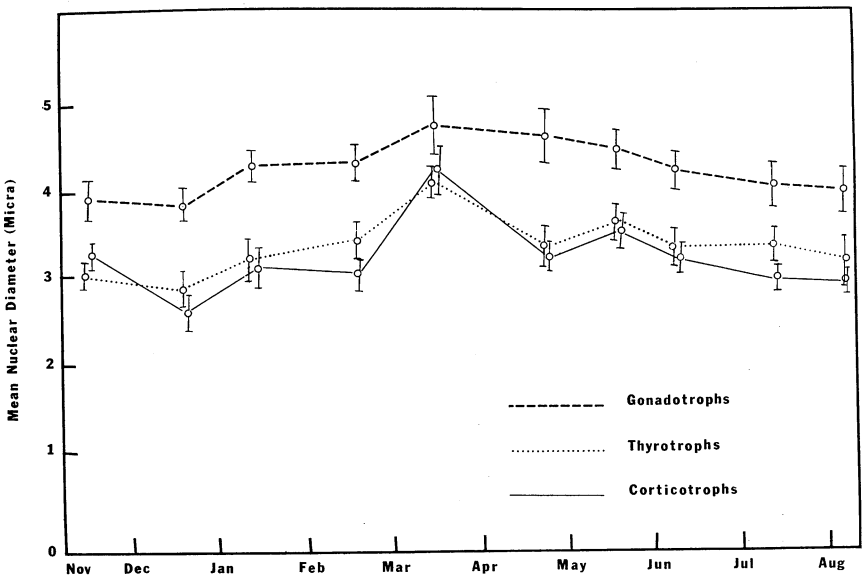

FIGURE 1. Annual Size Variations of Gonadotroph, Thyrotroph and Corticotroph Nuclei.

OBSERVATIONS AND DISCUSSION

Histology and cytology.

The pituitary gland of the alewife is very similar to that of its relative the herring (*Clupea harengus,* L) described by Buchmann (1940). The alewife gland is ovoid in shape with a tapering anterior region that ends in a narrow hypophyseal duct. According to Buchmann the duct is open to the pharynx in young herring but closed in adults. No pharyngeal connection was observed in adult alewives, although the duct extends for some distance in an anteroventral direction toward the pharynx. The major pituitary regions, neurohypophysis and adenohypophysis, are readily distinguishable in histological sections (Fig. 2).

The neurohypophysis consists largely of fiber tracts that originate in the hypothalamus and extend through the infundibular stalk to the posterior dorsal part of the gland. Here, the greatest concentration of neurohypophyseal tissue is located. From this area, fiber bundles of varying size ramify into the other pituitary regions and form interdigitations with groups of adenohypophyseal cells. Numerous glial cells with ovoid nuclei are scattered among the fibers. Aldehyde fuchsin-positive globules, presumed to be products of neurosecretion, are frequently present, especially in

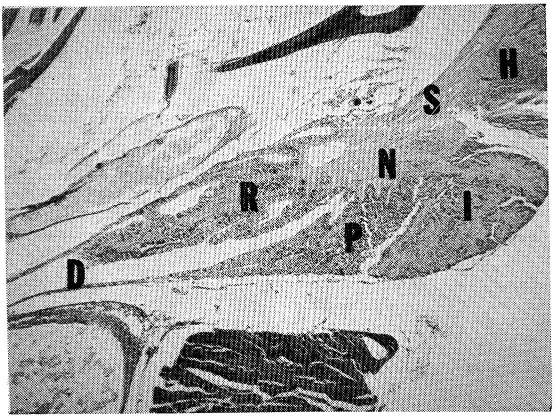

FIGURE 2. Mad-sagittal section of alewife pituitary gland (X 47). D, hypophyseal duct; H, hypothalamus; I, pars intermedia; N, neurohypophysis; P, proximal pars distalis; R, rostral pars distalis; S, infundibular stalk.

the posterior dorsal region. The neurohypophysis is well vascularized and small vessels are abundant in close proximity to adenohypophyseal cells.

The adenohypophysis is subdivided into the three regions characteristic of most bony fishes. From anterior to posterior they are: rostral pars distalis (pro-adenohypophysis), proximal pars distalis (meso-adenohypophysis) and pars intermedia (meta-adenohypophysis).

The rostral pars distalis constitutes about 40% of the adenohypophysis. The cells are arranged for the most part in follicles of varying size and shape. (Fig. 3). With the techniques used, little stainable material is seen in the follicular lumina. Neurohypophyseal fibers are interspersed among the follicles and the latter are bounded by basement membranes.

Examination of serial sections reveals that the follicles are not isolated units, but instead, have interconnecting lumina. Furthermore, every lumen is in contact directly or indirectly with the lumen of the hypophyseal duct. Thus, the follicle cells form a continuous, folded epithelium surrounding passages that are essentially ramifications of the hypophyseal duct. The functional significance of this morphological pattern is not clear.

The follicle wall consists principally of a layer of large columnar cells whose outer surfaces are adjacent to the basement membrane. Their nuclei are either basal in position or centrally located. The cytoplasm usually contains granules that stain with erythrosine and orange G although agranular, poorly stained cells are not

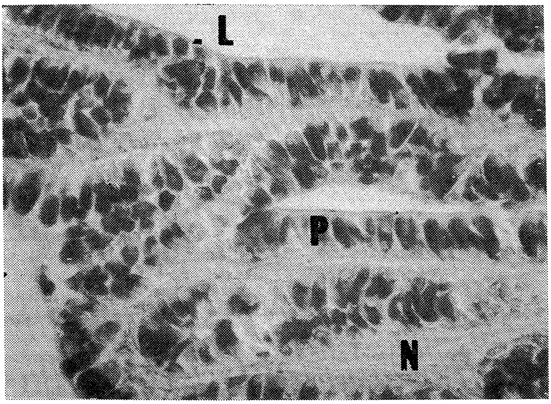

FIGURE 3. Portion of rostral pars distalis showing follicular arrangement (X216). L, follicular lumen; N, neurohypophyseal branch; P, prolactin cells.

uncommon. Substantial evidence from several species of euryhaline teleosts indicates that these cells produce a prolactin-like hormone that promotes sodium retention in low saline environments (reviewed by Ball and Baker, 1969). An extremely thin layer of non-secretory squamous cells lines the follicular lumina and covers the apical borders of the prolactin cells. This layer is continuous with the lining of the hypophyseal duct.

A second secretory cell type occurs in inconspicuous clusters between the prolactin cell follicles and the neurohypophyseal fiber tracts in the dorsal part of the rostral pars distalis. The cells are small and round or polyhedral in shape with central nuclei. Their cytoplasm is scanty and contains granules that stain weakly with lead hematoxylin. (Figs. 8 and 9). Similar cells in *Poeceilia latipinna* and *Anguilla anguilla* show hyperactivity under the influence of the adrenocortical inhibitor, metopirone, suggesting that they are ACTH-producing corticotrophs. (Ball and Olivereau, 1966).

The proximal pars distalis is situated ventral and posterior to the rostral pars distalis. (Fig. 2). It comprises from 20% to 30% of the adenohypophysis, attaining its greatest size before and during the spawning period. The cells are arranged in cords or masses around neurohypophyseal terminations. Three kinds of cells can be identified.

One of the cell types is distinguished by the presence of fine orange G-positive granules in the cytoplasm. These cells are relatively small, round or polyhedral in shape with large spherical nuclei. They are most concentrated dorsally along the neurohypophyseal branches but are also scattered throughout the remainder of the proximal pars distalis. In certain teleosts, changes in these cells during the normal growth cycle (Olivereau, 1963) or as a result of experimental alterations in growth (Sage, 1967) suggest that they are somatotrophs which produce growth hormone.

A second cell type shows variations closely associated with the reproductive cycle. These are large round or irregularly shaped cells with large nuclei (Figs. 4 and 5). They are most abundant in the centers of cell cords in the posterior and central areas of the proximal pars distalis. Characteristically, the cytoplasm stains strongly with the PAS technique and with aldehyde fuchsin, but under certain circumstances cytoplasmic degranulation and vacuolation are widespread. It is highly probable that these cells are gonadotrophs since their cyclical activity, and tinctorial reactions are essentially like those reported for this type of cell in other teleost studies (Sokol, 1961, Robertson and Wexler, 1962a and b, Sathyanesan, 1963, Olivereau and Herlant, 1964, Lagios, 1965, and Olivereau, 1967 and 1969).

Cells of the third type also react positively to PAS and aldehyde fuchsin, but they differ from gonadotrophs in several other ways. They are usually smaller and cone-shaped or spindle-shaped with eccentric nuclei. (Figs. 6 and 7). They are less numerous than gonadotrophs, and are confined mainly to the anterior ventral zone of the proximal pars distalis. Cytoplasmic granulas are finer in texture and cyclical changes in granulation and vacuolation are less pronounced. Histophysiological studies showing changes in similar cells under the influence of hypothyroidism and hyperthy-

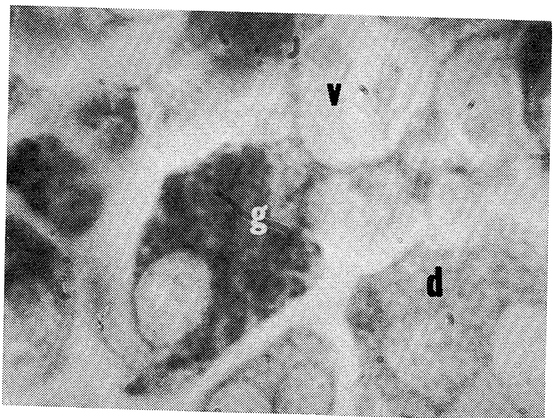

FIGURE 4. Pre-spawning gonadotrophs, March (X2164), g, granulated cell, d, degranulated cell; v, blood vessel.

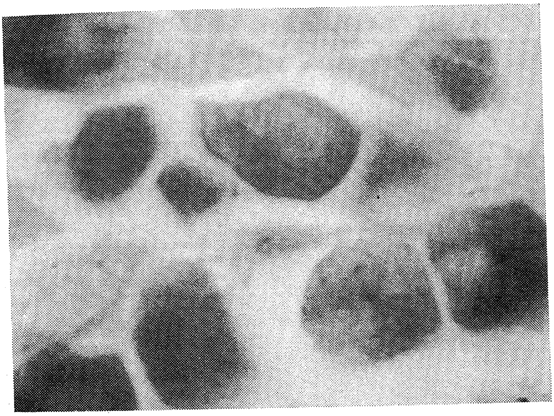

FIGURE 5. Post-spawning gonadotrophs, November (X2164).

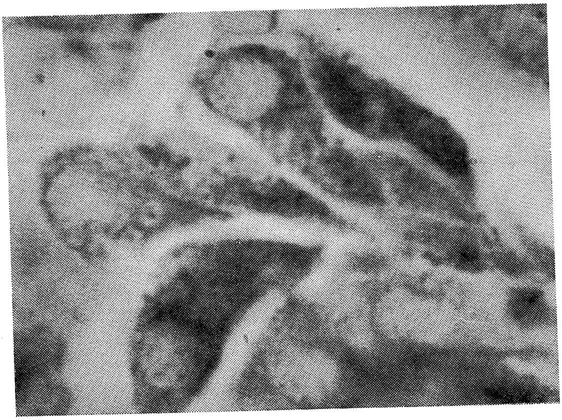

FIGURE 6. Pre-spawning thyrotrophs, March, showing partial degranulation (X2164).

roidism suggest that they are thyrotrophs (Atz, 1953, Olivereau, 1954 and 1963, Barrington and Matty, 1955, Sokol, 1955 and 1961, Sage, 1967, Bromage and Sage, 1968 and Sage and Bromage, 1970).

The pars intermedia makes up 40% or less of the alewife adenohypophysis. It is closely associated with the main trunk of the neurohypophysis in the posterior part of the gland (Fig. 2). The cells are aggregated in masses around short, broad neurohypophyseal terminations. Two types of small, faintly acidophilic cells are recognizable, one type, spherical, with a central nucleus, and the other, angular, with an eccentric nucleus. Olivereau (1969) described two types of pars intermedia cells in *Leuciscus rutilis*.

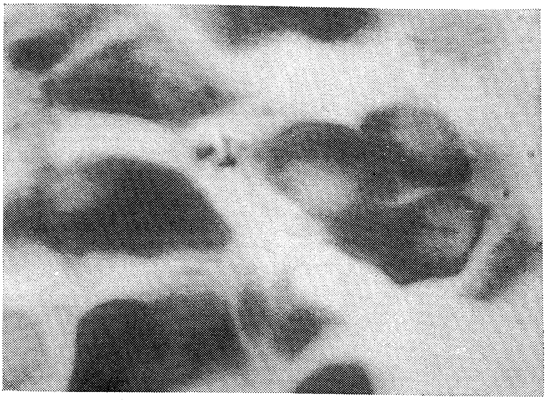

FIGURE 7. Post-spawning thyrotrophs, November (X2164).

The functions of these cells are unknown although in fishes as in other vertebrates the pars intermedia is assumed to produce the hormone, intermedin.

Cyclical pituitary changes.

Variations in pituitary cytology are evident when glands from different collection dates are compared. The gonadotrophs, thyrotrophs and corticotrophs were selected for detailed studies of these changes. To facilitate description the annual pituitary cycle is arbitrarily subdivided into three periods related to reproductive activity. They are the *pre-spawning phase* from early January to mid April, the *spawning phase* from late April to early August and the *post-spawning phase* from mid August to late December.

Annual variations in mean nuclear diameters of gonadotrophs, thyrotrophs and corticotrophs are shown in Figure 1. In the three cell types studied, nuclear size is at a maximum during the pre-spawning phase in March and at a minmum near the end of the post-spawning phase in December. The differences between maxima and minima for all cell types are statistically significant. Gonadotroph nuclear diameters increase to the pre-spawning peak and then gradually decrease during the remainder of the year. Nuclear size in thyrotrophs is somewhat more variable. A decline occurs in April followed by a rise in May, but neither is statistically significant. Thereafter, mean nuclear diameters decrease with minor fluctuations to the December minimum. Mean diameters of corticotroph nuclei show the greatest variability. The annual maximum in March as well as two secondary size peaks in May and November all are significantly greater than mean nuclear diameters for preceding and succeeding months.

The more subjective cytological variations are considered separately for each cell type. The gonadotroph cycle parallels the reproductive cycle, but precedes it by several weeks. Maximum cell size is attained during the pre-spawning phase in March (Fig. 4). Coarse, intensely stained granules are abundant in the cytoplasm. Relatively few cells show cytoplasmic degranulation and vacuolation. At the peak of spawning activity during June and July, gonadotrophs are much more variable. Large heavily granulated cells, partially degranulated cells and agranular vacuolated cells may be found closely associated. This variability may indicate functional differences in individual cells as regards hormone production, storage and depletion. Decreasing size and increasing degranulation and vacuolation are characteristic of late spawning and early post-spawning gonadotrophs. Some nuclear pycnosis is present, but widespread cellular degeneration as noted by Robertson and Wexler (1962*b*) in Pacific salmon does not occur. The post-spawning picture is incomplete because of the lack of September and October specimens, but during November and December cell size reaches a minimum. The cytoplasm shows typical PAS and aldehyde fuchsin staining reactions although granules are either very small or absent (Fig. 5).

Thyrotroph size is also at a maximum during the pre-spawning period in March. Most cells are elongated and cone-shaped (Fig. 6). Partial cytoplasmic degranulation is widespread. This condition has often been related in previous pituitary studies to a high level of thyrotroph activity. During the spawning phase thyrotrophs vary widely in size, although the characteristic shape is main-

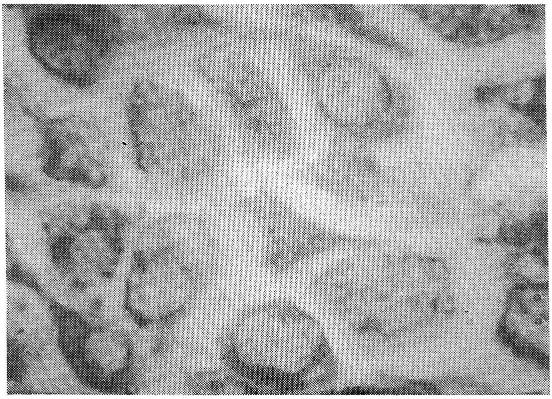

FIGURE 8. Pre-spawning corticotrophs, March, showing large size, reticular cytoplasm and large vacuole (X2164).

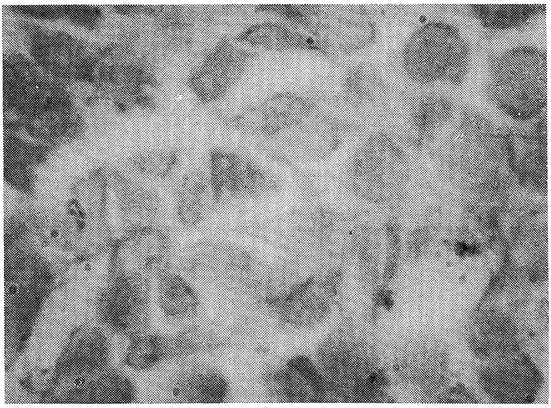

FIGURE 9. Post-spawning Corticotrophs, November (X2164).

tained. The more elongated cells are about twice the length of the shorter ones. Cytoplasmic degranulation is rare, indicating a lower level of activity than during the pre-spawning phase. Unlike gonadotrophs during the spawning phase, vacuolation does not take place. Except for a general size decrease, little change is seen in post-spawning thyrotrophs. (Fig. 7).

As in the other two cell types, the peak of corticotroph activity occurs during the pre-spawning phase in March. At this time cell size is at a maximum. (Fig. 8). Nucleoli attain their greatest degree of prominence. The relatively abundant cytoplasm presents a reticular appearance suggestive of degranulation. Occasional very large cytoplasmic vacuoles are present. Spawning and post-spawning corticotrophs show decreases in size, nucleolar prominence and cytoplasmic reticulation and vacuolation (Fig. 9). Subjective evaluation of corticotroph activity is difficult because of their small size and sparse granulation. Variation in mean nuclear diameters over the annual cycle appears to be a more reliable indicator of the corticotroph functional state.

From the foregoing cytological observations it may be inferred that high levels of gonadotrophic, thyrotrophic and adrenocorticotrophic hormones are secreted by the alewife pituitary gland just prior to the spring spawning migration. The expected result is stimulation of the appropriate target organs, the gonads, thyroids and interrenals. This is obviously true of the gonads which undergo marked growth and increased functional activity. Histological evidence of thyroid stimulation in alewives during the spring was noted by Hoar (1952) and Boyles (unpublished communication, 1970.[1] In certain other teleosts, increased thyroid function parallels

[1] Dr. Marcia Boyles, Biology Department, Grand Valley State College, Michigan.

reproductive activity (Berg, *et al*, 1959, Bromage and Sage, 1968). There is no published information concerning the alewife interrenal but in Pacific salmon, extreme interrenal hyperplasia and elevated plasma levels of 170H corticosteriods were found during the spawning migration (Robertson and Wexler, 1959, Hane and Robertson, 1959). In the alewife and other migratory fishes, the increased endocrine activity associated with spawning may be partly an adaptive response to environmental changes encountered during their shoreward migration.

The possible effects of hormonal variations on alewife mortality may now be considered. It seems unlikely that pituitary gonadotrophins and gonadal steroids are primarily involved since sexually immature fish and adults in spawning condition are both abundantly represented in the spring dieoffs (Brown, 1968).

Changing levels of thyroid hormones may be more significant. Thyroid function in fishes is not well understood, but effects on osmoregulation, growth and migratory and motor behavior have been noted (Gorbman, 1969). The original suggestion of Hoar (1952) that thyroid induced osmoregulatory failure may be a factor in alewife mortality should receive further attention.

Changes in interrenal function may be even more pertinent. Corticosteroids cause electrolyte and fluid shifts in fishes but their exact roles in normal osmoregulation are not clear. These hormones also mediate responses to stress. (Chester Jones, *et al*, 1969). Stanley (1969) found significant shifts of sodium from plasma to muscle in apparently healthy alewives taken from Lake Michigan in June and July. In a laboratory study, Stanley and Colby (1971, in press) demonstrated that cold shock lowered plasma sodium levels in alewives maintained in fresh water. Holzer (1971) obtained similar results, and in addition found plasma sodium depletion and tissue hydration in dying alewives. These changes may denote partial or complete osmoregulatory failure possibly related to interrenal insufficiency.

In the present study, there are cytological indications of decreases in thyrotroph and corticotroph activity after pre-spawning peaks in March. These may signify reduced TSH and ACTH secretion during the spawning migration. A resulting decline in thyroid and interrenal function could, therefore, contribute to the mass alewife mortalities in June and July.

Since firm conclusions cannot be drawn from cytological evidence alone, it is obvious that endocrine-related physiological data must be obtained before the role of hormones in alewife mortality can be fully evaluated.

SUMMARY

Alewives were collected from Lake Michigan during all seasons to study annual variations in pituitary cytology. The alewife pituitary gland like those of other isospondylons teleosts has a hypophyseal duct and a follicular type rostral pars distalis. A total of seven adenohypophyseal cell types were recognized, two in the rostral pars distalis, three in the proximal pars distalis and two in the pars intermedia. Detailed studies of gonadotrophs, thyrotrophs and corticotrophs reveal basically similar annual patterns of change in secretory activity. Maximal stimulation is indicated in March just prior to the shoreward spawning migration and minimal activity occurs in December after the fish have returned to deep water. Thyrotrophs and corticotrophs are somewhat more variable in their cyclical patterns than gonadotrophs. Decreasing thyrotroph and corticotroph activity during the spawning run may lead to thyroid and interrenal deficiencies that are related to the annual spring and early summer mortalities.

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OVIPOSITIONAL SITE PREFERENCES OF THE OAK DEFOLIATING GRASSHOPPER, *DENDROTETTIX QUERCUS*,[1] IN WISCONSIN[2, 3]

Douglas A. Valek and *Harry C. Coppel*

Nymphs and adults of *Dendrotettix quercus* Packard feed largely on oak foliage (Valek and Coppel, 1971). The species has a 2 year life cycle in Wisconsin with most individuals in a particular population appearing during the same summer. Complete defoliation occurs occasionally, but tree mortality is infrequent. Previous observations indicated that most of the grasshopper damage occurred near the area of eclosion. Bruner (1887) reported, indirectly, that *D. quercus* egg pods, in Texas, were "deposited in the ground about the bases of the trees or indifferently scattered about the surface among the decaying leaves." The purpose of this study was to characterize the sites preferred for oviposition and thereby aid in the determination of sites predisposed to oak defoliation. Emphasis was placed upon the relationship of light and amount of non-woody organic matter to oviposition.

Methods and Materials

The study was conducted in Jackson County, Wisconsin, in 1969, on a site with a large *D. quercus* population. The study area was sandy and covered mainly by the sedge *Carex pensylvanica* Lam. and 15–20 ft. black and northern pin oak (*Quercus velutina* Lam. and *Q. ellipsoidalis* E. J. Hill) with occasional quaking aspen (*Populus tremuloides* Michx.), white oak (*Q.* alba L.), and red pine (*Pinus resinosa* Ait.). A sandy surfaced road passed through the study area. The road had 20–30 ft. margins which contained 3–6 ft. coppice black and northern pin oaks. Four parallel lines of sample units were established on the ground, crossing the road perpendicularly. Each line contained 33 sample units, each 1 ft. square, 4 ft. apart, center to center. The center of each sample unit was marked by a stake in the ground. The lines were randomly spaced 45–60

[1] Orthoptera: Acrididae.

[2] Research supported by the College of Agricultural and Life Sciences, University of Wisconsin, Madison, and in part by the Wisconsin Department of Natural Resources and the University of Wisconsin Research Committee of the Graduate School with funds supplied by the Wisconsin Alumni Research Foundation. Received for publication January 13, 1972.

[3] Part of a thesis submitted by the senior author in partial fulfillment of the requirements for the Ph.D. degree in Entomology at the University of Wisconsin.

ft. apart. The beginning of each line was arbitrarily set in regard to its distance from the road, but each line was crossed by the road near its center.

Light intensity measurements were taken over each sample unit during September 18–21, when most oviposition had already occurred. A Weston Illumination Meter, Model 756 (Weston Electric Instrument Co., Newark, N.J.) was used. The mean of 3 light intensity measurements, randomly taken over each sample unit, was recorded. Light intensity under bracken fern, raspberry, or other plants taller than the average herbaceous cover was measured, but the light meter was held high enough to minimize the influence of herbaceous plants directly over the meter's sensor. One mean light intensity measurement was obtained over each sample unit in early morning, late morning, early afternoon, and late afternoon. The time necessary to take readings at each point plus the traveling time through the entire study area caused a variation in the measurements due to changes in ambient light with passage of time. This was especially apparent in the early morning and later afternoon readings. Therefore, a measurement of ambient light intensity near the ground was made in the center of the road, near the middle of each line, when that point was reached during the operation. These 4 measurements served as standards to which the mean measurements in each line were corrected by the factor that its standard varied from the mean of the 4 standards for each general day period. The combined means of the light intensity measurements taken at the 4 general day periods, in their corrected forms, produced light intensity values for each sample unit which were compared with the others. The term, "light intensity index", described the final light intensity value derived from each sample unit.

When oviposition ceased, but before appreciable numbers of leaves had fallen, the sod units with all vegetation and other non-woody organic matter, in situ, were cut from the ground. Each unit was removed by cutting around a square foot wood template with a flat shovel and placed into a large plastic bag for transportation and storage. In the laboratory, the vegetation on each sample unit was removed by first scraping off loose material such as decaying leaves or grass. Rooted plants were clipped at the soil line. The remaining material, which consisted largely of plant remnants, fungal hyphae, and humus, was swept from the surface of the sample unit with a stiff, long-bristled brush until only mineral soil and small roots remained. The soil was examined for egg pods by cutting the square into 6–8 strips with a heavy knife and tearing the strips into pieces small enough to allow detection of the pods when squeezed with the fingers. Plant material removed from the samples was dried at room temperature for 3 or more days. Most of the sand was removed from the dry organic matter with cold water and detergent. The sand settled to the bottom of the wash container as the material was squeezed and stirred by hand. Floating organic matter was strained from the water and drained. All woody plant parts such as twigs over 0. 2 inch in diameter and current year's acorns were arbitrarily removed. The wet material was dried at 60°C for a minmum of 4 days before it was weighed.

Results

No egg pods were found in the 20 sample units taken from the nearly barren sand road. It was felt that the information gained from the analysis of the data on this relatively unimportant situation was not particularly useful and the extreme effect of high values in light intensity and low values in ground cover on the total analysis warranted the deletion of these units. It may be argued that sample units taken from the road had no pods because they were located the maximum distance from the grasshopper's food sources. However, adult grasshoppers commonly traversed the road and there was sufficient opportunity for oviposition there.

In the remaining 112 sample units, 37 contained 1 or more egg pods each. There was a significant difference between the light intensity indices of those sample units containing egg pods and those not containing pods (99% level, chi square in a 2 × r contingency table, Steel and Torrie, 1960). The mean light intensity index of the sample units with at least 1 egg pod was 2149 ± 1630 (SD) foot–candles and it was 775 ± 1056 ft.-c. for the units without pods.

Egg pod density was highest in the highest light intensity index classes (Fig. 1). The number of pods per sample unit remained below 2.0 pods/sq. ft. in the 3 lowest light intensity index classes, but increased to 6.78 and 4.62 pods/sq. ft .in the 2 highest classes.

The relationship of non-woody organic matter to oviposition activity revealed a significant difference in the amount of organic matter between those sample units with at least 1 egg pod and those with none (99% level, chi square in a 2 × r contingency table, Steel and Torrie, 1960). The mean dry weight of organic matter on the 37 sample units with at least 1 egg pod was 60.7 ± 21.8 g., whereas on those without pods it was 70.0 ± 17.1 g.

The highest mean density of egg pods was found generally in the median weight classes (Fig. 2). Since the results from the 20 sample units from the road were not considered, the length of the bar in the 0–9 g. weight class in the figure reflects the influence of the

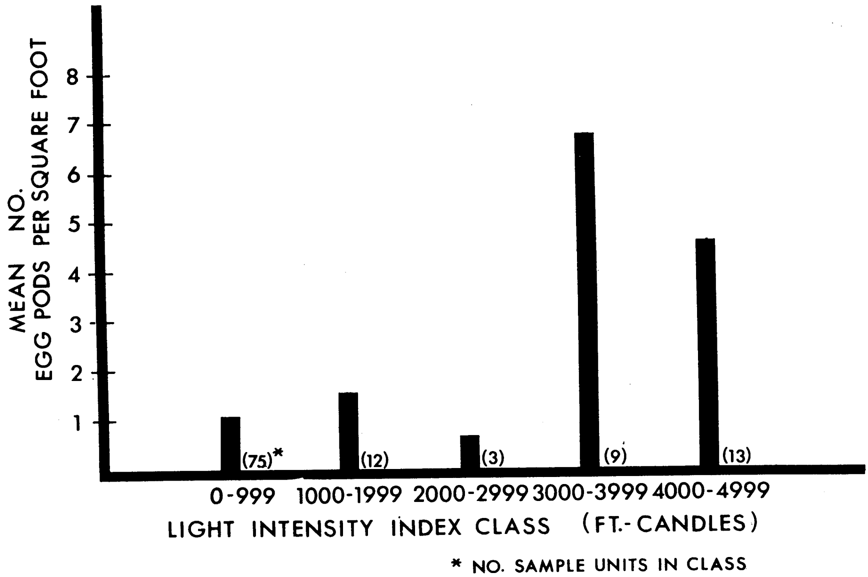

FIGURE 1. The relationship between the light intensity index class and the mean number of *D. quercus* egg pods per sq. ft.

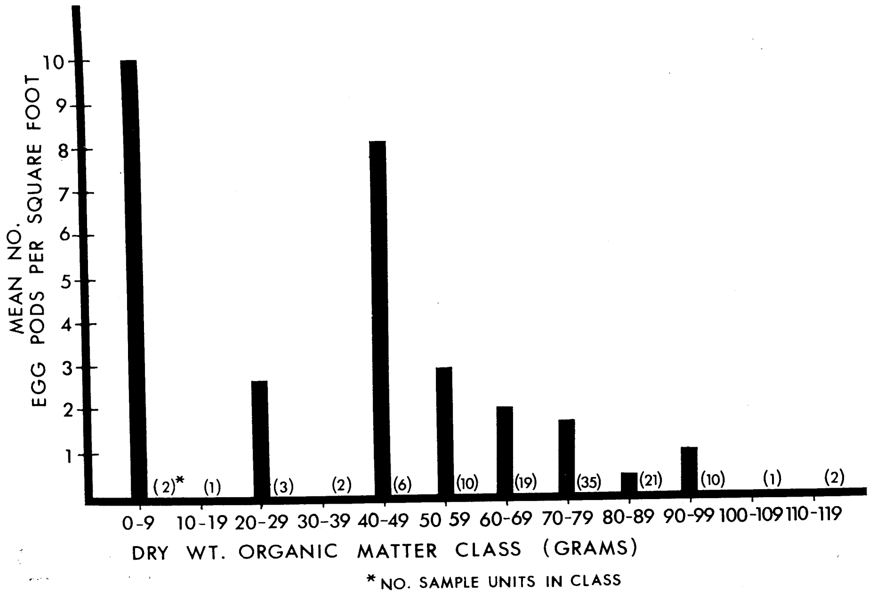

FIGURE 2. The relationship between the dry weight of organic matter class and the mean number of *D. quercus* egg pods per sq. ft.

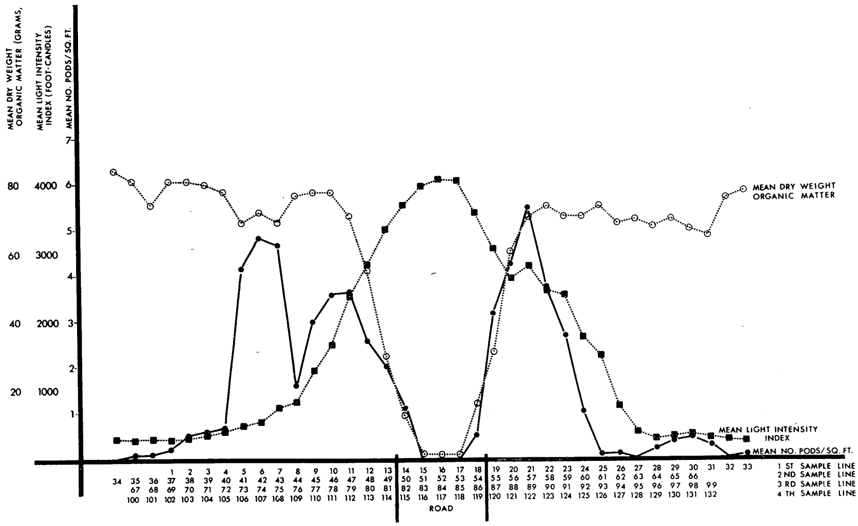

FIGURE 3. A profile of the spatial distribution of organic matter, light intensity, and *D. quercus* egg pods.

unusual case of 19 pods in 1 of the 2 units falling into the class. No explanation can be given for the large amount of oviposition in this area. Pods were sometimes concentrated in small areas of soft soil caused by burrowing animals, but it is not known if such a disturbance occurred in this instance.

The spatial relationship of the egg pod density to the distribution of sample units of varying light intensity indices and organic matter weight is presented as a profile (Fig. 3) where the values of the sample lines have been combined. The 5 sample units from each line falling in the road have been placed together to align the sample lines and the running means of the columns of sample units have been used for the plotted values. The plotted values of the light intensity indices in the figure show that the light intensity was the lowest at the left and right margins of the profile, corresponding to the light reaching near soil level under the large trees, and highest toward the center of the profile, corresponding to the light reaching the soil in the open area. The dry weight of non-woody organic matter appeared uniform at both margins of the profile, corresponding to the areas near or under the tall trees, but fell uniformly to 0 in the center of the road. There was no relationship between the light intensity index and dry weight of organic matter (regression analysis, 95% level). Density of egg pods was greatest in the areas between the tall trees and the road. This distribution of egg pods is in accord with previous observations by the authors in which pods and emerging nymphs were most commonly encountered near the margins of woods.

The highly attractive nature of certain small areas to the ovipositing females indicated that the measurement of light intensity, and especially the amount of organic matter covering the soil, could probably be conducted more profitably with a sample unit of 0.67 or 0.50 sq. ft.

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WILD RIVERS OF NORTHEASTERN WISCONSIN (WILD RIVERS COOPERATIVE RESEARCH PROJECT)[1]

George Becker

The birth of the wild river concept in Wisconsin must surely go back many years. Perhaps the best-known elegy came from Aldo Leopold who in 1943 wrote the essay "Flambeau—the Story of a Wild River." Modern-day Wisconsin voyageurs like Joe Mills and J. J. Werner of the John Muir Chapter (Sierra Club) probed the white waters of the state with their canoes. They made mental notes of unusually primitive waters and began talking up wild rivers.

During the early 1960's the Wisconsin Conservation Department fought against proposed construction of dams on the Wolf and Popple rivers in northeastern Wisconsin. Perhaps the biggest thrust was made by Walter E. Scott, then administrative assistant to the director. In 1964 Walter (as his many friends call him) delivered an address in Madison entitled "Preserving Wisconsin's Wild Rivers." He summarized clearly the outlook for wild rivers as being both "bitter and sweet," as having "great possibilities as well as serious setbacks and failures."

When he became President of the Wisconsin Academy of Sciences, Arts and Letters (1964–65), Walter proposed that the Academy initiate a research program on Wisconsin's wild rivers. There were two reasons for this. First he recalled that in the early 1940's the Conservation Department made a series of basic studies on the famous Brule River in northwestern Wisconsin. These studies appeared in installments over several issues of the Transactions. They have since become definitive and useful references. Second, a wild river needs basic research which can be shown to the State Legislature. This is one of the paradoxes of human nature—secrets must be unlocked before the organism, in this case the river, is allowed to keep its secrets. The bill for setting aside the Pine, Popple and Pike rivers of northeastern Wisconsin was already in the legislative hopper. A going program of research on these streams would hopefully influence the Legislature to pass the bill.

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[1] Paper No. 1 in a series, "Studies on the Pine-Popple Wild Rivers Area of Northeastern Wisconsin", which will appear in this and succeeding issues of the Transactions of the Wisconsin Academy. As an account of the history, objectives and development of the project it is written, quite properly, by Professor George Becker, who as its coordinator was largely responsible for its organization, progress and supervision.—Lowell E. Noland, editor.

Early in 1965 Walter asked me to assume organization of a wild river study for the Pine, Popple, Pike and Wolf rivers. I accepted the task with some misgivings. There were no funds at hand for getting such a program under way, nor did there appear to be much opportunity for getting financial aid. Also the people we thought most likely to perform the research were already actively engaged in other research and publishing. Could they be persuaded to turn time, effort and money in this direction?

I spent several days talking to these people. They were enthusiastic about the wild rivers of northeastern Wisconsin and about the mysteries to be unravelled. On October 16, 1965, the organizational meeting was held at the Hill State Office Building in Madison. Present were James Anthony, Robert Dicke, William Dickinson, Lewis Posekany, Edward Schneberger, Walter Scott, Howard Young, Stan Welsh and James Zimmerman. The committee decided to complete its report over a five-year period, culminating with the Academy Centennial in 1970. Plans were to collect all information into a bound book which would be distributed to members of the Academy and to other interested agencies. During later deliberations the committee voted to direct its research primarily toward the Pine and Popple basins, leaving the Pike and Wolf basins until after the first phase was completed.

The Wild Rivers bill became law in November, 1965. It set up a program for the preservation of the Pine, Pike and Popple rivers in Florence, Forest and Marinette counties. It designated the Conservation Commission to provide leadership in the development of a practical management policy. Late in 1965 the Wisconsin Society for Ornithology, Inc., donated to the Wisconsin Academy a sum of $2500 for the study of birds in the wild rivers area.

Perhaps the most memorable meeting of the Wild Rivers Cooperative Research Project took place at the Trees for Tomorrow Camp at Eagle River, October 22–23, 1967. Arranged by Art Oehmcke, it was designed to show members of the committee and their families the beauties and the scars of the Pine and Popple rivers. Speaker for the occasion was Philip Archibald, then Forest Supervisor, Nicolet National Forest, who discussed "The U. S. Forest Service and Its Management of Wild Rivers." The text of this paper appeared in the 1966 Fall–Winter issue of the Wisconsin Academy Review, pp. 77–80.

At the very start of our research it became apparent that adverse activities were going on in the basins of the Pine and Popple. Some of this activity was initiated by individuals and towns who feared that unless "improvements" were made immediately, wild river policy restrictions, which were in the process of being developed by state and federal agencies, would forbid the desired "improvements."

These conflicting activities were called to my attention by Art Oehmcke, then area supervisor with the Conservation Department at Woodruff. Late in 1966, with permission from the Academy Council, I named the Wild Rivers Advisory Policy Subcommittee, with Oehmcke as chairman. Members appointed were Phil Archibald, Joe Mills and Calvin Erickson. This committee would be advisory to the Conservation Department's wild rivers policy committee, but its main role would be that of watchdog. It would attempt to forestall any possible activities which appeared to be detrimental to the wild river program.

During the subsequent months, conflicting encroachments within the wild rivers basins were observed and appropriate action was taken. We are grateful to this sub-committee for its vigilance, which preserved a number of wild features that would otherwise have been lost.

It was a forester, Aldo Leopold, who said "The best way to manage a wild river is to let it be." Because sectors of the newly-named wild rivers are used for many purposes, the Wisconsin Department of Natural Resources in its policy statement has established a zoning system, allowing considerable man-use in some sectors. The U. S. Forest Service has developed yet another plan which, even within its "wild river" zones, feels man-directed embellishments are permissible. For instance, mature timber to a forester demands cutting, and, keeping things "wild" means proper landscaping.

I wonder, for instance, whether a lightning fire will be allowed to run its course or whether an insect infestation will avoid treatment? I wonder if the down-tree in the water must really be removed to make easy passage for the canoer, or whether the stabilization of naturally-eroding stream banks should be "top priority work within the zone?"

I personally take a dim view of a wild river program which prohibits damming of the main stem but makes no similar provision for its life-giving tributaries. These are but a few of the many objections which may be raised against "management" of our wild rivers.

Men are of many persuasions; men tend to relate the concept of wilderness to their own training and interests. Unfortunately the present state and federal criteria allow for considerable encroachment on the wildness of the area. It is my hope that our experts will soon come to the concept that "the best way to manage a wild river is to let it be," and that wilderness is its own master.

During the course of committee activity several reports were published and, in a sense, belong to the series which follows. Among these are: Olson, Gerald W. and Francis D. Hole "The Fragipan in Soils of Northeastern Wisconsin," Trans. Wis. Acad. Sci., Arts and Letters, 56 (1967–68), pp. 173–184; and Mason, John W. and Gerald D. Wegner "Wild Rivers Fish Populations (Pine, Popple and Pike Rivers)" Dept. of Nat. Resources, Madison, Wis., Research Report 35 (1970), 42 pp.

The following topics and prospective authors constitute the Wild Rivers series. This list is not arranged according to order of publication; nor is there assurance that all of these topics will appear. At this date a number of manuscripts have been received and are indicated by asterisks before the names of the authors.

Soils—*Prof. Francis Hole, Soils Dept., U.W., and Director of Soils Survey, Wis. Geol. & Nat. Hist. Survey, Madison (Co-author of another paper published in 1968 and mentioned above).

Water, resource planning and management—C. L. R. Holt, District Chief, U. S. Geol. Survey, Madison; Ed Oakes, Hydrologist, U. S. Geol. Survey, Madison; *Gerald L. Paul, Chief Hydrologist, Northeastern Wis. Regional Planning Comm., Appleton.

Inventory of surface waters—*C. W. Threinen, Administrative Assistant, Wis. Dept. of Nat. Resources, Madison.

Vascular plants—Prof. S. Galen Smith, Dept. of Biology, Wis. State Univ., Whitewater; Prof. Hugh Iltis, Dept. of Botany, Univ. of Wis., Madison; Dr. James Zimmerman, Naturalist, Univ. of Wis. Arboretum, Madison.

Non-vascular plants—*James A. Jesberger, Dept. of Biology, Univ. of Saskatchewan, Saskatoon.

Forest resources—Robert Train, Supervisor, Timber Management Staff Officer, Nicolet National Forest, Rhinelander.

Aquatic insects—*Prof. William Hilsenhoff, Dept. of Entomology, Univ. of Wis., Madison.

Fish parasites—Prof. James D. Anthony, Dept. of Zoology, Univ. of Wis., Milwaukee.

Fish populations studies—Jack Mason, Biologist, Wis. Dept. of Nat. Resources, Madison. (Paper published in 1970 and mentioned above).

Distributional list of fishes—Prof. George Becker, Dept. of Biology, Wis. State Univ., Stevens Point.

Amphibians and reptiles—*Dr. William E. Dickinson, Curator of Lower Zoology, Milwaukee Public Museum.

Mammals—*Prof. Robert McCabe, Chmn. Dept. of Wildlife Ecology, Univ. of Wis., Madison.

Birds—*Prof. Howard Young, Dept. of Biology, Wis. State Univ., La Crosse.

Wild rivers—*Joe Mills, Wild Rivers Chmn., Izaak Walton League of America, and John Muir Chapter of Sierra Club, Ripon.

History—John Winn, Field Representative, Office of Field Services, State Historical Society of Wisconsin, Madison.

Maps and mapping (historical)—Walter E. Scott, Asst. to the Deputy Secretary, Wis. Dept. of Nat. Resources, Madison.

Aboriginal occupants—*Prof. Robert Salzer, Logan Museum of Anthropology, Beloit College.

Literature and arts—Prof. Robert E. Gard, Director, Wisconsin Idea Theater, Univ. of Wis., Madison.

Climatology—Hans Rosendal, Weather Bureau Wisconsin State Climatologist, Madison.

Economic development—Pres. Walter Peterson, Univ. of Dubuque.

Development of a wild rivers policy—*Arthur A. Oehmcke, Asst. Dir. of the Bur. of Fish Management, Dept. of Nat. Resources, Madison.

Limitations imposed by zoning ordinances—Calvin Erickson, Editor, Florence County Mining News, Florence.

Case for public ownership of wild river stream banks—*John Chaffin, Forest Supervisor, Nicolet National Forest, Rhinelander.

In addition to the above I wish to recognize the following for their many contributions: Perry Olcott, Lewis Posekany, Ed Schneberger, Lyle Christenson, Lloyd Andrews, Eunice Bonow, Steve Field, Larry Seeger, and George F. Hanson; and, if special thanks are allowed, I wish to acknowledge the following for their steadfast encouragement and assistance: Walter E. Scott, Arthur A. Oehmcke, David J. Behling (Acad. Pres. 1966–67), John W. Thomson (Acad. Pres. 1967–68), Norman Olson (Acad. Pres. 1970–71), Jack Arndt (Editor, Wis. Acad. Review 1964–67).

I speak in behalf of the entire committee in expressing gratitude to Professor Lowell E. Noland (Academy President 1946–47) who has consented to edit this wild rivers series.

Finally, as an indication of the psychological effect of the Pine-Popple wild rivers region on those who have spent some time there, I submit the following poem written about 1930 by James M. Woodman, then a sports writer for the Chicago Tribune, and made available to me through the kind offices of Prof. L. G. Sorden, of the University of Wisconsin.

Where the Popple Joins the Pine

Far away from all the glitter of the busy city's life,
Where calm contentment drives away all worldly grief and strife,
Where the melody of songbirds lulls a fellow's soul to rest
When the slanting shadows greet him as the sun sinks in the west—
'Tis a spot that Nature moulded in a manner most divine,
Just a place of matchless beauty—Where the Popple joins the Pine.
There is music when the water ripples o'er the polished stones;
There is sadness when the balsam bows before the gale and moans;
And my heart leaps wild with rapture when I roam along the streams
Living o'er once more my boyhood in a mass of daylight dreams.
So I snuggle close to Nature claiming all her charms for mine
In that place of tranquil splendor—Where the Popple joins the Pine.
There I gaze upon the glory of the river's mirrored sky
And the magic of the boulders where the speckled beauties lie.
I can hear the partridge drumming to his faithful feathered mate—
Oh, it fills my heart with gladness and it drives away all hate
As I loiter in the shadows with my rod and reel and line,
Courting Nature in her homeland—Where the Popple joins the Pine.
When my brow by Time is furrowed and my hair grows silver white,
When my eyes are dimmed though eager for a never failing light,
When the Lord who in His wisdom sends a summons unto me,
When I leave this earthly turmoil for a Land-that-is-to-be,
I would lie forever sleeping where the sun and stars may shine
Through the branches of the hemlocks—Where the Popple joins the Pine.

(Written for and dedicated to my friend Oscar Franknecht, whose beautiful home occupies a most inspiring position where the Popple joins the Pine.—James M. Woodman.)

CANOEING THE WILD RIVERS PINE AND POPPLE[1]

Joe Mills[2]

Captain Jefferson Cram, of the U.S. Topographic Engineers, was among the first explorers to describe the Pine River. In his detailed report of 1840[3] on the Michigan–Wisconsin Boundary Survey, he wrote:

> The tributary of the Menominee called the Mus-kos Se-pe, is so low in summer as to be unnavigable for any but the smallest of canoes, and in some seasons it is almost dry. . . . The valley of this river is long, and contains deer in great abundance; and consequently, much resorted to by Indians . . . . for the winter hunt. This river is called by some Pine River.

Captain Cram's impression of the country was far from favorable:

> The country . . . . has an exceedingly desolate appearance; all the timber which was once pine has been consumed by fire, as far as the eye can reach all around on every side. The prospect is one of a broken landscape of barren hills, studded here and there with scarred pine stubs, with scarcely a living tree, except the second growth of white birch and poplar.

Making his observations during late summer and viewing the Pine River from the low profile of his canoe midstream on the Menominee, Captain Cram's conclusions were quite accurate, but far from complete. Hidden from his vision behind the first bend was a beautifully wild river, serene in its quiet stretches, boisterous as it dashed over falls and rapids, coursing along through a verdant forest.

Chippewa Indians inhabited the area. Those occupying the burned and barren district were referred to as the Badwater Indians. The stretch of the Menominee River here was known as "badwater". The Indians grew only potatoes, as it was too far north for the growing of corn. To the west at the headwaters of the Pine and its main tributary, the Popple, lay a vast region of forest and

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[1] This is Paper No. 2 in the series "Studies on the Pine-Popple Wild Rivers Area of Northeastern Wisconsin". It is included at the beginning of the sequence because it gives a vivid picture of the two rivers and adjacent land, as seen by a canoeist traversing their lengths.

[2] Mr. Joe Mills (688 Gary St., Ripon, Wis. 54971) is an enthusiastic member of the Sierra Club, and an honorary trustee of the Wisconsin Natural Resources Foundation. —Editor.

[3] Cram, Captain T. J., 1840. Report on the survey of the boundary between the State of Michigan and the territory of Wiskonsin. U. S. Senate Document 151, 26th Congress, 2nd session.

swamp. Much of the land was a flat pinery dotted with stands of mixed hardwoods. The swamps consisted of open bogs edged with cedar, tamarack, spruce and balsam. Deer were abundant, yarding in the thick cedar swamps to escape the heavy snows of winter. It was here that Chief Ca-sha-o-sha came with his band from their summer planting ground on Lake Vieux Desert for the hunt that was to supply them with meat for survival through the cold Wisconsin winters. From the Brule River they pushed their canoes south up Elvoy, Brule and Alvin Creeks. A short quarter-mile portage from the headwater springs of Alvin Creek put them on the North Branch of the Pine River. The western terminus of the portage trail was at the present location of the Forest Service canoe landing northwest of Windsor Dam Campground.

I began my exploration of the Pine River there (Fig. 1, *1*) on a bright summer day in 1963, with Nancy, my teen-age daughter in the bow of our light-weight aluminum canoe. I shoved hard, stepping lightly as I felt the keel leave the landing. We dug deeply into the sluggish current to gain momentum. Just around the point of land below the landing we found ourselves in the midst of a collection of loose-fitting logs. However, we had no problem extricating ourselves, as the logs moved easily from the pressure of our paddles. Out on the open river, zigzagging through an open swamp surrounded with white birch, popple, balsam and spruce, we settled back to enjoy the scenery. As we rounded a bend, suddenly a large boulder reared its dark form dangerously close to the bow. A rapid swish of the paddle and we averted a collision with only an inch to spare. Alert now, we cautiously avoided the rocks that appeared regularly ahead of us as we proceeded. A creek came in on the right, then the marsh broadened: we were in the flowage area of Windsor Dam (Fig. 1, *2*).

Built in 1891 for the purpose of facilitating the driving of logs, Windsor suffered the fate of all logging dams—abandonment and gradual deterioration. Later the fill was utilized in the approaches to the bridge for a public road, now designated as Forest Road 2174. Some of the original dam timbers can still be found imbedded in the river under the bridge.

Two other logging dams were constructed on the North Branch of the Pine. Gillett Dam, built a half mile below the entrance of the Lake Howell outlet (Fig. 1, *3*), occupied the open swamp in Sections 24 and 25. A mile downriver was Stones Dam.

The Pine River, as it flows from Butternut Lake, is too shallow and badly clogged with windfalls to be floated in a canoe. Furthermore, access is difficult. However in August 1967 Dr. Galen Smith, professor of biology at Whitewater State University, managed to get his canoe to the river over an abandoned logging–railroad grade.

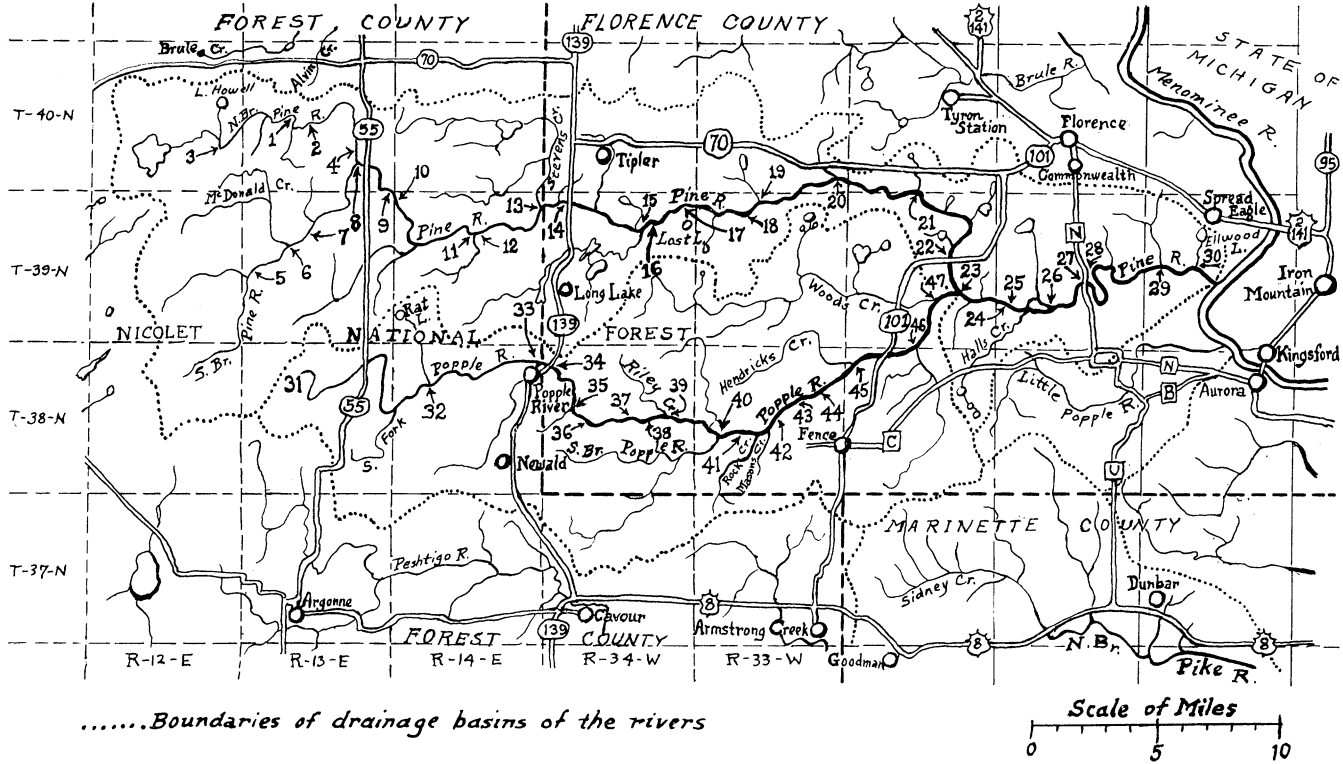

FIGURE 1. Map to show mentioned locations along the Pine and Popple Rivers. 1, Canoe Landing; 2, Windsor Dam; 3, Gillett Dam; 4, Beaver meadows; 5, Jones Dam; 6, Mouth of McDonald Creek; 7, Wildcat Rapids; 8, Junction of North and South Branches of the Pine River; 9, Site of Holt Lumber Company logging camp; 10, Lindel Spur Bridge; 11, Mouth of Kingstone Creek; 12, Pine Dam No. 3; 13, Mouth of Stevens Creek; 14, Highway 139 Bridge; 15, Power line to Lost Lake; 16, Powers Dam; 17, Chipmunk Rapids; 18, Snake-tail Rapids; 19, Mouth of Lauterman Creek; 20, Mouth of Wakefield Creek; 21, Mouth of Seven Mile Creek; 22, Highway 101 Bridge; 23, Junction of Pine and Popple Rivers; 24, Location of Erickson cabin; 25, LaSalle Falls; 26, Pine River Dam; 27, Highway N Bridge; 28, Indian portage; 29, Mouth of Lepage Creek; 30, Mouth of Ellwood Lake outlet; 31, Source of Popple River; 32, Mouth of Rat Lake outlet; 33, Railroad Rapids; 34, Highway 139 Bridge; 35, Mouth of Martin Creek; 36, McDougal Rapids; 37, Burnt Dam Rapids; 38, Podunk Dam; 39, Mouth of Riley Creek; 40, Junction of South Branch with Popple River; 41, Masons Rapids; 42, Little Bull Falls; 43, Murphy Rapids; 44, Nine Day Rapids; 45, Mouth of Hendricks Creek; 46, Washburn Falls; 47, Jennings Falls.

He embarked from a crude bridge in Section 18, and found the river meandering a great deal, but with water of sufficient depth for good paddling.[4]

Gary Werner, a University of Wisconsin student, with two companions, paddled a canoe upriver from the Forest Service landing, in April 1966, as far as the Section 18–19 line. A minor log jam, several beaver dams and shallows in the vicinity of the Jeep trail across Section 17 hampered their travel. While the experiences of Werner and Smith imply that at least two miles of the upper North Branch are canoeable, the best choice for the beginning of a canoe trip is the Forest Service canoe landing, with the first portage at Windsor Dam.

All that is necessary at Windsor Dam is to slide the canoe under the bridge into the pool below. A small island obstructs the outlet. Immediately beyond, the river bottom becomes very rocky. Unless the river is extremely high, it is utterly impossible to paddle a loaded canoe. Wading is not difficult as the current is slow, posing no threat to canoe or contents. This condition persists for a half mile. Finally the banks flatten into an alder swamp and the river deepens. From this point on we enjoyed good canoeing for about a mile and a half. Once we caught a glimpse of an otter. Twice later we sighted the animal and attempted to catch up with it as it swam downriver. As we entered big timber, rocks began ripping the surface of the river, and from ahead came the sounds of a rapids. We got as far as the logging-road bridge A clearing fifty yards north of this is the location of a logging camp. The road on the other side of the river continues into the timber inviting further exploration. The residue of a campfire tells us that this is an ideal campsite.

Wading the canoe through the rocks, we find the river turning southward and improving. Once more we clamber back into our seats, and proceeding onward pass dense thickets of balsam and spruce towered over by an occasional white pine. The remains of another logging bridge slip by. Three huge boulders, probably rolled there by loggers clearing the channel many years ago, doze in the sun. Then one of us points to the spinning propeller of a windcharger over the tops of balsams ahead of the canoe. What a shocking intrusion into a wild river area! Presently we come to a road, a bridge and a log cabin, the retreat of some city dweller. We tarry long enough to pull the canoe over the bridge and to glance disapprovingly in the direction of the cabin.

Paddling again, we discover the North Branch taking on the characteristics of a beaver meadow (Fig. 1, *4*). The river divides into several channels. Sloughs lead off on both sides. Abandoned

[4] Smith, Galen S., and Robert K. Rose, 1967. Canoeing the Pine and Popple Rivers.

beaver lodges dot the clumps of willow and alder. Due ahead a break in the conifers marks the location of the South Branch, emerging to join the North Branch (Fig. 1, *8*).

The Forest Service rates the South Branch an excellent canoe trail, and has provided a fine landing at the Pine River Campground bridge. The two mile stretch to Jones Dam is ideal for a leisurely family outing. The current is slow in the sinuous river as it courses, fringed with willows and alders, through an open swamp. A number of beautiful wild swamp–river–forest vistas open up. Almost all of the scenic views of the South Branch include tall sentinel white pines which miraculously escaped the axes of loggers.

Built in the same year and for the same purpose as Windsor Dam on the North Branch, Jones Dam (Fig. 1, *5*) was once the site of a farm. Ramsay and Jones, an outfit operating camps in the area, cleared the land for the raising of potatoes and the pasturing of horses. When the company moved out, the buildings were abandoned, but not for long. A woods character known as Whitewater Mike moved in.[5] In those days there were always a number of lazy, smelly bums inhabiting the woods eking out a living by trapping, poaching game and stealing provisions from the logging camps. One night a barn burned at one of the camps destroying eight fine teams of horses. Whitewater Mike, who had had trouble with James Holmes, the tough camp boss, was suspected of setting the blaze. Sometime later Whitewater Mike was found shot dead. The forest fire which destroyed Whitewater Mike's last abode also consumed the timbers of Jones Dam. Civilian Conservation Corps boys in the 1930s planted the potato fields with Norway pines.

Downriver from Jones Dam is a much longer and more varied canoe trip with a rapids to be lined or portaged. A full day ought to be scheduled for passing through it. The current, for the most part, is slow, and the river continues to meander from side to side touching the fringes of spruce and balsam. Beaver are numerous, and one often encounters their dams. A mile below McDonald Creek (Fig. 1, *6*) the river bottom becomes rocky, a fitting prelude to Wildcat Rapids (Fig. 1, *7*). Nicolet National Forest game biologist Ed Wilder rates Wildcat Rapids high as a forest beauty spot. "The area is a green garden of beauty", he wrote in a report to forest supervisor Phil Archibald, "with giant moss-covered boulders, a nearly solid canopy of conifers and the greatest fall of water per distance involved of any rapids on the river."[6]

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[5] Information obtained from James Huff in 1969; personal communication.

[6] As cited by Edwin Wilder in a 1967 report to Philip Archbald, of the U. S. Forest Service, Rhinelander, Wis.

A deer trail, conveniently located on the left, can be used for the 100-yard portage, or the canoe can be lined through the rapids. A log jam just above the confluence with Wildcat Creek requires another pullout. Farther on, a low footbridge spans the river, and the plywood camp of a beaver trapper follows on the right. The river then bends north. The remnants of a bridge cribbing mark the river where it leaves Argonne Township to enter Alvin Township. An access road from Highway 55 terminates here at the location of a farmstead long abandoned. A log cabin occupies a grove of pines on the east bank, while on the opposite side a barn overgrown by popples decays into oblivion. The canoe float may be terminated at this location or continued to the confluence with the North Branch and a landing at the highway bridge.

A second road from the highway provides access to three cabins standing in a clearing a mile downriver. An improvised log bridge spans the river here, barely high enough to provide clearance for a canoe. The South Branch joins its counterpart, the North Branch, in a wide open flat (Fig. 1, *8*). Merged into a broader stream, the river swings southeast between high banks covered with popple, white birch and balsam, occasionally dominated by tall white pines. As we pass a large log cabin on the left, the bridge looms into sight. The landing is on the left. Brush almost hides an unsightly dilapidated cabin. A summer home and two additional cabins stand on the roadside under the shade of many pines.

From Highway 55 to Highway 139 the Pine is wild, fast-flowing, and an adventure to canoe. It is no longer a quiet river for family outings. Only the daring, white-water canoeist should venture onto these waters; and any attempt to canoe them should be made during above-normal water conditions of early spring, or following periods of heavy rains, preferably with a minimum of gear. The low water levels of late summer expose long stretches of rocks, and to canoe at this time would necessitate dragging for miles.

Leaving the Highway 55 bridge behind, the river moves moderately fast between pleasantly timbered banks which soon widen into an open swamp, the flowage site of Forks Dam. The Pine cuts through a narrow opening, pouring into a large, deep, circular pool. The exit from the pool is at the extreme right under the canopy of a huge balsam. The canoe is immediately caught by the fast current of a sharp pitch. A hundred yards of Grade 1 rapids lie ahead. For two miles the river is a series of fairly easy rapids, separated by brief stretches of quiet water. A large clearing on the left is the location of a logging camp once operated by the Holt Lumber Company (Fig. 1, *9*). Low rectangular mounds outline the shape of the buildings. A nearby spring was the camp's source of water.

On the opposite side of the river is the overgrown site of an older camp.

A half mile downriver the sagging timbers of a railroad bridge arch overhead. Known as Lindels Spur (Fig. 1, *10*) it penetrated the timber of the upper Pine River. Over its tracks went the hardwood logs passed up during the river drives. The right-of-way, virtually all of it over lands controlled by the Forest Service, crosses the river again north of Long Lake.

Near Zepp Farm the river traverses private land. Cottage developments threaten the wild character of the banks. One new A-frame home has been constructed in a manner overhanging the river. The Zepp buildings stand in a field empty and abandoned. Below Upper Zepp Bridge the current slows perceptibly, and the river deepens as it swings to and fro through swampy bottomland. Two cottages with outbuildings and a collection of tin cans, bottles and assorted junk flank the river. Lower Zepp Bridge is an arched wooden structure with a locked gate on its south approach. The excellent gravel road is public, but the bridge and both banks are privately owned.

Ten minutes of paddling beyond this point will put the canoeist at the head of another long series of rapids. In the middle of the first rapids an island is approached. The canoe should be directed into the left channel to be followed with a course directly in the center of the river. The last rapids in this series is in Section 16. After leaving the island at the base of the rapids, the canoeist can relax a bit.

After we had descended the rapids safely, the weather took a turn for the worse. We were enveloped in one of those early spring, wet, sticky snowstorms sweeping the country. Despite the thickly falling flakes, we discerned a large bird perched in the top of a dead pine. We surmised it was a bald eagle, and not wishing to alarm the bird we headed the two canoes toward a suitable landing. The moment we rose from our seats the suspicious eagle spread its broad wings and soared out of sight into the storm. Feeling frustrated we climbed the high river bank, built a fire in the shelter of several protecting pines, and ate our lunches while we listened to the moan of the wind above our heads. After this we were glad to pick up our paddles, for the activity would warm our shivering bodies.

Shortly thereafter we pass a huge boulder on the left where a small stream draining a swamp enters the Pine. The terrain is flat and the current sluggish. The northeastwardly flowing river suddenly turns sharply southwest. We shoot a short rapids before Kingstone Creek (Fig. 1, *11*) enters the river. Then comes Pine Dam No. 3 (Fig. 1, *12*), a huge affair of rock, gravel and protruding timbers. The water flowing through the sluiceway is deep enough for the passage of a canoe, but the menacing protruding spikes pose a serious menace to the canoes. So we drag them over the jumble of rocks and timbers to the river a safe distance below.

Having escaped one hazard we confidently resumed our journey downriver, but misfortune strikes one of the canoes in a boulder-strewn rapids. In a moment of carelessness the bow of the light-weight Grumann strikes a midstream rock, and the rear paddler fights desperately against the current to prevent the stern from swinging dangerously downstream. Jammed against another rock, the canoe is doomed. The two occupants in hip-deep icy water watch the canoe as it buckles from the pressure of tons of water against its frail frame. For an hour we struggled with rope and poles to free the wrecked craft from the clutches of the river. On a gravel bar we straightened the canoe as best we could, sealed the rivet holes with adhesive tape from a first aid kit, and with a lone paddler in the damaged canoe resumed the slow trip to the next bridge three miles downriver. Some of the romance and glamor of canoeing a wilderness stream had gone out in the humiliating upset. Running the remaining rapids to Forest Road 2169 seemed devoid of challenge and excitement. Our spirits depressed, we concentrated on getting through to our cars and a change into dry clothes.

On another date and in a better frame of mind, we pushed the canoe into the current of the Pine River, leaving behind Forest Road 2169 bridge. We pass several cottages that flank the river. One of the few active farms on the Pine is located on the right bank. Cattle graze the fields, and a small sawmill supplements the income from the land. On the left a substantial home has been erected on the river's floodplain. A short rapids precedes Stevens Creek (Fig. 1, *13*). Then follows a mile-long straight shot of fast water that in the right stage affords a safe and exciting run. The canoe bounces from wave to wave, sweeps around a bend, cuts through Lindel Spur right-of-way, then settles down in the gentle current, as Highway 139 bridge (Fig. 1, *14*) is reached. The stretch to the next bridge is devoid of interest. The sounds of highway traffic, the highway trestle, and the odor of septic tank discharges from nearby homes detract significantly from the river's attractiveness. Past the bridge and beyond the next bend, charm returns to the Pine. The only intrusion on the landscape is the power line to Lost Lake (Fig. 1, *15*).

Powers Dam is soon reached (Fig. 1, *16*). It was one of the four dams constructed on the Pine River by the Menominee River Boom Company, a conglomerate of the logging companies operating on the Menominee and its tributaries. In all, the company operated

41 dams. The purpose of the dams was to store water so that a sufficient river level was available to float the logs over falls and rapids. During the winter months the various logging camps assembled huge piles of logs at landings on the river banks. Just prior to the breakup in the spring, the Company sent expert scalers to estimate the quantity of logs awaiting the drive so that equitable tolls could be assessed. The peak of logging on the Pine and Popple rivers occurred in the winter of 1895–96, when 31½ million feet were banked on the Pine, 9 million on the South Branch, 3 million on the North Branch and 22½ million on the Popple. Thereafter the Boom Company handled a steadily decreasing volume. In the winter of 1916–17, the mill companies banked their last crop of logs on the Menominee watershed. In 1918 the Marinette & Menominee Paper Company purchased all deadhead logs piled in rollways along the river. The curtain rang down on the drama of the river drives in 1919 when the Roper Lumber and Cedar Company drove its winter cut of cedar on the Pine River down to Marinette.[7]

Below Powers Dam is Chipmunk Rapids (Fig. 1, *17*). Several white cottages occupy a farm field. A road skirts the left bank, and if the decision is not to run the rapids the canoe can be landed where the river bends sharply east to go into the first pitch. A good canoeist will find Chipmunk Rapids not difficult although a reading of the river prior to the run will help assure safe passage. Beyond the lower pitch, rocks continue to rip the fast current, but these diminish as the bridge and campground are neared.

Don Quinn and I departed from Chipmunk Rapids Campground early in the day with 20 miles of river ahead of us, much of it rapids. The day before, we had attempted to gain access at a number of points. A washout in the Goodman Grade forced us to turn around. The road at Seven Mile Creek was too soft for car travel. The Highway 101 bridge would have to be our exit. We were prepared for a long, hard day filled with adventure.

A moderate current carried the canoe along at a rapid pace. On the left charred stumps indicated that the area had once been ravaged by a forest fire; but the new forest of white birch, popple and balsam had made remarkable recovery. Tall elms again stood on the wide flats. Wild ducks were constantly flushing ahead of the canoe. A kingfisher rattled his disdain at our invasion of his domain. Attention could not be divorced fully from the river, for occasional rocks had to be spotted and avoided. There was the additional hazard of cedar sweeps close to the banks. We passed a weatherbeaten hunting camp in a clearing on the left. The hunters had stretched a cable overhead to give them access to the woods on the south bank. Entering Section 4, we passed a log jam in

[7] Burke, Fred C., 1946. Logs on the Menominee.

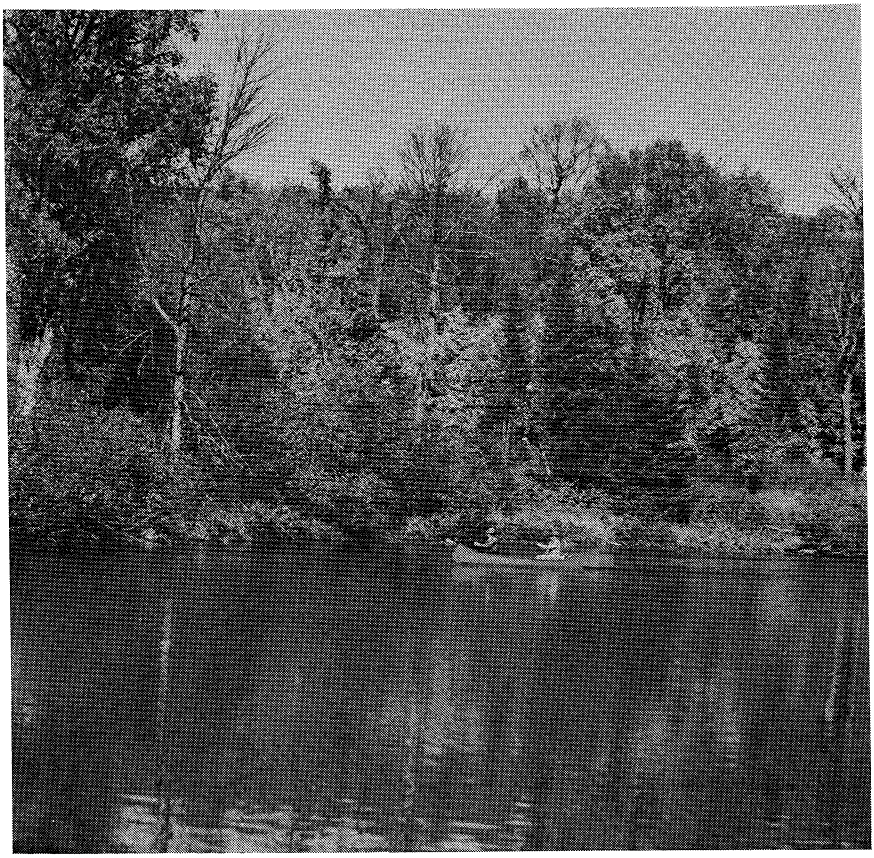

FIGURE 2. View of lower Pine River, in Florence County. Photo taken in October 1938 by Dorothy Ferguson; print furnished by Walter E. Scott, courtesy of Wisconsin Department of Natural Resources.

midstream, then noted a quickening current. We were nearing Snaketail Rapids (Fig. 1, *18*) and, upon catching the first sound of the white water, began hugging the left bank. Backpaddling, we eased along and eventually located the beginning of the portage trail.

The river boils into a furious frenzy among the rocks, filling the surrounding forest with the noise of rushing water. Very few canoeists who dared accept the challenge of Snaketail Rapids have made it. The wild beauty of the spot has attracted many. The portage trail is marked by the coals of numerous campfires. Complete privacy is unattainable because of a recently constructed log cabin. Unfortunately Snaketail Rapids is just outside the east boundary of the Nicolet National Forest. The cabin owner has access by road from the north. The road is private and the public is not encouraged to use it.

The portage trail is unimproved; it winds between the boulders and tends to peter out at its eastern terminus. The canoe can be launched in the wide eddy below the rapids for the short 100-yard float to Lower Snaketail Rapids, which can be safely run by an expert canoeist. An island is followed by a quick left and right turn, then a short, easy rapids. The current continues fast. Rips and riffles are common.

The Pine River in the Calumet Hecla lands is truly delightful. The practice of selective logging, pioneered in Wisconsin by the Goodman Lumber Company, the former owners of the tract, is being continued. One is struck by the majesty of the forest here in contrast with the second growth of the upper river.

Ten minutes below Lauterman Creek (Fig. 1, *19*) is a short rapids easily run on the left. Beyond Kieper Creek, Meyer Falls is located in Section 36. Rocks fill the river in the approach to the falls. Wading becomes necessary. The river plunges 6 or 8 feet through a narrow cut in the outcropping of rock. The portage on the right bank is about 20 yards long. A cottage on a leased location intrudes on the scene.

The river to Wakefield Creek (Fig. 1, *20*) has a number of small islands, all of them with lodged logs and debris. A clearing on the right was the location of one of the Goodman Lumber Company camps. Logs were concentrated here in a huge landing for transportation by rail to the company's mills at Goodman, Wisconsin. A root cellar with its sagging roof is all that remains of the camp buildings. The camp was large, and a stroll through the site will reveal the location of many buildings. The railroad crossed the Pine River to penetrate the company timber to the north. For a number of years after steel was pulled, the bridge was maintained for the big trucks hauling logs. But with the advent of hard-surfaced public roads the usefulness of the bridge ended; and, with maintenance discontinued, it is no longer safe. In its sad state of neglect the bridge has a picturesque quality about it, marred only by the distracting presence of a hunting camp.

A half mile below the bridge, in Section 31 where the river bends east, a rather long series of brawling rapids begins. Some maps indicate Bull Falls here, but this is an exaggeration. Good canoeists successfully run these rapids. Those not wishing to risk an upset can resort to wading or lining their canoes. A mile and a half will leave the worst rapids behind. Small rapids continue to characterize the river. The banks, where Seven Mile Creek enters, are high and sunny, a good place to look for early spring flowers. The river bottom is shallow and gravelly. The river has exposed a slaty schist type of rock. In the vicinity of Bessie Babbet Lake, the river is very shallow. In low water, canoeing would be no joy in this area. The increasing number of cottages and cabins hint of heavy private ownership. Some of the higher banks are eroded. One worried landowner has constructed a bulkhead to shore up his slumping real estate. The river is being encroached upon from all sides. A "No Park—Police" sign reminds us, by contrast, of the "Bide-A-Wee" signboard observed by Aldo Leopold on the Flambeau River. As Don and I approached the Highway 101 bridge (Fig. 1, *22*), our thoughts were of the famous conservationist. Our experience had been the same as his. We had been seesawed between the serenity and beauty of the Nicolet National Forest, the Goodman timber, and the ugly degradation of civilization.

Beyond Highway 101, the Pine River flows languidly, shallowing where the rock crop lies close to the surface. On a shelf above the river on the left an unusual formation thrusts its granite form upward. In the distance to the north are two cottages. A cluster of white cottages and green lawns overlooks the confluence of the Popple River with the Pine (Fig. 1, *23*). The Popple sparkles in the sun as it emerges from the forest and flows purposefully to join its parent. At this location a trading post grew to a sizable settlement named LaSalle by 1868. The discovery of iron ore at Florence and Commonwealth drained the population. The bridge washed out in a flood, erasing the last vestige of a busy community of a bygone era; but the river murmurs on, a sense of immortality in its movement.

The Pine, a big river now, moves along slowly, its youthful vigor seemingly expended. During the log drives thousands of feet of logs became lodged in the silt of the slow current. None of the boom companies bothered to collect the deadheads. But in 1947 a couple of enterprising sawmill operators, Mr. Walter Buza and Mr. Emmanuel Konell, initiated a salvage project. From the sand and debris they pulled out an estimated 250,000 feet of hemlock logs in an excellent stage of preservation. Still discernible in the butt ends were brands of at least three different boom companies.

Over the line in Section 25 on the right (Fig. 1, *24*) is a new log cabin owned by Cal Erickson, editor and publisher of the Florence County Mining News. If Cal is about, he will more than likely wave the canoeist in for a cup of coffee. When Cal isn't trout fishing or deer hunting he is at his typewriter making a living. In many an acid editorial he has attacked the despoilers of nature and wild areas. Cal has particularly criticized the building of roads into the county's last bits of wilderness. He is fighting a proposed road to LaSalle Falls (Fig. 1, *25*), an outstanding scenic attraction in the next section. The falls is at present accessible only by river or trail.

Pine Island is passed enroute. The faint, muffled roar of the Falls will be picked up around the next bend. The portage is on the left just past a small island and log jam. Extreme caution must be exercised in the approach to the portage to avoid being caught in the fast current. The crash of the water over the 20-foot falls is almost deafening. Below, the Pine River boils through a half mile gorge. The portage is easily followed through a pleasant birch woods. The lower end of the carry is down a steep and rocky bank. On the opposite side of the river a trail skirts the gorge, climbs the crest of rocks overlooking the falls, from which excellent photographs can be made. The trail continues to the head of the falls where the timbers of a log sluiceway used during the drives rot into dust. All about are signs of heavy public use. Fishermen come up the river from Pine River Dam (Fig. 1, *26*). Some walk in on the trails. A few come down by canoe, make the carry, photograph the falls, and continue downriver perhaps to camp on the shores of the dam. Wisconsin–Michigan Power Company has provided excellent access facilities on the north and south shores of its power dam. The shoreline is wooded, and not a single man-made structure intrudes on the scene. The rocky points and quiet bays make ideal campsites; indeed all the sites are occupied on weekends and holidays. No wonder, for in looking over the scene of rocks, water and forest, one is reminded of the Canadian bush country.

Construction of the dam commenced in 1920 immediately on the heels of the last log drive in 1919. The 42-foot high structure produced a 170-acre reservoir. Drowned were two falls, each about 8 feet high, a half mile rapids, and a third falls of 12 feet. LaSalle Falls was the only survivor. One of the obliterated falls can be felt where the river suddenly drops a foot a short distance above its confluence with Halls Creek.

The most popular embarkation point for down-river canoe trips is the County Highway N Bridge (Fig. 1, *27*). The float can be lengthened by beginning at the power plant. To reach the river it is necessary to clamber down a high embankment with canoe and gear. The river below the plant is broad and shallow in midsummer. The surrounding hills are the highest anywhere in the watershed. The river forms three oxbows in the next eight miles. The Indians eliminated five miles of paddling with a half-mile portage beginning a short distance upriver from the Highway N bridge. The modern day canoeists might indulge in a bit of intriguing diversion by trying his hand at tracing the probable route of the portage. The trail went up the small stream west of the gravel pit, turned northeast to cross the present blacktop roughly four tenths of a mile north of the river. If highway trucks haven't hauled away the bones, an Indian grave remains near the gravel pit.

The oxbows are not without interest. The banks are either very low or quite high. The forest is a delightful mixture of red and white pine (some of them leaning giants), birch, balsam, and (on the flats) alder and elm. While the first appearance of jack pine is between LaSalle Falls and Pine River Dam, the species becomes common here. The gravelly richer soils of the upper river are giving way to poor sand in the lower stretches. A large boulder midstream has formed a log jam, but there is no difficulty in finding a passage.

The end of the second oxbow finds the river almost touching Highway N north of the bridge. A roadside clearing is traversed by a faint road and an eroded path down the bank to a muddy landing on the river. Canoeists use this access, the likely eastern terminus of the Indian portage trail mentioned earlier (Fig. 1, *28*).

Past the elm and birch flat below the landing the left bank rises steeply. Like other similar banks downriver it is marked perpendicularly by otter slides. Beyond Johnson Creek, where the river bends south, a panoramic view of river and forest can be had by climbing to the top of the left bank. The overlook on county forest lands is an advertised tourist stop on a recently improved gravel road. Majestic pines stand on the river bank as the river swings south and east around the next bend. In the next section a local group of sportsmen, who call themselves Sons of the Pioneers, have built a new lodge with four picture windows glaring on the river. There simply had to be an unobstructed view of the river, so when the bulldozers went to work not a bush or blade of grass remained. As a final act of desecration the low shoreline was pushed into the river. One can understand why men who love the outdoors are attracted by a river such as the Pine, but what impels men to such thoughtless destruction of nature? This sort of ravishment repeated over and over would ruin a river.

The open slopes east of Lepage Creek (Fig. 1, *29*) represent samples of the barrens Captain Cram observed at the mouth of the Pine while on his mission of surveying the Wisconsin–Michigan boundary. On the south side of the Pine River, up over the fringe of timber, is another segment of the barrens. The scene is typical, —scattered clumps of gnarled popples, the outcrop of rock, the scent of sweet fern. To complete the picture there ought to be a flock of sharptail grouse. The birds were quite numerous everywhere in northern Wisconsin 25 to 50 years ago. In the succession of logging, fires and farming, sharptails found the combination of openings and forest ideal habitat. The suppression of fires and the gradual closing in of the openings set in a decline, so that today it is doubtful whether a single remnant flock remains on the Pine.

Ellwood Lake Outlet (Fig. 1, *30*) enters noisily into the river. Tethered to a cedar nearby is a green flat-bottomed boat named "Agnes." A path leads into the woods, and we wonder if there isn't a beaver trapper's cabin among the trees. If so, he has more compassion for the natural environment than do the Sons of the Pioneers. He has hardly left a trace of his whereabouts.

Ellwood Lake landing is a small space in the rocks and sweet fern to turn around. A rutted road climbs up the slope away from the river. I fervently pray that it will never be improved and blacktopped, that the barren here will always remain undisturbed, for this is the very same barren that Captain Cram saw and wrote about 125 years ago. The rapids are gone, buried by the dead-waters of Henry Ford Dam on the Menominee River, but the land is little changed. Let us hope that the landowners, Florence County, Wisconsin–Michigan Power Company, and several individuals aware of the historical significance of their ownerships, will leave a heritage to the future,—a barren.

THE POPPLE

There are few historical references to the Popple. Since it was away from the principal canoe routes of the Indians and explorers, fame was to come later with the penetration of the watershed by loggers and settlers, and later still it acquired a reputation as an outstanding trout stream. Free flowing throughout its length, the Popple was threatened early in the 1960s by a dam. With statewide attention centered on the controversy, the Public Service Commission denied a construction permit, explaining it had done so to keep the river free flowing. The Pete Blankenheim and Paul Babbington canoe trip in September 1960 proved that 50 miles of the Popple was floatable.[8] The exploration of the river from Highway 55 to the confluence with the Pine in 1967 by Sierra Club canoeists confirmed the wild, rugged character of the Popple River Canoe Trail.

The Popple River is born in the swamps west of Highway 55 (Fig. 1, *31*). Flowing serenely northeast, the stream's nature is deceptive. Within a mile it narrows to a noisy, stony brook flowing under countless windfalls through tangles of willows and alders. Bending southward the stream meanders through a beaver meadow. Although the water is deeper, canoeing is difficult because of the

[8] From an article, "One down on Aspen Lake" in the Wisconsin Academy Review, 1961, spring issue.

dense alder growth. Though it is virtually a jungle of water and alders we finally stumbled upon a passageway cut by a beaver trapper for his boat. An interesting feature of the beaver meadow is the dozen or so dead pine rampikes rearing their dark huge hulks above the alders. Upon examining one of the fallen monsters, we found the trunk so solid as to defy the sharpest axe.

The bridge in Section 12 on the access road from the highway is safe, but is barred by a locked gate. Clearings occupy both banks. The river is rocky, and progress by wading or paddling is necessarily slow. Signs of recent logging litter the banks. A plank bridge abandoned by loggers has been washed out on the boulders. A green tar-paper hunting camp stands on a glacial moraine to the north. A shaky footbridge spans the river where an old tote road once crossed. On the south side is a watercress-filled spring hole, source of fresh water for the camps. Away from the river, under the spruces at the edge of the clearing, is another camp, a log cabin. East of the cabin the clearing is littered with the rusty furnishings of a camp destroyed by fire.

The river meanders in tight bends through a narrow swamp edged heavily with alders. In a deep, dark stream the South Fork merges with the Popple. The black spruce swamp from which the South Fork emerges is so inviting that we paddle into it to disembark from the canoes where a logging road crosses it. Our topographic map indicates the location of a camp a short walk up the road. We searched in vain concluding it was moved out or had completely disintegrated in the wet swampy environment. In the search we found several huge yellow birch trees growing on the higher ground. We wondered why they had not been harvested long ago.

Back in the canoes on the Popple River, paddling northeast, we feel the quiet remoteness of the river and the vast black spruce swamp. Black ducks flush ahead of us, and a blue hereon flaps over the timber. An occasional white pine rears its ragged top above the spruce. Dead snags point to the sky. The old tote road skirting the river on the north side crosses the river in Section 8, and here at the bridge a log jam has formed. A half mile further on, the Rat Lake outlet (Fig. 1, *32*) enters on the left and another unnamed stream from the right. The remaining half mile to Forest Road 2167 is broad, shallow in places, and a number of boulders dot the channel. A good landing has been provided by the U. S. Forest Service beside the bridge, a new steel and concrete structure. This is a nice location except for a summer cottage on the north bank. No downriver canoe trip should be commenced here, however.

Below the bridge and around the first bend a huge log jam has formed. Below the jam the river channel is shallow, extremely rocky, and utterly impassable for a canoe. The rapids terminate in an oblong pool a half mile southeast of the bridge and just a short carry from Forest Road 2167.

In April, when Tom Sbonik and I carried our canoe to the pool, we found it still ice-covered. Snow lingered in the timber, but the river was open. To overcome the chill bite of the early morning air, we paddled briskly, passing an occasional floating chunk of river ice. In a half hour we were at the head of a challenging rapids. Large boulders were numerous, but the first pitch didn't appear very difficult. We attempted a run and made it, experiencing one heart-stopping moment when the canoe hung up momentarily on a rock. The second pitch we approached with a degree of trepidation. The drop here was considerable; and, with the river in flood stage, an upset in the icy water would spell disaster. Tom and I prudently decided to portage. The third pitch, though not severe, was a long one. We continued to drag the canoe through the open timber on the right bank, the canoe sliding easily over the foot-deep snow. In a final frenzied dash through a narrow chute the river calms in a pool shadowed by surrounding hemlocks. We returned the canoe to the river, and over placid water paddled between banks of popple, white birch, elm, maple and scattered thickets of balsam. A large swamp opened into a beaver meadow. The current began picking up in Section 11; boulders were again appearing, and the banks were higher. A log jam had formed at a large midstream boulder. A minute or two of paddling below the jam brought us to the head of a rapids 100 yards long. We chose the more open timber on the right, avoiding the dense pines and balsams on the opposite bank. After the portage the river meanders between flat alder banks. Fence posts and barbed wire suggest that we are approaching abandoned farmlands along the town road. Tom and I landed the canoe at the edge of a field on the left, and carried it northeast along the base of a low hill and over the road to the river below the rapids. The portage we had made was over private lands. Tom and I felt guilty of trespassing; and, had we been accosted by the owners, were prepared humbly to confess our guilt. Local people are generally quite forgiving. It is usually non-residents highly protective of their property rights who put up "No Trespassing" signs.

The river sweeps along at a good pace as it moves into the forest. Boulders dot the channel. Railroad Rapids (Fig. 1, *33*) will soon be heard. Tom and I found the alder flat at the head of the rapids flooded. We headed the canoe toward higher ground on the right, and found an old road along which we carried the canoe up and over the railroad embankment to the river on the other side. A plantation of red pine in neat rows flanks the railroad. Soon we were away from the sounds of white water and in the silence of a broad elm flat, interrupted only by the twitter of birds. Tom, who had always lived in a big city, was overwhelmed by the quiet solitude. The serenity we experienced was short-lived, however, for all too quickly Highway 139 bridge (Fig. 1, *34*) hove into sight.

Later by canoe and white water boat, I accompanied Marlene and Gil Bortleson in the exploration of the Popple from Highway 139 to the confluence with the Pine. The water level gauge at the bridge read 4.60 when in mid-April we pushed the canoe into the current. Swinging gradually to the right the river half circles a roadside picnic grounds built by the Civilian Conservation Corps boys in the 1930s. The site fell into disuse, and is now overgrown with popples; but hidden in the grass and briars are fireplaces constructed of mortar and stone, still sound, evidence that the boys had built solidly. Their camp stood in a clearing a mile north on Highway 139.

Ahead the river's meandering was to take us through extensive swamps. Far from being a dull monotonous float, this stretch offered some of the finest skylines in the wholewatershed. Off to the south were the ragged spires of pines piercing the sky. Closer at hand the blue river was rimmed with the waving dead marsh grass framed with dark stands of spruce and balsam. Birch, maple and elm occupied the higher sites.

Nailed to nearby elms were nesting boxes put up by a conservationist interested in the welfare of the colorful wood duck. On the other hand beaver trappers, encouraged by the Wisconsin Conservation Department, were relentlessly pursuing the beaver. We found their wicked steel traps everywhere. We wondered how the animals could survive the onslaught of trappers and a state agency, but somehow enough remain to keep the Popple populated with beavers. For years the Department has been coping with the problem of too many beavers. Trout fishermen contend that the decline of trout fishing in the Popple is due to the activities of beavers, and the Conservation Department, in an attempt to quell the cry, has liberalized seasons and bag limits, not to completely eradicate the beaver, but to control the number of dams to a point at which water temperatures tolerable to trout could be maintained.

Beyond Martin Creek (Fig. 1, *35*) the Popple turns east, and a huge log jam fills the river from bank to bank. We discovered the high water of the river spilling out among the trees. We poked the bow of the canoe into the alder brush, and by weaving this way and that we managed to float around the jam. This feat could not be accomplished during normal water levels. A short paddle and we were at the head of McDougal Rapids (Fig. 1, *36*). While

Gil and Marlene went to scout the rapids I began the tough portage on the left. The carry was fairly flat but very difficult because of stumps, brush, rocks and windfalls. We finally met at the foot of the rapids, and Gil reported that the descent consisted of three pitches, every one of them swift. Though Gil rated the rapids as No. 1 or No. 2 in difficulty, he felt that canoeists would be well advised to scout these rapids for log obstructions before attempting a run.

Resuming our journey between pleasant banks, we pass through a cut-over land with an occasional white pine missed by loggers. Beavers keep the riverside popples pretty well harvested. An unpainted hunting camp is our clue that we are nearing a road. We stop to chat with a beaver trapper, and learn that he is from Shawano and was attracted to the Popple because of the abundance of beaver reputed to be here. His car is parked by the bridge.

Ten minutes of paddling below Forest Road 2398 is over a broad, deep and slow current. The original forest here was almost a pure stand of pine, one of the largest in the entire watershed. Logging and the fires that followed changed the ecology so drastically that only a few scattered pines remain today.

Burnt Dam Rapids (Fig. 1, *37*) begins around the bend below the hunting camp on the right bank. Garnet Tinsman, of Newald, who owns the camp, states that a logging dam was located at the head of the rapids to supply sufficient water to take logs through it, but a forest fire consumed the timbers of the structure so thoroughly that it is difficult today to believe that a dam ever existed there.

Gil and Marlene decide to run the rapids. Before entering the timber on the left to scout out a possible portage route, I watch the couple cautiously pass around a huge floating log, then, caught in the fast current of the first pitch, whisk downriver, bouncing easily over the white crests. Half way through the rapids a log jam divides the river into two channels; Gil and Marlene find themselves among the trees trying to find a route back to the main channel. The divided waters ultimately regroup into a straight chute of white water for the remaining distance to the base of the rapids.

Meanwhile I learn that a portage would not be difficult. Deer trails and logging roads provide a clear path, with only a short struggle through the brush at both ends of the portage.

Leaving the rapids, the left bank is high with a light scattering of balsams, Norway pines, white birches and popple. Sweet ferns blanket the open ground. Of the original pinery only the charred stumps remain. A Forest Service plantation of pine is growing well. The river passes a hunting camp, located high on the left bank under a clamp of pines, bends, then enters the broad willow flats, once the flowage behind Podunk Dam. The south horizon is a ridge of ragged pine tops.

Where the river cuts through a glacial esker, uncanny loggers constructed Podunk Dam (Fig. 1, 38). The esker runs north–south, then bends southwest, its location in the forest marked by tall pines. Don Quinn and I had discovered Podunk Dam a year earlier at the end of a faint road. Parking the Jeep in the brush, we climbed to the top of the pine-needled esker; and, as we gazed out over the sweep of swamp and forest to the west, resolved to come back another time with tent and pack to really savor the solitude we felt.

The opportunity came the following spring. We hiked in over a trail from the south, set up our tents, and built a fireplace with rocks salvaged from the dam fill. After supper, as the setting sun was painting the western horizon vivid red and yellow, I wandered off to investigate the bogs we had skirted coming in. Suddenly the evening stillness was broken by the yipping of a coyote to the north, followed by a chorus of yips and yaps from a pack to the east. Another coyote responded from the west. The blended voices of all the coyotes filled the forest with wild, vibrating sounds. A shiver ran up my spine. Were they communicating my presence? Or were they just giving expression to their free-roaming way of life? Timber wolves have disappeared from Wisconsin along with the wilderness, but the coyotes remain to add character to the North Woods.

Old timers tell an interesting tale about Podunk Dam. The story illustrates graphically the shrewd bargaining methods of the lumber barons. It is said that a Scandinavian farmer by the name of Annunsen from Winnebago County had exchanged his rich farmlands near Lake Poygan for pine lands on the Popple River. To get the logs out, the river had to be improved, dams built, the channel cleared of boulders. Having exhausted his funds on the land exchange, Annunsen went to his friend Philetius Sawyer of Oshkosh, a man once a farmer who had become wealthy from dealings in timber. Sawyer, sensing an opportunity for a prime grab, quickly put up the money, to the tune of $30,000. Before Annunsen could establish his camps and begin cutting, Sawyer foreclosed on the loan. Sawyer's ruthlessness left Annunsen destitute. Sawyer later becme U. S. Senator, and continued to negotiate for government timber. As if to atone for his misdeeds, Sawyer donated a library to the City of Oshkosh.[9]

Riley Creek (Fig. 1, *39*) enters the Popple below Podunk Dam in a broad expanse of open marsh. To the north is a vista of for-

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[9] The information in this paragraph was related to me in 1969 in a personal communication from Clarence Harrison.

ested hills. Snags protrude above the willows. Sentinel pines grace the swamp edges; jack pine forest, a high sandy moraine on the south. From the top of the moraine there is a view of a large open bog, part of it flooded. A corrugated metal hunting camp on the left is followed by a white summer cottage on the right. The river current picks up and protruding boulders appear. The first pitch encountered is very short, and can be run with a good water level. A pool of quiet water about a hundred yards distant leads into the main rapids. In high water the lower rapids are "tops" for an exciting run. Gil Bortleson rated the difficulty a solid Grade 2. Those who will shoot the rapids will find heavy "curlers" and "boilers" in the sharp drops. The current is very swift, producing waves two to three feet high. The river bends sharply in two places, requiring good control of the canoe to avoid smashing into large boulders. Below the second bend, the course is straight ahead to the bridge. Under the bridge the rapids terminate in a broad pool. A parking area has been provided, and trout fishermen have tramped an easily followed trail along the river. The canoe can be portaged over the trail, or a logging road farther north can be used.

One-fourth mile below Forest Road 2159 Bridge, the South Branch of the Popple River (Fig. 1, *40*) joins the main Popple. Though an important tributary, the South Branch is unsuited for canoeing. Beaver dams, windfalls, old bridges, and log jams frequently obstruct passage. Heddin Dam, a logging dam between Forest Road 2159 and 2383 is in an excellent state of preservation. The canoeist will find the shallows below the dam difficult to navigate, even in high water. Canoeing the South Branch would entail unfavorable conditions at any time.

The next two miles of the main Popple is punctuated with numerous rocks, a number of riffles, and several short rapids. In places the river is shallow and rocky. A dense forest blankets both sides. Masons Rapids (Fig. 1, *41*) is in two pitches. The first pitch is sharp but short, followed by a hundred yards of fast but safe canoeing. The canoe can be landed on the right below the lone pine tree leaning over the river from the north bank. The river is white water as it circles to the north in a half moon course. Nearing the foot of Masons Rapids, the river becomes a virtual rock garden. Any lead chosen for the canoe will result in a hang-up. Any canoeist running Masons Rapids can expect to wade to extricate his craft from the rock pile.

An old corduroy road cuts across the neck of land half circled by the river beginning at the landing below the white pine. It can be used for the portage. An excellent popular campsite is located at the base of the rapids. Fishermen coming up the river in motor boats to fish the rapids often camp here.

of the gravel pit, turned northeast to cross the present blacktop roughly four tenths of a mile north of the river. If highway trucks haven't hauled away the bones, an Indian grave remains near the gravel pit.

The oxbows are not without interest. The banks are either very low or quite high. The forest is a delightful mixture of red and white pine (some of them leaning giants), birch, balsam, and (on the flats) alder and elm. While the first appearance of jack pine is between LaSalle Falls and Pine River Dam, the species becomes common here. The gravelly richer soils of the upper river are giving way to poor sand in the lower stretches. A large boulder midstream has formed a log jam, but there is no difficulty in finding a passage.

The end of the second oxbow finds the river almost touching Highway N north of the bridge. A roadside clearing is traversed by a faint road and an eroded path down the bank to a muddy landing on the river. Canoeists use this access, the likely eastern terminus of the Indian portage trail mentioned earlier (Fig. 1, *28*).

Past the elm and birch flat below the landing the left bank rises steeply. Like other similar banks downriver it is marked perpendicularly by otter slides. Beyond Johnson Creek, where the river bends south, a panoramic view of river and forest can be had by climbing to the top of the left bank. The overlook on county forest lands is an advertised tourist stop on a recently improved gravel road. Majestic pines stand on the river bank as the river swings south and east around the next bend. In the next section a local group of sportsmen, who call themselves Sons of the Pioneers, have built a new lodge with four picture windows glaring on the river. There simply had to be an unobstructed view of the river, so when the bulldozers went to work not a bush or blade of grass remained. As a final act of desecration the low shoreline was pushed into the river. One can understand why men who love the outdoors are attracted by a river such as the Pine, but what impels men to such thoughtless destruction of nature? This sort of ravishment repeated over and over would ruin a river.

The open slopes east of Lepage Creek (Fig. 1, *29*) represent samples of the barrens Captain Cram observed at the mouth of the Pine while on his mission of surveying the Wisconsin–Michigan boundary. On the south side of the Pine River, up over the fringe of timber, is another segment of the barrens. The scene is typical, —scattered clumps of gnarled popples, the outcrop of rock, the scent of sweet fern. To complete the picture there ought to be a flock of sharptail grouse. The birds were quite numerous everywhere in northern Wisconsin 25 to 50 years ago. In the succession of logging, fires and farming, sharptails found the combination of openings and forest ideal habitat. The suppression of fires and the gradual closing in of the openings set in a decline, so that today it is doubtful whether a single remnant flock remains on the Pine.

Ellwood Lake Outlet (Fig. 1, *30*) enters noisily into the river. Tethered to a cedar nearby is a green flat-bottomed boat named "Agnes." A path leads into the woods, and we wonder if there isn't a beaver trapper's cabin among the trees. If so, he has more compassion for the natural environment than do the Sons of the Pioneers. He has hardly left a trace of his whereabouts.

Ellwood Lake landing is a small space in the rocks and sweet fern to turn around. A rutted road climbs up the slope away from the river. I fervently pray that it will never be improved and blacktopped, that the barren here will always remain undisturbed, for this is the very same barren that Captain Cram saw and wrote about 125 years ago. The rapids are gone, buried by the dead-waters of Henry Ford Dam on the Menominee River, but the land is little changed. Let us hope that the landowners, Florence County, Wisconsin–Michigan Power Company, and several individuals aware of the historical significance of their ownerships, will leave a heritage to the future,—a barren.

The Popple

There are few historical references to the Popple. Since it was away from the principal canoe routes of the Indians and explorers, fame was to come later with the penetration of the watershed by loggers and settlers, and later still it acquired a reputation as an outstanding trout stream. Free flowing throughout its length, the Popple was threatened early in the 1960s by a dam. With statewide attention centered on the controversy, the Public Service Commission denied a construction permit, explaining it had done so to keep the river free flowing. The Pete Blankenheim and Paul Babbington canoe trip in September 1960 proved that 50 miles of the Popple was floatable.[8] The exploration of the river from Highway 55 to the confluence with the Pine in 1967 by Sierra Club canoeists confirmed the wild, rugged character of the Popple River Canoe Trail.

The Popple River is born in the swamps west of Highway 55 (Fig. 1, *31*). Flowing serenely northeast, the stream's nature is deceptive. Within a mile it narrows to a noisy, stony brook flowing under countless windfalls through tangles of willows and alders. Bending southward the stream meanders through a beaver meadow. Although the water is deeper, canoeing is difficult because of the

[8] From an article, "One down on Aspen Lake" in the Wisconsin Academy Review, 1961, spring issue.

dense alder growth. Though it is virtually a jungle of water and alders we finally stumbled upon a passageway cut by a beaver trapper for his boat. An interesting feature of the beaver meadow is the dozen or so dead pine rampikes rearing their dark huge hulks above the alders. Upon examining one of the fallen monsters, we found the trunk so solid as to defy the sharpest axe.

The bridge in Section 12 on the access road from the highway is safe, but is barred by a locked gate. Clearings occupy both banks. The river is rocky, and progress by wading or paddling is necessarily slow. Signs of recent logging litter the banks. A plank bridge abandoned by loggers has been washed out on the boulders. A green tar-paper hunting camp stands on a glacial moraine to the north. A shaky footbridge spans the river where an old tote road once crossed. On the south side is a watercress-filled spring hole, source of fresh water for the camps. Away from the river, under the spruces at the edge of the clearing, is another camp, a log cabin. East of the cabin the clearing is littered with the rusty furnishings of a camp destroyed by fire.

The river meanders in tight bends through a narrow swamp edged heavily with alders. In a deep, dark stream the South Fork merges with the Popple. The black spruce swamp from which the South Fork emerges is so inviting that we paddle into it to disembark from the canoes where a logging road crosses it. Our topographic map indicates the location of a camp a short walk up the road. We searched in vain concluding it was moved out or had completely disintegrated in the wet swampy environment. In the search we found several huge yellow birch trees growing on the higher ground. We wondered why they had not been harvested long ago.

Back in the canoes on the Popple River, paddling northeast, we feel the quiet remoteness of the river and the vast black spruce swamp. Black ducks flush ahead of us, and a blue hereon flaps over the timber. An occasional white pine rears its ragged top above the spruce. Dead snags point to the sky. The old tote road skirting the river on the north side crosses the river in Section 8, and here at the bridge a log jam has formed. A half mile further on, the Rat Lake outlet (Fig. 1, *32*) enters on the left and another unnamed stream from the right. The remaining half mile to Forest Road 2167 is broad, shallow in places, and a number of boulders dot the channel. A good landing has been provided by the U. S. Forest Service beside the bridge, a new steel and concrete structure. This is a nice location except for a summer cottage on the north bank. No downriver canoe trip should be commenced here, however.

Below the bridge and around the first bend a huge log jam has formed. Below the jam the river channel is shallow, extremely rocky, and utterly impassable for a canoe. The rapids terminate in an oblong pool a half mile southeast of the bridge and just a short carry from Forest Road 2167.

In April, when Tom Sbonik and I carried our canoe to the pool, we found it still ice-covered. Snow lingered in the timber, but the river was open. To overcome the chill bite of the early morning air, we paddled briskly, passing an occasional floating chunk of river ice. In a half hour we were at the head of a challenging rapids. Large boulders were numerous, but the first pitch didn't appear very difficult. We attempted a run and made it, experiencing one heart-stopping moment when the canoe hung up momentarily on a rock. The second pitch we approached with a degree of trepidation. The drop here was considerable; and, with the river in flood stage, an upset in the icy water would spell disaster. Tom and I prudently decided to portage. The third pitch, though not severe, was a long one. We continued to drag the canoe through the open timber on the right bank, the canoe sliding easily over the foot-deep snow. In a final frenzied dash through a narrow chute the river calms in a pool shadowed by surrounding hemlocks. We returned the canoe to the river, and over placid water paddled between banks of popple, white birch, elm, maple and scattered thickets of balsam. A large swamp opened into a beaver meadow. The current began picking up in Section 11; boulders were again appearing, and the banks were higher. A log jam had formed at a large midstream boulder. A minute or two of paddling below the jam brought us to the head of a rapids 100 yards long. We chose the more open timber on the right, avoiding the dense pines and balsams on the opposite bank. After the portage the river meanders between flat alder banks. Fence posts and barbed wire suggest that we are approaching abandoned farmlands along the town road. Tom and I landed the canoe at the edge of a field on the left, and carried it northeast along the base of a low hill and over the road to the river below the rapids. The portage we had made was over private lands. Tom and I felt guilty of trespassing; and, had we been accosted by the owners, were prepared humbly to confess our guilt. Local people are generally quite forgiving. It is usually non-residents highly protective of their property rights who put up "No Trespassing" signs.

The river sweeps along at a good pace as it moves into the forest. Boulders dot the channel. Railroad Rapids (Fig. 1, *33*) will soon be heard. Tom and I found the alder flat at the head of the rapids flooded. We headed the canoe toward higher ground on the right, and found an old road along which we carried the canoe up and over the railroad embankment to the river on the other side. A plantation of red pine in neat rows flanks the railroad. Soon we were away from the sounds of white water and in the silence of a broad elm flat, interrupted only by the twitter of birds. Tom, who had always lived in a big city, was overwhelmed by the quiet solitude. The serenity we experienced was short-lived, however, for all too quickly Highway 139 bridge (Fig. 1, *34*) hove into sight.

Later by canoe and white water boat, I accompanied Marlene and Gil Bortleson in the exploration of the Popple from Highway 139 to the confluence with the Pine. The water level gauge at the bridge read 4.60 when in mid-April we pushed the canoe into the current. Swinging gradually to the right the river half circles a roadside picnic grounds built by the Civilian Conservation Corps boys in the 1930s. The site fell into disuse, and is now overgrown with popples; but hidden in the grass and briars are fireplaces constructed of mortar and stone, still sound, evidence that the boys had built solidly. Their camp stood in a clearing a mile north on Highway 139.

Ahead the river's meandering was to take us through extensive swamps. Far from being a dull monotonous float, this stretch offered some of the finest skylines in the wholewatershed. Off to the south were the ragged spires of pines piercing the sky. Closer at hand the blue river was rimmed with the waving dead marsh grass framed with dark stands of spruce and balsam. Birch, maple and elm occupied the higher sites.

Nailed to nearby elms were nesting boxes put up by a conservationist interested in the welfare of the colorful wood duck. On the other hand beaver trappers, encouraged by the Wisconsin Conservation Department, were relentlessly pursuing the beaver. We found their wicked steel traps everywhere. We wondered how the animals could survive the onslaught of trappers and a state agency, but somehow enough remain to keep the Popple populated with beavers. For years the Department has been coping with the problem of too many beavers. Trout fishermen contend that the decline of trout fishing in the Popple is due to the activities of beavers, and the Conservation Department, in an attempt to quell the cry, has liberalized seasons and bag limits, not to completely eradicate the beaver, but to control the number of dams to a point at which water temperatures tolerable to trout could be maintained.

Beyond Martin Creek (Fig. 1, *35*) the Popple turns east, and a huge log jam fills the river from bank to bank. We discovered the high water of the river spilling out among the trees. We poked the bow of the canoe into the alder brush, and by weaving this way and that we managed to float around the jam. This feat could not be accomplished during normal water levels. A short paddle and we were at the head of McDougal Rapids (Fig. 1, *36*). While

Gil and Marlene went to scout the rapids I began the tough portage on the left. The carry was fairly flat but very difficult because of stumps, brush, rocks and windfalls. We finally met at the foot of the rapids, and Gil reported that the descent consisted of three pitches, every one of them swift. Though Gil rated the rapids as No. 1 or No. 2 in difficulty, he felt that canoeists would be well advised to scout these rapids for log obstructions before attempting a run.

Resuming our journey between pleasant banks, we pass through a cut-over land with an occasional white pine missed by loggers. Beavers keep the riverside popples pretty well harvested. An unpainted hunting camp is our clue that we are nearing a road. We stop to chat with a beaver trapper, and learn that he is from Shawano and was attracted to the Popple because of the abundance of beaver reputed to be here. His car is parked by the bridge.

Ten minutes of paddling below Forest Road 2398 is over a broad, deep and slow current. The original forest here was almost a pure stand of pine, one of the largest in the entire watershed. Logging and the fires that followed changed the ecology so drastically that only a few scattered pines remain today.

Burnt Dam Rapids (Fig. 1, *37*) begins around the bend below the hunting camp on the right bank. Garnet Tinsman, of Newald, who owns the camp, states that a logging dam was located at the head of the rapids to supply sufficient water to take logs through it, but a forest fire consumed the timbers of the structure so thoroughly that it is difficult today to believe that a dam ever existed there.

Gil and Marlene decide to run the rapids. Before entering the timber on the left to scout out a possible portage route, I watch the couple cautiously pass around a huge floating log, then, caught in the fast current of the first pitch, whisk downriver, bouncing easily over the white crests. Half way through the rapids a log jam divides the river into two channels; Gil and Marlene find themselves among the trees trying to find a route back to the main channel. The divided waters ultimately regroup into a straight chute of white water for the remaining distance to the base of the rapids.

Meanwhile I learn that a portage would not be difficult. Deer trails and logging roads provide a clear path, with only a short struggle through the brush at both ends of the portage.

Leaving the rapids, the left bank is high with a light scattering of balsams, Norway pines, white birches and popple. Sweet ferns blanket the open ground. Of the original pinery only the charred stumps remain. A Forest Service plantation of pine is growing well. The river passes a hunting camp, located high on the left bank under a clamp of pines, bends, then enters the broad willow flats, once the flowage behind Podunk Dam. The south horizon is a ridge of ragged pine tops.

Where the river cuts through a glacial esker, uncanny loggers constructed Podunk Dam (Fig. 1, 38). The esker runs north–south, then bends southwest, its location in the forest marked by tall pines. Don Quinn and I had discovered Podunk Dam a year earlier at the end of a faint road. Parking the Jeep in the brush, we climbed to the top of the pine-needled esker; and, as we gazed out over the sweep of swamp and forest to the west, resolved to come back another time with tent and pack to really savor the solitude we felt.

The opportunity came the following spring. We hiked in over a trail from the south, set up our tents, and built a fireplace with rocks salvaged from the dam fill. After supper, as the setting sun was painting the western horizon vivid red and yellow, I wandered off to investigate the bogs we had skirted coming in. Suddenly the evening stillness was broken by the yipping of a coyote to the north, followed by a chorus of yips and yaps from a pack to the east. Another coyote responded from the west. The blended voices of all the coyotes filled the forest with wild, vibrating sounds. A shiver ran up my spine. Were they communicating my presence? Or were they just giving expression to their free-roaming way of life? Timber wolves have disappeared from Wisconsin along with the wilderness, but the coyotes remain to add character to the North Woods.

Old timers tell an interesting tale about Podunk Dam. The story illustrates graphically the shrewd bargaining methods of the lumber barons. It is said that a Scandinavian farmer by the name of Annunsen from Winnebago County had exchanged his rich farmlands near Lake Poygan for pine lands on the Popple River. To get the logs out, the river had to be improved, dams built, the channel cleared of boulders. Having exhausted his funds on the land exchange, Annunsen went to his friend Philetius Sawyer of Oshkosh, a man once a farmer who had become wealthy from dealings in timber. Sawyer, sensing an opportunity for a prime grab, quickly put up the money, to the tune of $30,000. Before Annunsen could establish his camps and begin cutting, Sawyer foreclosed on the loan. Sawyer's ruthlessness left Annunsen destitute. Sawyer later becme U. S. Senator, and continued to negotiate for government timber. As if to atone for his misdeeds, Sawyer donated a library to the City of Oshkosh.[9]

Riley Creek (Fig. 1, *39*) enters the Popple below Podunk Dam in a broad expanse of open marsh. To the north is a vista of for-

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[9] The information in this paragraph was related to me in 1969 in a personal communication from Clarence Harrison.

ested hills. Snags protrude above the willows. Sentinel pines grace the swamp edges; jack pine forest, a high sandy moraine on the south. From the top of the moraine there is a view of a large open bog, part of it flooded. A corrugated metal hunting camp on the left is followed by a white summer cottage on the right. The river current picks up and protruding boulders appear. The first pitch encountered is very short, and can be run with a good water level. A pool of quiet water about a hundred yards distant leads into the main rapids. In high water the lower rapids are "tops" for an exciting run. Gil Bortleson rated the difficulty a solid Grade 2. Those who will shoot the rapids will find heavy "curlers" and "boilers" in the sharp drops. The current is very swift, producing waves two to three feet high. The river bends sharply in two places, requiring good control of the canoe to avoid smashing into large boulders. Below the second bend, the course is straight ahead to the bridge. Under the bridge the rapids terminate in a broad pool. A parking area has been provided, and trout fishermen have tramped an easily followed trail along the river. The canoe can be portaged over the trail, or a logging road farther north can be used.

One-fourth mile below Forest Road 2159 Bridge, the South Branch of the Popple River (Fig. 1, *40*) joins the main Popple. Though an important tributary, the South Branch is unsuited for canoeing. Beaver dams, windfalls, old bridges, and log jams frequently obstruct passage. Heddin Dam, a logging dam between Forest Road 2159 and 2383 is in an excellent state of preservation. The canoeist will find the shallows below the dam difficult to navigate, even in high water. Canoeing the South Branch would entail unfavorable conditions at any time.

The next two miles of the main Popple is punctuated with numerous rocks, a number of riffles, and several short rapids. In places the river is shallow and rocky. A dense forest blankets both sides. Masons Rapids (Fig. 1, *41*) is in two pitches. The first pitch is sharp but short, followed by a hundred yards of fast but safe canoeing. The canoe can be landed on the right below the lone pine tree leaning over the river from the north bank. The river is white water as it circles to the north in a half moon course. Nearing the foot of Masons Rapids, the river becomes a virtual rock garden. Any lead chosen for the canoe will result in a hang-up. Any canoeist running Masons Rapids can expect to wade to extricate his craft from the rock pile.

An old corduroy road cuts across the neck of land half circled by the river beginning at the landing below the white pine. It can be used for the portage. An excellent popular campsite is located at the base of the rapids. Fishermen coming up the river in motor boats to fish the rapids often camp here.

The Popple below Masons Rapids is known locally as "Deadwater". The setting is an open grassy marsh. Tall hemlocks stand where Rock Creek enters. Masons Creek is next on the right, with beautiful vistas of pine on the north. Since leaving the bridge we have been traversing the timber lands of Calumet Hecla. Where the river crosses the line between Sections 27 and 22 is the site of Camp No. 1 used when Goodman Lumber Company operated a railroad to haul logs to their mills. Deer hunters salvaged some of the materials from the original buildings to build a crude hunting shack. Of the remaining buildings only their outlines can be observed. Fishermen launch their boats here for the cruise up to Masons Rapids. The railroad bridge over the Popple River is being maintained and is safe for travel. Beyond, cottages appear on the right, some distance back from the river. The steel town bridge has replaced an older wooden structure. A gauging station has been erected here by the U. S. Geological Survey. The embankment next to the gauging station is the embankment of Anderson Dam, named for Rudy Anderson who drowned here in a logging accident. The current bridge rests on a rock ledge over which the Popple River drops.

None but the most daring canoeists should attempt the stretch of the Popple between the Iron Bridge and Highway 101. "This is no ordinary stretch of the river," testified Ralph Hovind at the Public Service Commission hearing on the proposed Aspen Dam. Voicing the Conservation Department's opposition, Hovind continued, "It is a tumbling series of falls, rapids and quiet areas thrown together in a jumbled mixture in a remote, hilly country."[10]

Little Bull Falls (Fig. 1, *42*) is a half mile below the Iron Bridge. A weatherbeaten, beautifully designed log cabin with steep roof overlooks the falls from the left, while a new cabin stands on the right. Spruce, balsam and cedars shade the outcrop of rock which constitutes the falls. Grade 2 rapids continue half a mile below Little Bull Falls. Fisherman trails border the river.

Murphy Rapids (Fig. 1, *43*) is reached after passing a high rock outthrust on the left. The approach is over a wide, sluggish stretch of quiet water. The first brief pitch of Grade 1 difficulty ends in a short pool followed by a quarter-mile of Grade 1 and 2 whitewater including a sharp bend. An island marks the end of Murphy Rapids. Deer use Murphy Rapids to cross the river; their trails converge on both sides.

Enroute to Nine Day Rapids (Fig. 1, *44*) a log jam requires a short portage. The name Nine Day Rapids originated during the river drives. One spring a huge log jam occurred. Loggers

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[10] From same reference as Footnote 8.

struggled for nine days to free the logs, and ever since the rapids have been referred to as the Nine Day Rapids.[11] They begin as Grade 2, tapering to Grade 1 whitewater, with plenty of rock-dodging thrown in. The current throughout is very swift. Low water summer conditions would make running difficult.

Hendricks Creek (Fig. 1, *45*) is the beginning of fast water leading into Big Bull Falls. Inexperienced canoeists should not proceed into the fast current, but are advised to begin the portage on the right. The falls are approximately 10 feet high over a formidable rock formation. A trail approaches the falls from downriver on the left bank. The canoe, launched into the pool at the base of the falls, can be paddled a hundred yards to rapids which continue almost to Highway 101 bridge. During high water a thrilling ride is in store. On the downriver side of the bridge is a wayside and landing.

This beautiful stretch of the Popple River would have been lost had Aspen Dam been built just above Hendricks Creek. Nine Day Rapids, Murphy Rapids and the river all the way to Little Bull Falls would have been obliterated. The 35 foot high structure would have blotted out over half of the vertical drop from bridge to bridge. Local sporting interests and the Florence County Board supported the Elco Corporation's application to build the dam; but conservationists, assisted by the Wisconsin Conservation Department, presented convincing testimony. Paul E. Klopsteg, a riparian owner, testified that he "would must prefer a first class river, which the Popple is, to a third class lake, which the Aspen might occur. . . . The river is most attractive as it now is; I cannot believe that an artificial lake would make it so". On April 3, 1961, the Public Service Commission denied a permit. In its decision, the Commission ruled that the Popple River in its natural state offers greater scenic value for the public than the proposed flowage. The dam would violate enjoyment of natural scenic beauty by the public, the Commission stated. The Elco Corporation sold its river holdings to the State following the PSC denial. "A large stretch of this segment of the Popple River is now public property," wrote Walter Scott in the spring 1961 issue of the *Wisconsin Academy Review*. "This preservation is vitually important for the enjoyment of those who want to fish the rapids of a stream so rough that it can hardly be waded, so precipitous and rocky that canoeing is a serious challenge, and so scenic that it embodies rugged northwoods beauty at its best."

The rapids continue for a mile below the wayside. The gradient is not severe and the canoeist needs only to avoid the white-tails in the fast current. A road skirts the right bank, while a farm is

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[11] Personal communication from Horace McClain, 1969.

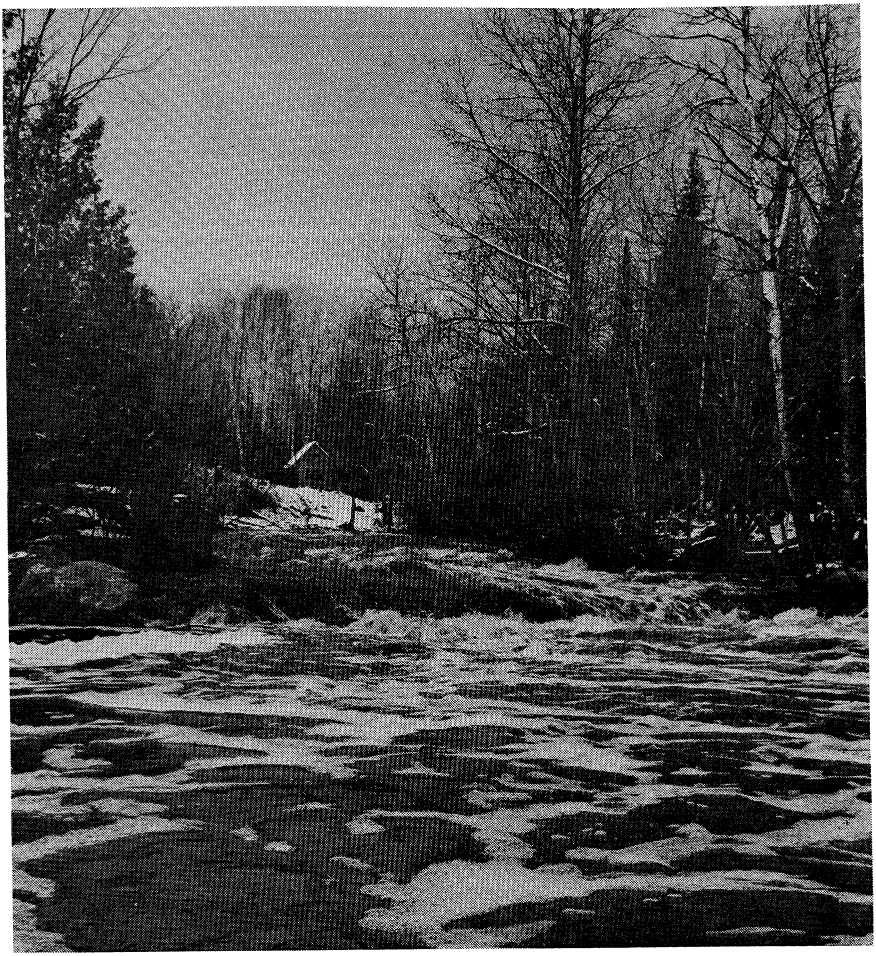

FIGURE 3. View of rapids, looking upstream, in lower Popple River, in Florence County. These rapids would have been submerged and lost, had the "Aspen Lake" dam been built. Photo taken May 1, 1960, by Lewis Posekany; print furnished by Walter E. Scott, courtesy of Wisconsin Department of Natural Resources.

located on the left. Considerable destruction of the bank and cover has occurred. A trash dump is an eyesore. The river is broad and sluggish to Burnt Bridge, where the Girard Lumber Company logging railroad crossed years ago. Two fishing camps are located on the right near Montagne Creek. Fishermen use this area heavily. Below Burnt Bridge the river grows increasingly faster. Two large boulders, one on the left, the other on the right, are a warning to begin a portage over a brush flat on the left to the pool below Washburn Falls (Fig. 1, *46*).

Jennings Falls (Fig. 1, *47*) is two miles farther down. The current is swift with numerous riffles. Deadhead logs, occasional rocks, and small jams are obstructions to look for and avoid. Sweepers reach out over the river where cedar swamps are traversed. The river is wide and, in the vicinity of Woods Creek, shallow with a gravel bottom. The river then bends south, and ahead is the sound of Jennings Falls. By hugging the right bank the canoeist may continue cautiously for another 100 yards to a small cove, where the portage can begin northeast on the right. Immediately ahead, the river narrows into a deep gorge to roar and twist among the boulders. Carrying the canoe one should stay in the depression, avoiding the higher rock on either side. At best the portage is a difficult one. Jennings Falls is very impressive in its wild, rocky setting overgrown with pine and balsam.

The remaining mile and a half to the Pine River is prime trout water. The terrain is rough and the river's current fast, as it moves over a shallow gravelly bottom. Rock outcrops are numerous on both banks. A few rise in high bluffs. Rounding a final bend the Popple flows eagerly toward its union with the Pine River.

Thus, with Sierra Club members as my companions, I had canoed the Pine and Popple, two of northeastern Wisconsin's wild rivers. In a series of weekend trips during the springs of 1966 and 1967 we had paddled the sparkling waters of the rivers, felt the excitement of running rapids, sensed the solitude of wild stretches, gazed at the vistas of river, swamp and forest. Of the pages of history written on land and river we could only imagine the scenes: Indians with flashing paddles in birch bark canoes, traversing a thin blue thread in a vast unbroken forest. In a stump-studded clearing a lonely logging camp. Lumberjacks cursing the elements as they struggle to break a log. A settler scanning his domain of fire-charred stumps and barn. We observed nature struggling to heal the scars inflicted by man. We thought of coming generations. Would their heritage include a wild river?

AN ARCHAEOLOGICAL SURVEY OF THE PINE, PIKE AND POPPLE RIVERS[1]

Robert J. Salzer

The area of northeastern Wisconsin which is located in the drainages of the Wild Rivers—the Pine, Popple, and Pike—is, like so many other regions in the Upper Great Lakes area, almost completely unknown to the culture historian. It is certainly true that the major prehistoric developments in eastern North America will never be properly understood until these uninvestigated regions have received the close scrutiny of the trained investigator. This report contains the results of an attempt to make a preliminary assessment of the archaeological and anthropological resources of one such area.

During the month of July, 1968, a survey crew composed of Beloit College students under the direction of the author and under the field supervision of Mr. J. Edson Way, was sent into the Wild Rivers area of northeastern Wisconsin with the purpose of locating and describing sites of prehistoric human activity. Surface collections of the debris resulting from these activities were made and are now housed in the collections of the Logan Museum of Anthropology, Beloit College. The survey program was run at the same time that excavations were being conducted in nearby Oneida and Vilas counties by the Beloit College Archaeological Field School. These latter activities limited the author's opportunities to accompany the Wild Rivers survey crew, with the result that the bulk of the actual work in the field was under Mr. Way's supervision.

One of the results of the experience derived from four years' archaeological operations in northern Wisconsin is the knowledge of techniques which are best suited to survey procedures in a heavily-forested environment. However, the particular characteristics of vegetation cover and drainage in the Wild Rivers area made surface observation of prehistoric aboriginal remains particularly unproductive and frustrating. In addition, the widespread absence of access roads to the rivers and the small number of farms adjacent to the rivers made the work of the survey crew unusually difficult. As a result of these factors and as a result of

[1] This is Paper No. 3 in the series "Studies on the Pine–Popple Wild Rivers Area of Northeastern Wisconsin." Submitted November 1, 1969.

limited time and funds, our 1968 survey was limited to restricted areas along the banks of the streams and lakes within the drainages of these three wild rivers. The various loci of prehistoric habitation which were located in the course of the survey do not, therefore, represent more than a fraction of the total number of such sites to be found in the area.

Not only were such archaeological sites difficult to find, but the heavy vegetation cover encountered precluded the recovery of extensive surface collections of cultural debris. Some of the sites are represented in our collections by a mere handful of the wastage which results from aboriginal stone-working techniques. Such small assemblages seldom include artifact forms which can be considered to be diagnostic of even very broad temporal or cultural divisions of Upper Great Lakes prehistory. This is a highly significant limitation of our data, particularly in view of the generally scanty and imperfect understanding of Upper Great Lakes prehistory which is now available.

Fortunately, our work in Oneida and Vilas counties and the work of Dr. Ronald J. Mason in Door County to the southeast, provide some measure of control and furnish some sort of framework within which our data may be assessed.

The following list of archaeological sites constitutes the results of our survey. Each site described has been given a site name, a Wisconsin Archaeological Survey codification number immediately following the site name, and a catalog number in the collections of the Logan Museum of Anthropology, Beloit College (e.g. LMA #) at the end of the paragraph dealing with that site. For convenience, the sites are grouped according to the particular drainage system in which they are located.

THE PINE RIVER DRAINAGE

The *Franknecht Site* (Fl2) is situated on the north bank of the Pine River at the confluence with the Popple River. It is located in the SW ¼ of the SE ¼ of the SW ¼ of Section 23, Township 39 North, Range 17 East, in the Town of Fern, Florence County. Surface collections from the eroded bank include two quartz hammerstones, two chert flakes, 51 quartz flakes, nineteen quartz cores, six bipolar cores (Figure 1, I), and 12 irregular quartz chunks. (LMA #21460)

The *Two Banks Site* (Fl3) is located in the SW¼ of the NW¼ of the SE ¼ of Sec. 7, T 39 N, R 18 E, Town of Commonwealth, Florence County. It is situated on a ridge on the southeast side of the stream which crosses County Road D at Emily Lake. Surface collections from the road cut consist of one welded tuff hammerstone, a utilized quartz flake, 38 unmodified quartz flakes, and 3 quartz cores. (LMA #21461)

The *Troika Site* (Fl4) appears to be confined to the north side of County Road D on the northwest side of the stream leaving Emily Lake, in the SW ¼ of the NW ¼ of the SE ¼ of Sec. 7, T 39 N, R 18 E, Town of Commonwealth, Florence County. It is possible that this site is a continuation of the Two Banks Site. One broken chert side-notched projectile point (Fig. 1, C), one broken quartz small triangular projectile point with serrated edges (Fig. 1, A), two utilized quartz flakes, one utilized quartzite flake, 11 unmodified quartz flakes, one chert flake, and three quartz cores were found on the surface. (LMA #21462)

The *End of Road Site* (Fl5) is on a point on the southeast side of the junction of the Pine River and the drainage of Bessie Babbit Lake. It lies in the SE ¼ of the NE ¼ of Sec. 3, T 39 N, R 17 E, in the Town of Fern, Florence County. The surface collection consists of 304 unmodified quartz flakes, 48 quartz chunks, 36 quartz cores, 2 utilized quartz flakes, and two quartz wedges (Fig. 1, E and F). Wedges are tools which are thought to have been used in the manufacture of bone tools. (LMA #21463)

The *North End Site* (Fl6) lies on a rise to the west of the stream which flows out of the north end of Long Lake, in the NE ¼ of the NW ¼ of Sec. 19, T 39 N, R 15 E, Town of Longlake, Florence County. The surface of the site yielded 17 plain shell-tempered bodysherds (fragments of pottery vessels), 2 plain-surfaced, grit-tempered bodysherds, and 3 unidentifiable fragments of pottery. Also collected were three burned chert flakes, one rhyolite flake, 14 quartz flakes, and two bipolar cores—one of quartz (Fig. 1, H) and one of quartzite (Fig. 1, J). The entire site appears to have been plowed at some time in the past. (LMA #21464)

The *Merganzer Point Site* (Fr3) is situated on the large peninsula on the northwest shore of Franklin Lake in the SW ¼ of the NW ¼ of Sec. 21, T 40 N, R 12 E, Town of Hiles, Forest County, in the Nicolet National Forest. Surface collection yielded 7 quartz flakes and one quartz bipolar core (Fig. 1, G). The site appears to have been badly disturbed by erratic digging activities. (LMA #21465)

The Pike River Drainage

The *Eichenger Ring Site* (Mt33) is located on the west bank of the Menominee River about one-quarter mile upstream from the mouth of the Pike River. It is situated on a high ridge in the NW ¼ of the SW ¼ of Sec. 2, T 34 N, R 21 E, Town of Amberg, Marinette County. The site is intriguing because of the presence of two low earthen "dance rings", some small earthen mounds which

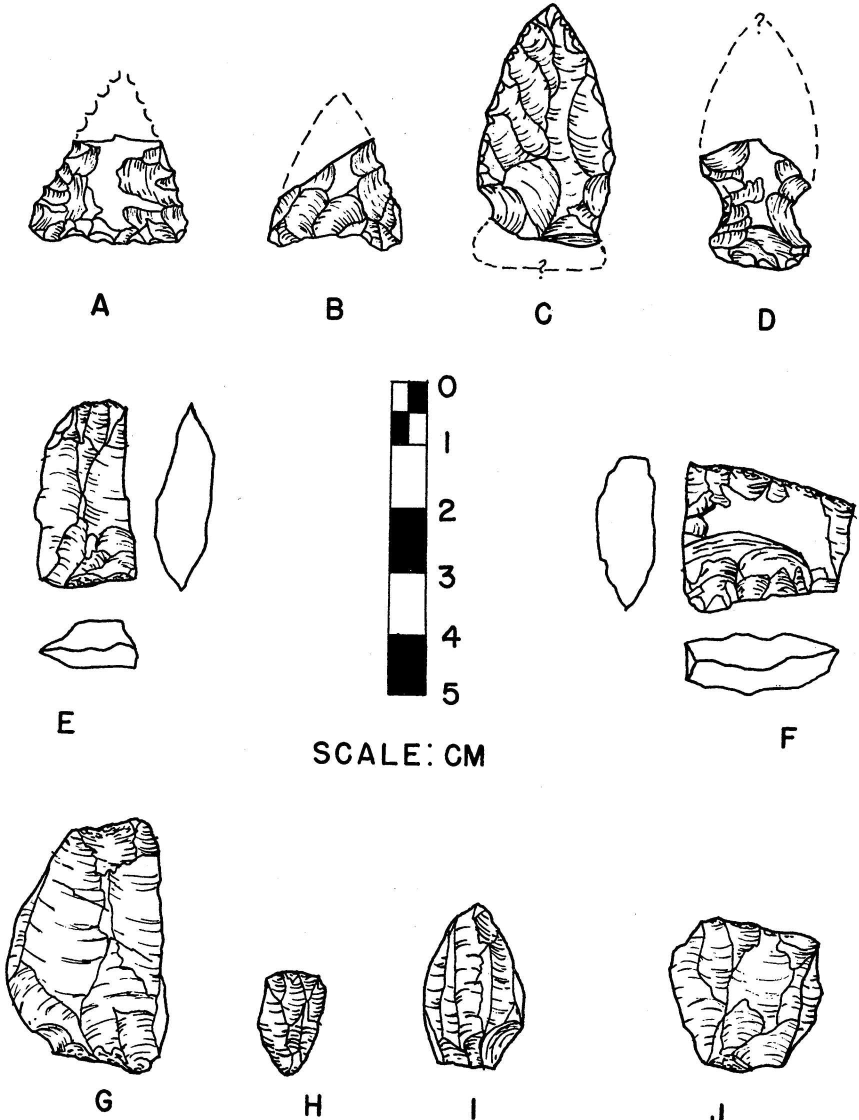

FIGURE 1. Artifacts found in the archeological survey of the Pike, Pine and Popple Wild Rivers Area. A, small, triangular projectile point, with serrated edges, from Troika site; B, small triangular projectile point fragment, from Eichenger Ring site; C, side-notched projectile point, from Troika site; D, side-notched projectile point base, from Eichenger Ring site; E and F, quartz wedges, from End of Road site; G, quartz bipolar core, from Merganser Point site; H, quartz bipolar core, from North End site; I, quartz bipolar core, from Franknecht site; J, quartzite bipolar core, from North End site.

may be burial mounds, and several regular depressions which may be graves. The site is narrow and about one-quarter mile long. Surface collection yielded artifacts which suggest that the site was occupied several times by aboriginal groups. Included are: a broadly side-notched chert projectile point base (Fig. 1, D), a small triangular quartz projectile point fragment (Fig. 1, B), one utilized chert flake, 3 quartz flakes, one chert chunk (burned?), and a quartz bipolar core. Historic artifacts found on the surface include bowl and stem fragments of a white kaolin pipe, a rivet-type cast brass sleigh (dance?) bell, and fragments of glass and glazed ceramic vessels. Also collected are several small fragments of both burned and unburned animal bone. Although this site technically lies outside the Pike drainage, it is included here because of the interesting information it contributes to the general area. (LMA #21466)

The *Mathis Farm Site* (Mt34) is located on a hill to the south and east of the old Mathis farm house in the SE ¼ of the NW ¼ of Sec. 36, T 35 N, R 19 E, Town of Athelstane, Marinette County. Due to extensive and prolonged corn agriculture between 1900 and 1935, sand from the back of the hill has been blown over the site, in places to depths of five feet. The owners report that they have found many "arrowheads" over the years on the site. Our collections were extremely meagre and include one quartz flake and one chert flake. (LMA #21467)

Twin Oaks Site (Mt35). This site is located in the NE ¼ of the SE ¼ of Sec. 3, T 34 N, R 21 E, in the Town of Wausaukee, Marinette County, on a ridge on the north bank of the Pike River about 150 yards upstream from its confluence with the Menominee River. The surface collection includes one felsite flake, 4 quartzite flakes, 28 quartz flakes, two quartz cores, two chert cores, and a chert wedge. (LMA #21468)

The *Dolan Lake Site* (Mt36) is located on a ridge which separates Dolan and Coleman lakes, to the southwest of a small connecting stream, in the SE ¼ of the SW ¼ of Sec. 10, T 35 N, R 19 E, Town of Athelstane, Marinette County. The site is largely undisturbed and does not appear to be very large or to have a deep deposit. The surface collection consists of 2 felsite flakes, and 5 quartz flakes. (LMA #21469)

The Popple River Drainage

No sites were found in the Popple basin. The survey crew felt that this apparent lack of aboriginal activity may very well be explained by survey limitations. Access roads are few and widely separated and much of the river is in low, swampy areas with heavy growths of alder along the banks.

DISCUSSION

The results of our field survey are frustratingly meagre, which is not surprising in view of the limitations under which it was conducted. In spite of our small collections, however, some rather important observations can be made. The most obvious of these is the conclusion that the drainages of the Pike, Pine and probably also the Popple were clearly exploited by aborigines in both recent and prehistoric times. Also, the discovery of village and campsite debris gives an important clue to the sorts of exploitative patterns which were present. The relative lack of diagnostic tool forms which were recovered from these deposits by our survey crew makes the task of determining when and by whom these artifactual remains were deposited a difficult one.

The impression that the area contains a small number of small sites with shallow deposits should be considered a function of the limitations of surface collection techniques in a heavily forested area. Experience derived from the application of similar techniques in Oneida and Vilas counties suggests that such surface indications are seldom representative of the quantity of debris or the depth of the deposit which lies beneath the humus.

If our primary data are meagre, and do not permit a direct evaluation of local culture history, recent discoveries by Dr. Ronald J. Mason in the Door County–Green Bay area to the southeast, and in the lacustrine district of Oneida and Vilas counties to the west provide bases for at least a preliminary assessment of the broad outlines of human history in the Pine, Pike, and Popple drainages. The general chronology used here is a modified version of that used by George I. Quimby in his *Indian Life in the Upper Great Lakes* (1960).

The Paleo–Indian period (10,000 to 7,000 B.C.)

No direct evidence for human exploitation of the Wild Rivers area during this period is known. Indeed, intensive investigations in adjacent areas clearly indicate that only the southern margins of the Great Lakes region were settled by the mastodon hunters which moved north during the Twocreekan. In Wisconsin, occupations by these big-game hunters are found only in the southern half of the state.

The Late Paleo–Indian period (7,000 to 5,000 B.C.)

With the retreat of the Valders glacial advance, and the climatic amelioration which followed, northern Wisconsin and other areas of the Great Lakes apparently become more attractive to human settlers. While we have no evidence of occupations during this period in the Pine, Pike and Popple basins, we do have information from adjacent areas such as Green Bay (Mason and Mason 1960) and from Oneida and Vilas counties (Salzer 1969a, 1969b) to indicate the presence of at least two phases of the cultural and temporal continuum which is identified as "Late Paleo–Indian". In addition, a 1968 survey crew from Beloit College discovered remains which date from this period in the Upper Wolf River valley and it seems likely that future research in the Pine, Pike, and Popple area will disclose similar evidences of such occupations.

The Archaic period (5000 to 500 B.C.)

Data from our survey are inconclusive but do not rule out the possibility of occupation during this period. The Archaic period is a lengthy and complex affair in the Great Lakes and includes innovations in technology such as ground stone tools (axes, gouges) and annealed native copper tools. In the Green Bay area, the Oconto cemetery site (Ritzenthaler and Wittry 1957) has provided radiocarbon assays which range from about 5600 B.C. to 3600 B.C. On the other hand, dates from the Riverside cemetery site (Hrushka 1967) located in the present city of Menominee, Michigan, range from 500 B.C. to about A.D. 1. In Oneida County, the Squirrel Dam Site and the Burnt–Rollways Site provide additional information on domestic, rather than burial, activities during this long period (Salzer 1969a, 1969b). It is likely that the copper tools which were found some years ago near Long Lake in Florence County represent the occupation of the Wild Rivers area by aborigines at this time (Ritzenthaler 1957).

The Early Woodland (500 B.C. to 100 B.C.) and the *Middle Woodland periods* (100 B.C. to A.D. 500)

During the first of these periods, pottery technology appears in the Great Lakes area, and again, although no diagnostic artifacts were found in our survey of the Wild Rivers area, data from adjacent areas strongly suggest that occupations dating from these two periods will ultimately be located. These two periods are somewhat difficult to distinguish in northern Wisconsin. This is largely due to the presence of at least two distinctive local developments which have been discovered in the area and to our still meagre understanding of the details of their origins and elaboration. The recently defined *North Bay Culture* (Mason 1966) is found in the Green Bay–Door County area and dates from around A.D. 100–200. Its development seems to have been strongly influenced by contemporary Middle Woodland groups in Illinois, Ontario, and New York. Adjacent to our area on the west is another Middle Woodland manifestation, termed the *Nokomis Phase* (Salzer 1968, 1969b), which is largely affected by still unclear connections to southeastern Wisconsin, although trade with *North Bay* is evident also. The Pine, Pike, and Popple, together with the Menominee river, certainly served as transportation devices in contact between these two northern Wisconsin areas and we can expect that further research in the Wild Rivers area will help to elucidate the mechanisms by which this trade and contact was accomplished. It is possible that the Troika Site (Fl4) and the Eichenger Ring Site (Mt33) may eventually supply some of these details.

The Late Woodland period (A.D. 500 to 1600)

This long time period is one of extremely complex developments and population movements in the Upper Great Lakes area, and it is very important to our understanding of the cultural processes which led to the formulation of the various Indian groups which were in the area at the time of contact with the Europeans. In Oneida and Vilas counties, this period is one of population growth. Not only are villages more numerous and of larger size, but the quantity and depth of debris and domestic garbage at these sites clearly indicates intensive and extensive sedentary life (Salzer 1969b). In the Wild Rivers area, the Troika Site (Fl4), the Eichenger Ring Site (Mt33), and the North End Site (Fl6) date from this period. Based on our experience from Oneida and Vilas counties, it is likely that most, if not all, of the sites described in this report were occupied during this period. Small triangular projectile points are diagnostic of the period and, in northern Wisconsin, crushed shell temper for pottery vessels was used only during this period.

The large quantity and universal occurrence of quartz chipping debris at the sites in the Wild Rivers area is instructive also, since in the area immediately to the west, this raw material was used almost exclusively for the manufacture of stone tools during this period. However, the low conical and linear burial mounds found to the west are conspicuously absent in the Wild Rivers area, with the possible exception of the Eichenger Ring Site. Mounds are similarly absent at Late Woodland sites in the Door County area (Mason 1966). However, burial mounds are present along the Menominee River in Menominee County, Michigan (Brose 1968). A similar situation prevails to the south along the Wolf River (Barrett and Skinner 1932), and also in the Peshtigo River drainage (Sperka 1962). The significance of these distributions can only be food for speculation until more research is accomplished in northeastern Wisconsin.

The major ceramic styles in all these areas are similar and involve round or somewhat conical jars of various size which are covered with impressions of a cord-wrapped paddle. Decoration is common and is usually found near the rim and consists of impressions of single twisted cords or cord-wrapped sticks or strings. Such pottery will undoubtedly be found in the Wild Rivers area as more work is done.

The Historic period (A.D. 1600 to the present)

At least one of the sites located by our survey, the Eichenger Ring Site (Mt33), appears to have been occupied by Indians during the Historic period. However, the artifactual remains would seem to suggest that this occupation was quite recent and probably does not date much before the middle of the 19th century. Two sites which were located in Oneida County in 1966 are similar in that they also provide evidence of modern artifacts, low earthen "dance rings", and shallow depressions suggestive of graves. In these instances, local traditions attribute the sites to occupations by the Potawatomi tribe in the late 19th century, and it is possible that the Eichenger Ring Site will eventually be similarly identified. The Forest band of the Potawatomi tribe have settlements in Forest County to the southwest of the Popple River. However, representatives of the Chippewa tribe have also been known for some time in the same general vicinity and they may have ranged into the Wild Rivers area in the recent past.

To the south and east of the area, the Menominee tribe has apparently maintained a relatively long-term residence, and, in fact, claims to have come into being as a recognizable social entity near the mouth of the Menominee River (Skinner 1913, p. 8). They were encountered at this locality in 1634 and they appear to have had additional villages in the general area at this time (Quimby 1960). It is probable, but by no means certain, that the Late Woodland occupations in the Wild Rivers area and in adjacent areas represent the material culture remains of the cultural ancestors of this tribe. Certainly, the Potawatomi, Chippewa, and other tribes known to have been in the area in recent times are late prehistoric and early historic immigrants and cannot account for the Late Woodland debris in the area.

Conclusions

A short-term archaeological survey of the proposed Wild Rivers area of extreme northeastern Wisconsin during the summer of 1968 succeeded in locating ten loci of prehistoric and historic cultural activities. Since the literature contains no examples of responsible excavation in this area, and, since the exigencies of surface survey in a largely undisturbed heavily-forested region severely limit the size and quality of artifactual recoveries, it is necessary to rely upon the data and interpretations resulting from research in nearby areas to evaluate the present data. A reasonable, although tentative, sequence of major cultural events for the Wild Rivers area can be offered on these bases. This culture history begins shortly after the retreat of the Valders ice sheet and terminates in the recent past.

It is hoped that full scale excavations will be conducted in this area in the future since research of this sort can be expected to produce information on several problems of local and regional significance. For example, we can anticipate the recovery of data relating to the specific mechanisms and modes of colonization by human groups in post-Valders times. The area should also provide details of the relationships between Middle Woodland groups in adjacent areas. Hopefully, some insight into the prehistoric basis of the Menominee tribe might result from such research also. Certainly, archaeological investigations beyond the scope of our preliminary survey will be required to fully assess the scientific and educational resources of the area.

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THE MAMMALS OF THE PINE AND POPPLE RIVER AREA[1]

Robert A. McCabe

The Pine and Popple rivers are located in Florence and Forest counties. These counties have perhaps fewer published natural history accounts than any others in the state. The human population there has always been low and the area is remote from institutions likely to investigate natural history. Historically, the region is also relatively sterile since there were no trading posts on either river. Records from such posts usually present data on occurrence and abundance for larger mammals and occasionally scattered records on noncommercial smaller mammals.

The primary source of information on Wisconsin mammals comes from H. H. T. Jackson's book, *Mammals of Wisconsin* (1961). This publication was the major reference used in forming this status report for the Pine and Popple rivers. Although the reference material is now over 15 years old, to my knowledge there are no additional data from this region. Jackson must be considered a "splitter" as a mammalian taxonomist. Treatment here will tend to "lump" rather than split since the approach will be ecological rather than taxonomic. The only other major work on Wisconsin mammals is that of Cory (1912). Although the taxonomy and the range maps are outdated, the records and life history data are very good, and in its day, the Cory bulletin was an outstanding publication.

There has been no systematic mammal survey of the Pine and Popple river watersheds, nor can this present report in any way be considered definitive. Dr. Howard F. Young, Professor of Biology at Wisconsin State University, La Crosse, and I spent four days trapping small mammals in the various habitat types along the two rivers. From June 13–16, 1966, our total of about 520 trap nights produced only the common small mammals: short-tailed shrew, field mouse, deer mouse, masked shrew, and least chipmunk.

Purdue University has a forestry summer camp on the Pine River from which two colleagues, R. E. Mumford and C. M. Kirkpatrick of that institution, have contributed data on the small mammals and observations on the larger forms.

[1] This is paper No. 4 in the series, "Studies on the Pine–Popple Wild Rivers Area of Northeastern Wisconsin."

Mr. and Mrs. Carey Anderson of Sea Lion Lake in Fern Township, Florence County, have collected specimens and sight records from that area and allowed me to use them in this report. Charles A. Long, Director of the Museum of Natural History at Wisconsin State University, Stevens Point, has also made available his records from Chipmunk Rapids and Lost Lake in Long Lake Township of Florence County.

All game and fur harvest figures are those of the Wisconsin Department of Natural Resources (formerly the Wisconsin Conservation Department). To eliminate repeated reference to the same work, information from the major sources will be designated by letters in brackets as follows:

[J] — H. H. T. Jackson, 1961
[A] — data contributed (in personal communication) by Mr. and Mrs. Carey Anderson
[C] — Cory, 1912
[P] — Purdue University Forestry Camp staff
[L] — Aldo Leopold, personal notes
[G] — Records of Charles A. Long
[S] — A. W. Schorger papers, 1942–65
[DNR] — Wisconsin Department of Natural Resources reports
[WCD] — Wisconsin Conservation Department, now the Department of Natural Resources

Isabel Brackbill of Madison compiled data from Department of Natural Resources records, and aided in numerous ways in preparing the manuscript.

The assessment below will follow the taxonomic sequence (but not necessarily the subspeciation or common names) of Jackson (1961). Walker (1964) was consulted and followed in some cases. All specimen records, observational data and kill records are assigned whenever possible to either Florence or Forest counties. Whenever the data are specific, the locality is identified, particularly within the watersheds of the two rivers involved.

CLASS MAMMALIA

ORDER MARSUPIALIA

FAMILY DIDELPHIDAE.

Didelphis virginiana (opossum). The opossum is the only member of this order found in Wisconsin, but there are no records in Jackson for either Florence or Forest counties. However, the kill reports [DNR] show that four were taken in Florence County in

1946, and 51 in 1954. These are the only two years for which I could find harvest information.

ORDER INSECTIVORA

FAMILY SORICIDAE (shrews).

Sorex cinereus (cinereous shrew, masked shrew, common shrew). Six specimens from Florence County, three from the vicinity of Florence, and three from Spread Eagle Lake [J]. "I have examined specimens from various localities in the interior and several of the most northern counties including Douglas, Iron, Florence and Vilas" [C, p. 411]. Cory also lists three specimens from Spread Eagle Lake. These may be the same specimens recorded later by Jackson. There is a specimen in the Purdue University collection from Lost Lake area of Long Lake Township, Florence County [P] and the Andersons have a preserved specimen of this shrew taken in Fern Township of Florence County [A]. Long collected a masked shrew on August 19, 1968 at Chipmunk Rapids [A]. Although I found no authentic record of this shrew in Forest County, it doubtless exists there in the same kinds of habitats (e.g., moist woods, marsh edges, along streams) in which it is found in Florence County.

Blarina brevicauda (short-tailed shrew, mole shrew). Seven specimens are recorded from Florence County, one from Florence and six from Spread Eagle; one specimen from Forest County (T 34 N, R 14 E). These are recorded as *B. b. kirtlandi* [J]. This species has also been taken at Lost Lake [P], and at Sea Lion Lake in Florence County [A]. I also trapped this shrew at Tipler in Florence County. The animal is apparently a common small mammal in both the Pine and the Popple watersheds.

Condylura cristata (star-nosed mole). One specimen is recorded from Newald in Ross Township [J]. Cory records a specimen from "Newbold" in Forest County. This may be a misspelling of the Newald location also recorded by Jackson. Another specimen was taken at Sea Lion Lake in Florence County [A].

ORDER CHIROPTERA

FAMILY VESPERTILIONIDAE (common bats).

Myotis lucifugus (little brown bat). Although extremely common throughout the state, there is only one authentic record of this bat, taken at Sea Lion Lake, Fern Township, in Florence County, on July 8, 1968 [A]. This bat is recorded as observed at Lost Lake in Florence County [P]. There are no other records of other bat species in Florence or Forest counties, largely because there have been few, if any, collections made there.

ORDER LAGOMORPHA

FAMILY LEPORIDAE (hares and rabbits).

Lepus americanus (varying hare, snowshoe hare). This sometimes superabundant hare has only one authentic record each for Florence and Forest counties (no specimens examined) [J]. This species was also observed at Lost Lake, Florence County [P]. A specimen was taken by Long near the entrance to the Purdue Science Camp above Lost Lake [G]. I also saw several hares in Florence County June 1966, in the Pine River watershed near Chipmunk Rapids. Leopold (1945) shows both Florence and Forest counties to be well within the range of this species in Wisconsin. The average annual kill of this hare for an 18-year period ending in 1956 was 2,605 for Florence County (peak in 1949 with a bag of 5,481) and 3,177 for Forest County (peak also in 1949, when 8,163 hares were taken) [DNR].

Sylvilagus floridanus (cottontail rabbit). There is one authentic record from both Florence and Forest counties (no specimens examined) [J]. The Forest County record is not in the Popple River watershed. Leopold (1945) records the first cottontail seen in Forest County in 1914.

The progress to abundance has been slow, and it is doubtful that either of these two watersheds will ever support high populations of cottontail rabbits. In the 18-year period prior to 1956 the average yearly kill was 342 for Florence County and 613 for Forest County. By way of comparison, a county with a high cottontail population, such as Dodge County, in 1956 produced a harvest of 63,384 cottontails [DNR].

ORDER RODENTIA

FAMILY SCIURIDAE (squirrels and allies).

Marmota monax (woodchuck, groundhog, marmot). One authentic record exists for each of Florence and Forest counties. The Forest County record is not in the Popple watershed (no specimens examined) [J]. Young saw woodchucks in the Pine–Popple watersheds in May 1969.

Tamias striatus (chipmunk, gray chipmunk). There is one authentic record from Forest County, and three specimens from Florence County (two from Spread Eagle Lake; one at T 40 N, R 16 E). The record from Forest County is not in the Popple River watershed. Jackson also lists the specimens recorded by Cory [C]. The Andersons have a specimen from Sea Lion Lake in Florence County [A]; as does the Purdue forestry camp for Lost Lake in Florence County [P]. I also saw numerous chipmunks in both Florence and Forest counties.

Eutamias minimus (least chipmunk, little chipmunk). Forest County has one authentic record (but not in the Popple River watershed), and two specimen records for Florence, Florence County [J]. There are also specimens from Chipmunk Rapids where this species was observed abundant [G]. I collected a specimen in June 1966.

Sciurus carolinensis (gray squirrel). This squirrel is now common in all parts of Florence and Forest counties. There is one authentic record in Florence County prior to 1900 [J]. Schorger (1949, p. 204) records: "The shooting of a gray squirrel at Florence in 1886, and again in 1895, in both instances induced the remark that this species was very rare in Florence County." As a hunted animal, the average annual kill (8-year record) has been 322 for Florence County, and 719 for Forest County [DNR].

Sciurus niger (fox squirrel). Although there are no authentic records of this species prior to 1900 [J] or any specimens examined, there has been an open season on fox squirrels in both Florence and Forest counties since 1948. A six-year average ending in 1956 shows that the annual harvest in Florence County was 122, and for eight years in Forest County the average harvest was 226 [DNR].

Tamiasciurus hudsonicus (red squirrel, chickaree). There is one authentic record since 1900 in Forest County. Two specimens were examined for Florence County (one from Richardson Lake; one from Section 26, T 40 N, R 16 E) [J]. The Richardson Lake specimen should have been recorded for Forest County, since Richardson Lake is in Sections 10 and 11, T 35 N, R 14 E of that county. There is at least one specimen from Lost Lake in Florence County [P]. This species is common in both the Pine and Popple watersheds. In the two years for which there are hunting statistics (1947 and 1948), 96 red squirrels were taken in Florence County and 1,002 in Forest County [DNR]. This small squirrel cannot be considered very highly as either a game or fur animal in Wisconsin.

Glaucomys sabrinus (flying squirrel). There is one authentic record for southern Forest County [J], one specimen record from Sea Lion Lake [A], and one from Lost Lake in Florence County [P]. This species is undoubtedly much more abundant than the records indicate since the species is nocturnal and is not sought after as a game animal.

FAMILY CASTORIDAE (beavers).

Castor canadensis (beaver). There were no specimens examined from either county. There is, however, a substantial population of these animals in both the Pine and Popple watersheds. In 1950–

1952 the population was relatively stable in Florence County and increasing in Forest County (Knudsen, 1953). The beaver has been observed in the Lost Lake area of Florence County [P]. Knudsen (1963), in his history of the beaver in early Wisconsin, lists the first record of beaver in Florence County from Tipler Township in 1920. In 1920 also the first record is given for Forest County in the town of Alvin. He also states that there were more beavers in the 1930's than in the 1960's. Schorger (1965, p. 167), however, points out that "A black beaver was caught by Paul Miller on Pine River, town of Commonwealth, Florence [County], 1886," and further that "Insofar as known, the beaver was never exterminated [from Forest County]."

The beaver, once on the verge of extinction, has been an important furbearer in both counties. In the 18 years for which we have harvest records, the average annual take of beavers for Florence County was 164, and 240 for Forest County [DNR]. Beavers have also been pests; between 1938 and 1948, for example, there were 29 complaints in Florence County and 38 in Forest County (Hovind, 1948). Such complaints have doubtless increased in recent years.

FAMILY CRICETIDAE (mice, voles, muskrats).

Peromyscus maniculatus (woodland deer mouse). Five specimens were examined from Florence County (four from Spread Eagle Lake; one from T 40 N, R 16 E) [J]. There are also specimens from Lost Lake, Florence County [P], and five specimens from Chipmunk Rapids [G]. This is doubtless a common species in both watersheds since Young and I trapped it in both watersheds in June 1966.

Synaptomys cooperi (lemming mouse). A specimen was collected at the Purdue Science Camp above Lost Lake, October 1959 [P]. There are no records from Jackson in either Forest or Florence county. This species perhaps occurs more regularly than the meager record shows. There appear to be large areas of suitable habitat.

Clethrionomys gapperi (red-backed vole). Six specimens were examined from Florence County (four from Spread Eagle Lake; two from Florence). One specimen was examined from Forest County (from Crandon) [J]. At least one specimen was taken at Lost Lake in Florence County [P], and one from Chipmunk Rapids [G]. I caught no specimens in either county while trapping in likely habitat (June 1966).

Microtus pennsylvanicus (meadow mouse). Four specimens were recorded from Florence County (all from Spread Eagle Lake), and one authentic record was from Forest County [J]. Specimens exist in the Purdue collection from Lost Lake, Florence County [P]. At Chipmunk Rapids one specimen was preserved and several were discarded [G]. I caught this species in both watersheds in June 1966.

Ondatra zibethicus (muskrat). There are two authentic records, one from each county [J]. The Forest County record was not in the Popple River watershed. Although there are no specimens from either county from 1927 to 1957, the trapping records for these counties show a take of 79,838 pelts: 22,806 from Florence County and 57,032 from Forest County [DNR].

FAMILY MURIDAE (Old World rats and mice).

Rattus norvegicus (Norway rat). There are two authentic records, one in northeastern Florence County and the other in southwest Forest County [J]. Neither was from the Pine–Popple watershed, although it is doubtful that farms in this watershed are completely free of Norway rats.

Mus musculus (house mouse). There is one authentic record of the house mouse in southwest Forest County, and one in Florence County by the Pine River [J]. The Andersons obtained a specimen of this mouse on September 8, 1968, about one mile from the Pine River at Sea Lion Lake [A]. It is very likely a common species.

FAMILY ZAPODIDAE (jumping mice).

Zapus hudsonius (jumping mouse). There were two specimens examined in Forest County, one at Crandon and the other at Richardson Lake (T 34 N, R 14 E); and one specimen was examined in northern Florence County (T 40 N, R 16 E) [J]. Five jumping mice were seen in the Chipmunk Rapids area [G], and one was taken by the Andersons on September 13, 1968, beside Sea Lion Lake, Fern Township, Florence County [A].

FAMILY ERETHIZONTIDAE (American porcupines).

Erethizon dorsatum (porcupine). There are two authentic records of the Canada porcupine, one in southwest Forest County, the other by the Pine River in Florence County [J]. Porcupines were seen in the Lost Lake area (1966–68) [P]. I also saw porcupines in the Pine–Popple watershed, June 1966.

ORDER CARNIVORA

FAMILY CANIDAE (wolf, coyote and foxes).

Canis latrans (coyote, brush wolf). Three authentic records are shown for southern Forest County, and one in northeast Florence County [J]. Coyotes were heard in the Lost Lake area, Florence County, 1966–68 [P], and Young saw a crippled coyote on June 9, 1969, two miles east of the town of Florence. The spread of the coyote in Wisconsin needs documentation and appraisal. The replacement of the wolf by the coyote was perhaps relentless until it was complete. The "brush wolf" was reported as common in Forest County in 1937 (Anon., 1937). While deer hunting in 1962 I found much sign and heard coyotes frequently in the Armstrong Creek area.

Canis lupus (timber wolf). There is one authentic record in Florence County along the Pine River and two in Forest County [J], all made after 1900. One specimen was taken in Forest County, Hiles Township [J]. There has been no reliable census of Wisconsin timber wolves in recent years. In the winter of 1941–42 Daniel Q. Thompson reported (to Leopold) wolves in the town of Tipler, northern one-third of the town of Long Lake, northwestern part of the town of Florence in Florence County, and the eastern one-half of the town of Alvin in Forest County [L]. Thompson's later paper (1952) does not repeat this detail of wolf range in Wisconsin. These were not, however, the only wolves in Wisconsin at that time. Oliver Flannery is reported (Anon., 1939) to have collected $185 in wolf and wildcat bounties in one week at Crandon in Forest County. Young talked to a fisherman in the Florence (town) area, who claimed he had seen a pair of timber wolves during the winter of 1968–69. There is little doubt that the timber wolf is a rare and endangered species in Wisconsin. The timber wolf, like a wild river, now requires the understanding, appreciation and protection deserving of a natural resource so intimately associated with Wisconsin history and heritage.

Vulpes fulva (red fox). There are two authentic records, one each in Forest and Florence counties. One specimen was examined in Forest County in Crandon [J]. Red foxes were seen in the Lost Lake area, Nicolet National Forest, Florence County (1966–68) [P]. The red fox apparently burst onto the Florence and Forest county scene in 1938 when 33 were recorded in the WCD [DNR] kill statistics. Prior to that time only gray foxes had been taken. Following 1938 an average annual kill of 204 animals occurred through 1955. At present it is the most abundant of the two resident foxes common to both the Pine and Popple watersheds.

The DNR harvest records show an average take in Florence and Forest counties to be 204 red fox (18 years) and 25 gray fox (25 years). These averages do not include years when there were no records. The first records which began in 1927 show a limited kill of gray foxes and *no* red fox. Eleven years later red fox harvest numbers increased markedly as the gray fox kill declined. This trend was maintained until 1955 when the last report of game harvest by species by counties was available. The trend is shown in Fig. 1.

Urocyon cinereoargenteus (gray fox). There are two authentic records, one in central Forest County and the other in the Popple watershed in Florence County [J].

FAMILY URSIDAE (bears).

Euarctos americanus (black bear). Four authentic records are listed, three from Forest and one from Florence counties between 1915 and 1935 [J]. Three authentic records are listed for Forest County and one for Florence County in Pine River watershed since 1935. Three specimens were taken in northeastern Florence County, west of Spread Eagle Lake [J]. Adult and cub tracks were seen on 22 July 1967, one mile east of Purdue Forestry Camp [G]. Black bears were also seen in this same area by the Purdue Camp staff [P] (1966–1968). In May 1969 Young sighted a black bear in the Pine River area near Chipmunk Rapids.

Black bears have undoubtedly been common in the Pine and Popple watersheds for many years. In 1937, when counties were given the option of closing or keeping open hunting season on

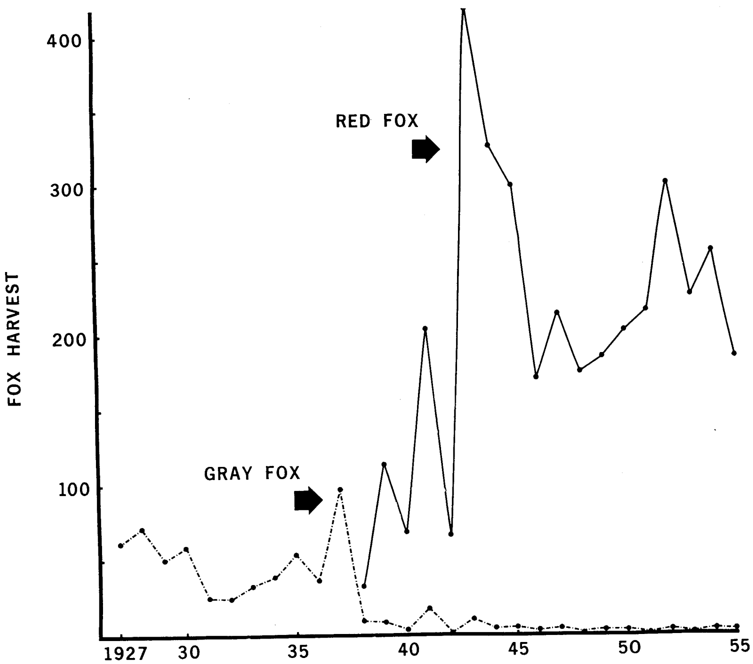

FIGURE 1. Red and gray fox harvest for Florence and Forest counties [DNR].

bears, Florence and Forest counties chose to keep the season open and concurrent with the deer season (Grimmer, 1937). Ten years later (Scott, 1947) the estimated black bear population was 105 for Florence County and 200 for Forest County. The annual harvest of black bear in these two counties is shown in Fig. 2. In 34 years between 1934 and 1968 when data were recorded, 923 black bears were harvested in Florence and Forest counties [DNR].

FAMILY PROCYONIDAE (raccoons).

Procyon lotor (raccoon). One authentic record exists for Forest County and one specimen was examined in Forest County at Laona [J]. Long treed a raccoon on 22 July 1967 in the Chipmunk Rapids area [G]. The Department of Natural Resources harvest record for the raccoon in Florence and Forest counties is erratic. In 30 years ending in 1956, raccoons were taken in only 10 years in Florence County, and in 11 years in Forest County. The average annual harvest was 12 and 23 raccoons for the respective counties.

FAMILY MUSTELIDAE (weasels and allies).

Martes americana (American marten). One authentic record is shown for the Pine River watershed, Florence County [J]. Charles Cory wrote in 1912 that he had been informed that "martens are still to be found in the counties of northern Wisconsin . . . . based

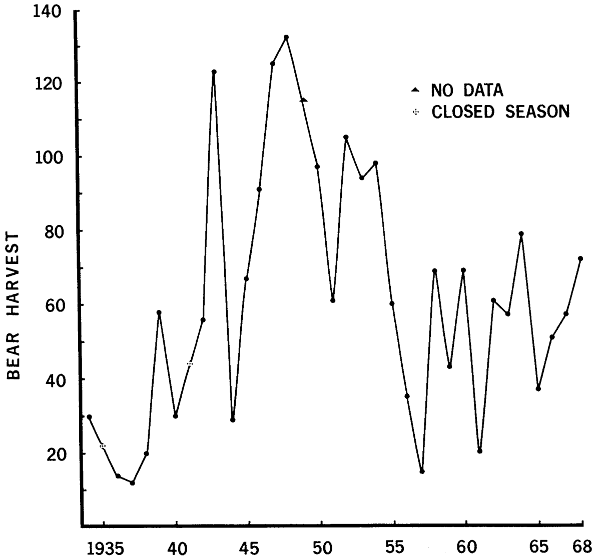

FIGURE 2. Black bear harvest for Florence and Forest counties [DNR].

upon personal knowledge or the testimony of reliable hunters and trappers . . . . ," and he listed Florence County among others [C., p. 383]. This furbearer was apparently present in the Pine and Popple watersheds but obviously not in great densities. In the personal records of Aldo Leopold is a notation that Mr. Jack Zatic saw a marten near Wabikan Lake, town of Laona in 1933 [L]. I found no published records of recent date. The marten is not on the list of furbearers that can legally be trapped in Wisconsin.

Martes pennanti (fisher). There are two authentic records for Forest County, one in the north near the Michigan line, the other on the Popple River [J]. Both records date from 1923. Tony Oliester, of Antigo, in 1923 claimed he saw fishers in northern Forest County just east of the Argonne game refuge and believes they are still there (as of 1939). Eugene Mayo agrees with Oliester, since he saw fishers in the same area in 1937 (Scott, 1939). Fourteen fishers (6 males; 8 females) were stocked under Conservation Department [WCD] auspices in a 40,000-acre "Fisher Wildlife Management Area" in a wilderness area within the Pine River watershed in northern Forest County, 1955–1957 (Bradle, 1957). Stocking continued so that 60 fishers in total were released in the Nicolet Forest from 1956 to 1960. They were shortly thereafter surviving and extending their range (Olson, 1966). Sightings have been made up to the present.

Mustela erminea (short-tailed weasel, ermine). One authentic record is listed for southwestern Forest County and one at the Popple River in Florence County [J]. The Andersons took a specimen on 18 October 1968 near Sea Lion Lake, Fern Township, Florence County [A]. This little mustelid is, however, a common species in both the Pine and Popple watersheds. A 30-year harvest record shows an average annual take from Florence County of 436, and 732 from Forest County. In 1927, 3,424 weasels were reported as taken from Forest County alone [DNR].

Mustela vison (mink). There is one authentic record in northwestern Forest County and one in Florence County along the Pine River [J]. Mink are doubtless present along both rivers and their tributaries. A 28-year average lists a harvest of 290 mink annually for Florence County and 359 for Forest County [DNR]. In an article on the Popple River, *Know a River* (Erickson, 1962) is the line: "You must watch for the mink that plays along the bank. . . ."

Taxidea taxus (badger). One authentic record is listed for southwestern Forest County and one in Florence County near the Popple River [J]. Badgers are not abundant anywhere in Wisconsin and harvest records for both counties show that in the years when at least one badger was reported the average annual harvest was 9 for Florence County and 6 for Forest County [DNR]. Since 1955 badgers have been a protected species.

Mephitis mephitis (skunk). One authentic record is located in south Forest County and one in Florence County south of the Pine River near Lake Michigan [J]. Three juveniles were observed in the Chipmunk Rapids area on 8 August 1968 [G], and a skunk was also seen in the Lost Lake area [P]. Skunks are common throughout Wisconsin, with the average annual kill of 109 for Florence County (28 years), and 89 for Forest County (29 years) [DNR].

Lutra canadensis (otter). There is one authentic record for Florence County in the Pine River watershed, and three authentic records for Forest County, one of these on the Popple River near its delta [J]. There is one specimen examined from Crandon, Forest County [J]. On a map showing the relative abundance of the otter in 1951 to 1953, Knudsen (1956) shows the otter to be fairly common in both Forest and Florence counties. In Leopold's personal notes he lists a Mr. F. Bell as seeing an otter on the Pine River in the town of Florence in 1924 [L].

The otter is rarely abundant anywhere in its Wisconsin range. The harvest data from Florence County show an annual harvest of 15 otters over a 22-year period, and 21 for Forest County over a 27-year period.

FAMILY FELIDAE (cats and allies).

Lynx canadensis (lynx). There is one authentic record of the lynx for Florence County [J]. There could have been and perhaps there still is an occasional lynx on either the Pine or Popple rivers. Published records, however, are meager. Fur-return records do not distinguish between lynx and the more abundant bobcat. The average annual harvest of "wildcats" for Florence and Forest counties is 62 (both counties over a 29-year period) [DNR].

Lynx rufus (bobcat). Two authentic records are listed, one in south-central Forest County, and one on the Pine River where it divides and turns north in Florence County [J]. One specimen was examined in Florence County (no locality) and three in Forest County, one at Laona and two at North Crandon [J].

ORDER ARTIODACTYLA

FAMILY CERVIDAE (deer and allies).

Odocoileus virginianus (white-tailed deer). Seventeen specimens have been examined from Florence County, 16 in the Spread Eagle area, and one in Florence. There are no records from Forest County [J]. Dahlberg and Guettinger (1956), in a range map of deer, show Forest and Florence counties as principal forest range, but that probable deer densities in both of these counties before 1800 were only about 10–15 deer per square mile. White-tailed deer were seen in the Lost Lake area (1966–1968) [P] and by Young in the Pine and Popple watersheds in May 1969. Schorger (1953, p. 224) records the first mention of deer for Florence County was in 1882, and also that "The following year, a party of four Ohio hunters . . . killed 18 deer in 25 days on the Popple River in 1888." Of Forest County Schorger says (p. 225), "There is no early information. Much game, including deer, was obtained by hunters in 1888. Indians bringing venison to Crandon in 1889 reported that there was not much game. Deer was scarce the following season. Indians had only fair success with deer in 1892; however, M. S. Barker bought 1000 pounds of venison from them at Armstrong. On October 26, 1893, John Bowers brought to Eagle River ten deer that were killed in the northern part of Forest County. The complaint was made that deer were being exterminated by market hunters so that few were left for the local people. Very few were killed at Three Lakes."

The deer harvest record for Florence and Forest counties is shown in Fig. 3 [DNR]. About twice as many deer are harvested in Forest County as in Florence County.

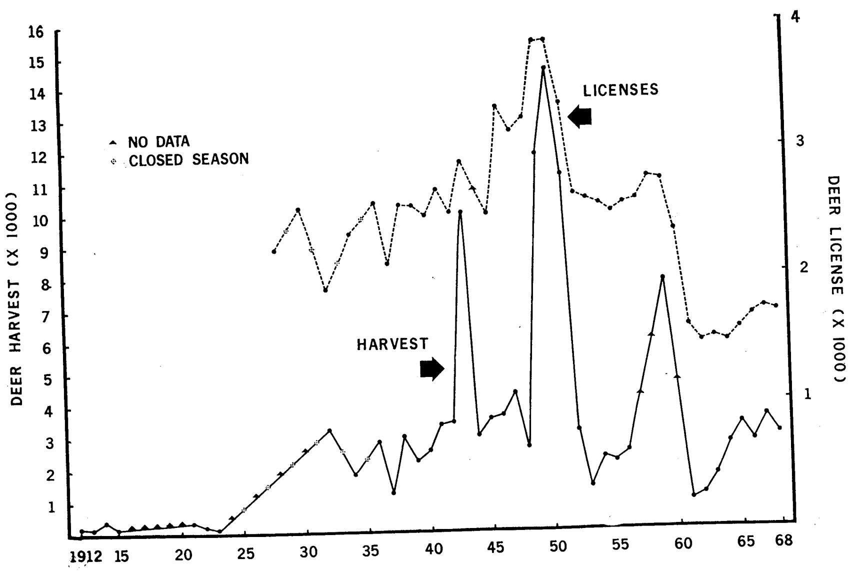

FIGURE 3. Deer license sales and deer harvest for Florence and Forest counties [DNR].

Alces alces (moose). There is one record of moose in southwestern Forest County (Schorger, 1956). He states (p. 7), "There is no authentic record of a native moose [for Florence County]." However he continues, "In October, 1885, a party of Indiana and Ohio hunters was reported to have killed 8 deer and a large moose. The locality was not stated. At this time most of the 'foreigners' hunted in Florence County (p. 4.) And further: "A bull moose that was supposed to have wandered down from Lake Superior, was killed at Rice Lake by Indians on March 18, 1873. . . . Rice Lake, town of Crandon, Forest County." It thus appears that there are no authentic (i.e., verified) records of native moose from either Florence or Forest Counties.

Discussion

In spite of the remoteness of Florence and Forest counties from centers of population, the first state game refuge, it appears, was in Forest County. In the personal records of Leopold there is a letter from W. F. Grimmer, then Superintendent of Game Management for the Conservation Department, State of Wisconsin, dated August 1, 1936. It reads: "On checking our records it appears that the first state refuge in Wisconsin was established by legislative act (Chapter 310, Laws of 1915, approved by the governor on June 23, 1915) and was known as the Forest County Game Refuge. The description of the refuge was Township 38 North Range 12 East and Township 38 North Range 13 East." Township 38 at that range includes the Pine and Popple rivers. Today that area is part of the Nicolet National Forest. The rationale for establishing a refuge at that time and place is vague at best.

As of 1970, there are 41 mammals recorded for Florence and Forest counties, any one of which either has been or is likely to be in the watersheds of the Pine and Popple rivers. The list is not complete for all possible resident species, nor has the subspecific grouping been thoroughly explored.

The fact that so little is known about the mammal fauna of the Pine and Popple watersheds should surprise no one. There has never been a county-by-county mammal survey of Wisconsin. Jackson's work (op. cit.) is an excellent starting point, as is Cory's (op. cit.) earlier report, but even in the former volume, published in 1961, the field work was completed ten years earlier, and much of it as many as 42 years earlier.

The much-needed survey would be expensive, but not exorbitant. The results could be used in problems of education, recreation, wildlife management, forestry, and in regional planning. It remains only for a public agency or teams of agencies to assume the initiative.

Some mammals, like wild rivers, may need to be protected and cared for so that they will remain on the Wisconsin scene as part of our historical heritage.

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THE AVIFAUNA OF THE PINE–POPPLE WATERSHED[1]

Howard Young

INTRODUCTION

The following account is based on observations made during eleven trips to the Pine–Popple area between May 1966 and June 1969. Acknowledgement for assistance in field work is made to Dr. Richard Bernard, Mr. Robert Fiehweg, Dr. William Hilsenhoff, Prof. Frederick Lesher, and Dr. Robert McCabe. This study was supported through funds made available by the Wisconsin Society for Ornithology.

Additional information was gleaned from back issues of the Passenger Pigeon (1939 to date), field records of the Milwaukee Museum, hunting kill estimates of the Wisconsin Department of Natural Resources, and personal correspondence with Dr. Alvin Throne, Waukesha, Wis., Mr. Samuel Robbins, Cadott, Wis., and Mr. William Hummel, Merrill, Wis.

The nature of the regular work assignments of people cooperating in this study made it possible for extensive observations to be made only during early summer. Most trips to the area were made in early June. Many of the early migrants were therefore missed. This is particularly noticeable in the case of waterfowl and shorebirds. In the former case some records of occurrence were obtained from hunting reports.

Another shortcoming involved the lack of time for intensive nest hunting, therefore the observers elected to spend their time censusing rather than searching for nests. Most of the definite breeding records were obtained from the field work of Pelzer and Stevens for the Milwaukee Museum in 1940. Indirect evidence was obtained for other species, but the records of breeding are very incomplete.

Careful quantitative measurements usually were not feasible; and, in the annotated list of 169 species which follows, statements of relative abundance are subjective. Those species simply listed without comment may be considered as generally common.

SPECIES OBSERVED

GAVIIFORMES. Common loon[3] (*Gavia immer*): observed at Lost Lake (Throne), Butternut Lake (Lesher), Stevens and Porcupine

[1] This is paper No. 5 in the series, "Studies on the Pine-Popple Wild Rivers area of Northeastern Wisconsin."
[3] Assumed breeder in the area of this study.
[4] See Table I, Duck Kill Reports.

Lakes (Young), and Emily Lake, 1968. While there are no published records of nests, this is well within the breeding range.

PODICIPEDIFORMES. No records. Grebes undoubtedly occur in the area, at least as transients.

CICONIIFORMES. Great blue heron[5] (*Ardea herodias*): seen in small numbers throughout the area; not common along Pine and Popple Rivers; rookery found in Goodman Timber, 1968. Green heron[3] (*Butorides virescens*): one individual at Howell Lake (Fiehweg); not common along Pine and Popple Rivers. American bittern[3] (*Botaurus lentiginosus*): observed along Pine River, 1940 (Pelzer and Stevens).

ANSERIFORMES. Canada goose (*Branta canadensis*): recorded October, 1957 (Passenger Pigeon 20 (1): 33). Snow goose (*Chen hyperborea*): Hilsenhoff observed a large mixed flock of this and the following species over Keyes Lake in November, 1966. Blue goose (*Chen caerulescens*): see preceding. Mallard[3,4] (*Anas platyrhynchos*): common; most frequently reported species in waterfowl kill estimates for Florence County. Black duck[3,4] (*Anas rubripes*): probably fairly common migrant. Gadwall[4] (*Anas streperus*): waterfowl kill estimates suggest that a few migrate through the study area. Pintail[4] (*Anas acuta*). Green-winged teal[4] (*Anas carolinensis*). Blue-winged teal[3,4] (*Anas discors*): seen in Franklin–Butternut area June 12, 1963, by Bernard; fairly common along Pine and Popple Rivers (Hilsenhoff). American widgeon[4] (*Mareca americana*). Shoveler[4] (*Spatula clypeata*). Wood duck[4] (*Aix sponsa*): pair on Halsey Lake, June 1967 (Lesher). Redhead[4] (*Aythya americana*). Ring-necked duck[3,4] (*Aythya collaris*). Canvasback[4] (*Athya valisneria*). Scaup[3,4] (*Athya spp.*). Common goldeneye[4] (*Bucephala clangula*): a record for August 2, 1968 (Hummel) probably represents a sick or injured bird, though there are several breeding records for northern Wisconsin (Kumlien and Hollister 1951). Bufflehead[4] (*Bucephala albeala*). Ruddy duck[4] (*Oxyura jamaicensis*). Hooded merganser[5] (*Lophodytes cucullatus*): female with young seen on Riley Lake; single female seen on Halsey Lake. Common merganser[3] (*Mergus merganser*): reported from the Pine River, July 1940 (Pelzer and Stevens). Red-breasted merganser[3] (*Merganser serrator*): reported present in good numbers, August 1941. (Pass. Pigeon 3 (9): 82).

FALCONIIFORMES. Turkey vulture (*Cathartes aura*): seen in April 1946 (Pass. Pigeon 18 (3): 129). Goshawk[3] (*Accipiter atricapillus*): seen in November 1943 (Pass. Pigeon 4 (4): 98):

[5] Breeding records exist for this species in the area of this study.

not common, but has also been recorded on Christmas censuses from adjacent Forest County. Sharp-shinned hawk[3] (*Accipiter striatus*): Pine River July 1940 (Pelzer and Stevens); Franklin Lake 1966 (Lesher): not common. Cooper's hawk (*Accipiter cooperii*): one seen at Lost Lake July 1939 (Throne); also on Pine River July 1940 (Pelzer and Stevens). Red-tailed hawk[3] (*Buteo jamaicensis*): fairly common. Broad-winged hawk[3] (*Buteo platypterus*): probably the most abundant hawk of the study area. Rough-legged hawk (*Buteo lagopus*): November 1957 (Pass. Pigeon 20 (1): 34); also thirteen were seen March 27–28, 1968, and three on April 12, 1968 (Hilsenhoff). Bald eagle[5] (*Haliaeetus leucocephalus*): immatures seen by Throne in June 1940, and by Lesher in 1966; adult at Stevens Lake 1966, and active nest near there 1968 and 1969; formerly nested at Lost Lake; apparently scarce in the area at present. Marsh hawk[3] (*Circus cyaneus*): two individuals seen (Young, Lesher 1968). Osprey[5] (*Pandion haliaetus*): several individuals seen (Throne 1940, Young and Fiehweg 1966); active nest near Long Lake in 1967, 1968 and 1969; not common. Sparrow hawk[5] (*Falco sparverius*): fairly common; seen in agricultural areas; nest with young found in Goodman Timber July 1968 by Bernard.

GALLIFORMES. Spruce grouse[3] (*Canachites canadensis*): Scott (1943) lists the last record for Florence County as a single bird seen in 1932, and estimates that as of 1951 the population for this area might lie between 10 and 50; no evidence of their presence since then has been discovered. Ruffed grouse[5] (*Bonasa umbellus*): common; seen with young chicks along Pine River 1940 (Pelzer and Stevens); estimated harvest for Florence County in 1967 was 8,832. Sharp-tailed grouse[5] (*Pediocetes phasianellus*): seen with young chicks along Pine River, 1940 (Pelzer and Stevens); reported at intervals since then, with last published record for April 1964 (Pass. Pigeon 27 (1): 32); estimated hunter kill in Florence County for 1960 was 200.

GRUIFORMES. Virginia rail[3] (*Rallus limicola*): reported in September 1945 (Pass. Pigeon 7 (4): 124). Coot[3] (*Fulica americana*): reports of hunters indicate the following harvests for Florence County: 23 in 1938, 515 in 1939, 34 in 1940, 30 in 1941, 181 in 1942, 183 in 1943.

CHARADRIIFORMES. Killdeer[3] (*Charadrius vociferus*): fairly common, lake edges and streams. Woodcock[3] (*Philohela minor*): two seen near Pine River, 1968; estimated hunter kill in Florence County for 1966 was 536. Upland plover[3] (*Bartramia longicauda*): one seen in June 1967 (Lesher), a pair in June 1969 in Florence cemetery (Young). Spotted sandpiper[5] (*Actitis macularia*): seen with young along Pine River in 1940 (Pelzer and Stevens) and with young on the Pine in 1968 (Hilsenhoff); not common in the watershed. Solitary sandpiper (*Tringa solitaria*): one individual seen along Pine River (Young, June 1967), two near Fence (Hummel, July 1968). Herring gull (*Larus argentatus*): seen in summer of 1966 (Fiehweg). Ring-billed gull (*Larus delawarensis*): flock of about 20 (Lesher, 1966). Common tern[3] (*Sterna hirundo*): sighted by Bernard at Franklin Lake in 1963, and by Young at Halsey Lake in 1966. Black tern[3] (*Chlidonias niger*): seen on several lakes in the watershed area.

COLUMBIFORMES. Mourning dove[3] (*Zenaidura macroura*): common in residential and agricultural areas.

CUCULIFORMES. Yellow-billed cuckoo[3] (*Coccyzus americanus*): uncommon; Franklin–Butternut area (Bernard, 1963; Lesher, 1966). Near Fence (Young, 1968). Black-billed cuckoo[3] (*Coccyzus erythrophthalmus*).

STRIGIFORMES. Great horned owl[3] (*Bubo virginianus*): heard by Young, 1966; Bernard, 1963. Barred owl[3] (*Strix varia*): heard on several occasions.

CAPRIMULGIFORMES. Whip-poor-will[3] (*Caprimulgus vociferus*): recorded Sept. 1956 (Pass. Pigeon 19 (1): 39); also commonly

TABLE I. DUCK KILL REPORTS.

Compiled from mandatory hunter reports made to the Wisconsin Department of Natural Resources for the years 1938 to 1943 inclusive. These figures should be viewed with caution, since many hunters are not accurate in their identifications. However, all species shown here are common migrants in Wisconsin.

SPECIES	1938	1939	1940	1941	1942	1943
Mallard	596	891	526	516	301	677
Black duck	89	217	126	67	97	145
Gadwall	—	—	4	6	41	—
Pintail	3	50	166	10	23	5
Green-winged teal	42	84	24	65	5	59
Blue-winged teal	89	171	126	130	33	89
American widgeon	30	52	2	15	3	16
Shoveler	13	2	—	—	26	—
Redhead	—	25	78	56	38	3
Ring-necked duck	1	8	88	31	82	—
Canvasback	13	29	—	10	5	5
Bluebill (scaup spp.)	564	1354	354	357	577	35
Common goldeneye	—	8	30	23	8	5
Bufflehead	—	—	18	8	8	3
Ruddy duck	1	—	—	17	—	—
"Merganser"	60	56	100	54	33	54
Miscellaneous	231	23	—	90	54	8

heard during this study. Nighthawk[3] (*Chordeiles minor*): fairly common on lower Pine River.

APODIFORMES. Chimney swift[3] (*Chaetura pelagica*). Ruby-throated hummingbird[5] (*Archilochus colubris*): nest with young, July 1940 (Pelzer and Stevens).

CORACIIFORMES. Belted kingfisher[3] (*Megaceryl alcyon*): common on streams and in lake areas.

PICIFORMES. Flicker[3] (*Colaptes auratus*): very common. Pileated woodpecker[3] (*Dryocopus pileatus*): not rare; also has been recorded in Christmas censuses from Forest County. Red-headed woodpecker[3] (*Melanerpes erythrocephalus*): found in less densely forested areas. Yellow-bellied sapsucker[5] (*Sphyrapicus varius*): nest found July 1940 (Pelzer and Stevens). Hairy woodpecker[3] (*Dendrocopus villosus*): while there is evidence that *D. villosus* is more abundant than *D. pubescens* in some parts of northern Wisconsin (Young, 1961), limited quantitative data suggest that they occur in approximately equal numbers in the study area. Downy woodpecker[3] (*Dendrocopus pubescens*): see preceding. Black-backed woodpecker[3] (*Picoides arcticus*): rare; seen along Pine River by Pelzer and Stevens (1940); another was reported Oct. 1943 (Pass. Pigeon 4 (4): 98). Northern three-toed woodpecker[3] (*Picoides tridactylus*): one seen in 1966 (Pass. Pigeon 29 (4): 120).

PASSERIFORMES: *Tyrannidae*. Eastern kingbird[3] (*Tyrannus tyrannus*). Great crested flycatcher[3] (*Myiarchus crinitus*). Phoebe[5] (*Sayornis nigricans*): nest found by Pelzer and Stevens, 1940; several nests also found in 1967 and 1968 (Hilsenhoff). Yellow-bellied flycatcher[3] (*Empidonax flaviventris*): May 31, 1969; one bird at Franklin Lake (Bernard). Traill's flycatcher[3] (*Empidonax traillii*). Least flycatcher[3] (*Empidonax minimus*): abundant. Wood peewee[3] (*Contopus virens*): very common. Olive-sided flycatcher[3] (*Nuttallornis borealis*): recorded by Lesher at Franklin Lake, 1966; apparently not common in the Pine–Popple area.

Alaudidae. Horned lark[3] (*Eremophila alpestris*): recorded Feb. 1964 (Pass. Pigeon 26 (3): 151), and March 1967 (Bernard).

Hirundinidae. Tree swallow[5] (*Iridoprocne bicolor*): common; seen nesting at Florence and at Sea Lion Lake; many immatures seen at other places. Bank swallow[5] (*Riparia riparia*): one colony near Fence, also near Lake Emily. Rough-winged swallow[5] (*Stelgidopteryx ruficollis*): two seen at Pine River bridge, 1968; nesting near Lake Emily, 1969. Barn swallow[5] (*Hirundo rustica*): common; seen flying to nests. Cliff swallow[5] (*Petrochelidon pyrrhonota*): common; seen flying to nests. Purple martin[5] (*Progne *subis*): common; seen flying to nests; arrival date of April 12, 1964 (Pass. Pigeon 27 (1): 37).

Corvidae. Gray jay[5] (*Perisoreus canadensis*): fairly common; seen in Goodman Timber and along Pine and Popple Rivers; young bird seen in May 1964 (Pass. Pigeon 27 (1): 38). Blue jay[5] (*Cyanocitta cristata*): seen feeding young, July 1940 (Pelzer and Stevens). Raven[3] (*Corvus corax*): common, timbered areas. Crow[5] (*Corvus brachyrhynchos*): seen feeding young, July 1940 (Pelzer and Stevens).

Paridae. Black-capped chickadee[3] (*Parus atricapillus*). Boreal chickadee[3] (*Parus hudsonicus*): three seen in November 1949 (Pass. Pigeon 11 (2): 87); also reported Sept. 1956 (Pass. Pigeon 19 (1): 40) and Aug. 1959 (Pass. Pigeon 21 (2): 86).

Sittidae. White-breasted nuthatch[3] (*Sitta carolinensis*): seen more commonly than the following during the period of this study. However, Christmas census records indicate that *S. canadensis* is the more abundant of the two in this region (Young, 1965). Red-breasted nuthatch[3] (*Sitta canadensis*): see preceding.

Troglodytidae. House wren[5] (*Troglodytes aedon*): common; observed nesting in houses (Florence), but also often heard in woods away from dwellings. Winter wren[3] (*Troglodytes troglodytes*): uncommon. Short-billed marsh wren[3] (*Cistothorus platensis*): found in several low lying meadows.

Mimidae. Catbird[5] (*Dumetella carolinensis*): nest with 4 eggs near Frog Lake, June 9, 1969. Brown thrasher[5] (*Toxostoma rufum*): nest with 3 young ready to fledge, June 9, 1969, near Frog Lake.

Turdidae. Robin[5] (*Turdus migratorius*): common nester, many local young observed. Wood thrush[3] (*Hylocichla mustelina*). Hermit thrush[5] (*Hylocichla guttata*): nest record for Lost Lake, 1939 (Pass. Pigeon 3 (2): 13). Swainson's thrush (*Hylocichla ustulata*): seen June 12–14, 1963, at Butternut Lake (Bernard). Veery[3] (*Hylocichla fuscescens*): abundant. Bluebird[3] (*Sialia sialis*).

Regulidae. Golden-crowned kinglet[3] (*Regulus satrapa*): recorded June 1970 (Robbins). Ruby-crowned kinglet[3] (*Regulus calendula*): uncommon; bird seen July 9, 1968, was probably a breeding bird (Hilsenhoff); pair seen June 1970 (Robbins).

Bombycillidae. Cedar waxwing[5] (*Bombycilla cedrorum*): abundant; nest with young, July 1940 (Pelzer and Stevens).

Laniidae. Loggerhead shrike[3] (*Lanius ludovicianus*): observed in Oct. 1957 (Pass. Pigeon 20 (1): 40).

Sturnidae. Starling[5] (*Sturnus vulgaris*): common in residential areas, nesting in martin houses; numerous young observed.

Vireonidae. Yellow-throated vireo (*Vireo flavifrons*): uncommon. Solitary vireo[3] (*Video solitarius*): four records (Lesher, 1966; Hilsenhoff, 1967; Bernard and North, 1968; Robbins, 1970). Red-eyed vireo[5] (*Vireo olivaceus*): abundant; seen feeding young 1940 (Pelzer and Stevens). Warbling vireo[3] (*Vireo gilvus*).

Parulidae. Black and white warbler[3] (*Mniotilta varia*). Golden-winged warbler[3] (*Vermivora chrysoptera*): fairly common along Pine and Popple Rivers (Hilsenhoff). Tennessee warbler (*Vermivora peregrina*): one record (Young, June 1967). Nashville warbler[5] (*Vermivora ruficapilla*): abundant; seen feeding young, 1940 (Pelzer and Stevens). Parula warbler[3] (*Parula americana*): uncommon. Yellow warbler[3] (*Dendroica petechia*). Magnolia warbler[5] (*Dendroica magnolia*): seen feeding young 1940 (Pelzer and Stevens); uncommon. Cape May warbler (*Dendroica tigrina*): one record, May 27, 1968 (Hilsenhoff). Myrtle warbler[3] (*Dendroica coronata*): observed by Fiehweg, 1966. Black-throated green warbler[3] (*Dendroica virens*): fairly common in maple areas. Blackburnian warbler[3] (*Dendroica fusca*). Chestnut-sided warbler[5] (*Dendroica pennsylvanica*): nesting record July 1940 (Pelzer and Stevens); very common. Bay-breasted warbler (*Dendroica castanea*): single bird seen by Lesher, June 1966. Blackpoll warbler (*Dendroica striata*): several seen by Lesher, June 1966. Pine warbler[3] (*Dendroica pinus*). Palm warbler (*Dendroica palmarum*): Hilsenhoff reported a single bird for May 10, 1968. Ovenbird[3] (*Seiurus aurocapillus*): abundant. Northern water thrush[3] (*Seiurus noveboracensis*): fairly common along Pine and Popple rivers. Mourning warbler[5] (*Oporornis philadelphia*): nesting record at Lost Lake 1939 (Throne); also 1940 (Pelzer and Stevens). Yellowthroat[5] (*Geothlypis trichas*): abundant; nesting record at Lost Lake 1940 (Throne). Canada warbler[3] (*Wilsonia canadensis*): uncommon. Redstart[5] (*Setophaga ruticilla*): abundant; nesting record at Lost Lake 1940 (Throne).

Ploceidae. House sparrow[5] (*Passer domesticus*): abundant in towns and near farms; numerous nests observed.

Icteridae. Bobolink[3] (*Dolichonyx oryzivorous*): common in grassland areas, particularly in eastern half of watershed. Eastern meadowlark[3] (*Sturnella magna*): common in grassland areas, often in close proximity to *S. neglecta*. Western meadowlark[3] (*Sturnella neglecta*): see preceding. Redwing[5] (*Agelaius phoeniceus*): abundant near lakes; nest with 3 downy young near Commonwealth, June 9, 1969. Baltimore oriole[5] (*Icterus galbula*): nest found July 1940 (Pelzer and Stevens). Brewer's blackbird[3] (*Euphagus cyano-*

cephalus) : common in agricultural areas. Bronzed grackle[5] (*Quiscalus versicolor*) : abundant; seen carrying food, Florence, 1969. Cowbird[3] (*Molothrus ater*) : abundant.

Thraupidae. Scarlet tanager[5] (*Piranga olivacea*) : nesting record July 1940 (Pelzer and Stevens).

Fringillidae. Cardinal[3] (*Richmondena cardinalis*) : uncommon. Rose-breasted grosbeak[3] (*Pheuticus ludovicianus*). Indigo bunting[3] (*Passerina cyanea*). Evening grosbeak[3] (*Hesperiphona vespertina*) : Fiehweg saw 5 late in June 1966; Hilsenhoff saw 25 on the Pine River in June 1968; also several winter records. Purple finch[5] (*Carpodacus purpureus*) : nesting record July 1940 (Pelzer and Stevens). Pine grosbeak (*Pinicola enucleator*) : one record Jan. 1967 (Bernard) ; reported quite regularly on Forest County Christmas censuses. Pine siskin[3] (*Spinus pinus*) : Hilsenhoff had March, April and May records in 1968. Goldfinch[5] (*Spinus tristis*) : nesting record July 1940 (Pelzer and Stevens). Red crossbill[3] (*Loxia curvirostra*) : "numerous" in Florence County during deer season, 1960 (Pass. Pigeon 23 (2) : 74). Twelve seen in March 1965 (Pass. Pigeon 28 (1) : 41). Whitewinged Crossbill (*Loxia leucoptera*) : a flock on the lower Pine in November 1966 (Hilsenhoff). Rufous-sided towhee[5] (*Pipilo erythrophthalmus*) : nest with 3 eggs, June 1968 (Young). Savannah sparrow[3] (*Passerculus sandwichensis*). Vesper sparrow[3] (*Pooecetes gramineus*). Slate-colored junco[3] (*Junco hyemalis*) : uncommon. Tree sparrow (*Spizella arborea*) : recorded Sept. 1959 (Pass. Pigeon 21 (2) : 89). Chipping sparrow[3] (*Spizella passerina*). Clay-colored sparrow[3] (*Spizella pallida*) : found in several areas in vicinity of Florence; previous 1943 record (Pass. Pigeon 5 (3) : 74). Field sparrow[3] (*Spizella pusilla*) : uncommon. White-throated sparrow[3] (*Zonotrichia albicollis*). Fox sparrow (*Passerella iliaca*) : four individuals seen by Hilsenhoff, April 11, 1968. Swamp sparrow[3] (*Melospiza georgiana*). Song sparrow[5] (*Melospiza melodia*) : nesting record July 1940 (Pelzer and Stevens) ; abundant. Lapland longspur (*Calcarius lapponicus*) : recorded Oct. 1957 (Pass. Pigeon 20 (1) : 45). Snow bunting (*Plectrophenax nivalis*) : Nov. record 1946 (Pass. Pigeon 9 (1) : 34) ; Bernard found them in agricultural areas, Jan. and March 1967.

Discussion

Early in the study, two 25-mile transects were established. One (Transect A) ran essentially west to east mainly through the Goodman timber, north of Highway 70, but also cut across some agricultural land for about 3 miles. The second (Transect B) started at Florence and ran primarily north to south along Highway 101, then curved west. This route traversed much agricultural area, but also intersected some timber.

These transects were run by automobile, with stops at half-mile intervals where observations were made for 3 minutes. Transect A was run 5 times, and a total of 82 species was observed. Transect B was run 6 times, with a total of 77 species observed. The transects give some opportunity for comparing the avifauna of the two areas traversed. The data are summarized in Table II.

If the two areas had identical avifauna, all species would be common to both transects; if they were entirely different, they would have no species in common. In this case we have 64/95 = .67 homogeneity. However, of the 28 species restricted to one transect or the other, 22 (79%) were seen only on a single run. It appears, therefore, that the observed differences between the two transects are probably fortuitous.

The considerably greater agricultural development in the eastern part of the watershed has not as yet resulted in any significant change in the composition of the avifauna. This reflects the persistence of large wooded areas in the agricultural area, some penetration of farming into the western portion, and the mobility of the birds.

The data are not adequate for a detailed discussion of species abundance. In the more heavily forested area (Transect A) there were more records of ruffed grouse, redstart and scarlet tanager. Along the B transect the following were distinctly more common than along A: starling, English sparrow, eastern meadowlark, western meadowlark, bronzed grackle. All of these species, however, were recorded on both transects.

Another view of the avifauna may be obtained by examining the results of both transects which were run simultaneously on July 14, 1968. Transect A was run by Drs. Richard Bernard, of Wisconsin State University, Superior, and Charles North, Wisconsin State University, Whitewater. Transect B was run by myself and Dr. Steven Goddard, Wisconsin State University, River Falls. The results are shown in Table III.

Typical patterns of abundance appear. On Transect A a total of 61 species and 324 individuals was recorded. Of these, 21 (34%)

TABLE II. SUMMARY DATA, TRANSECTS A AND B. COLUMN 1, NUMBER OF INDIVIDUALS; COLUMN 2, PERCENTAGE OF THE TOTAL.

	No.	%
Total species observed, both transects	95	100
Species common to both transects	64	67
Species observed only on Transect A	16	17
Species observed only on Transect B	12	13

TABLE III. FREQUENCY OF BIRD SPECIES OBSERVED ON JULY 14, 1968.

Fr. = frequency, or percentage occurrence, i.e., number of stops at which the species was seen divided by the total number of stops. *No.* = total individuals of the species seen that day on the whole transect. *Trans.A* = Transect A. *Trans.B* = Transect B.

Species	Trans. A		Trans. B	
	Fr.	No.	Fr.	No.
Common Loon	.02	1	.00	0
Great Blue Heron	.04	2	.00	0
Red-tailed Hawk	.02	1	.00	0
Marsh Hawk	.00	0	.02	1
Sparrow Hawk	.02	4	.04	2
Ruffed Grouse	.02	1	.02	3
Killdeer	.02	1	.06	4
Y.-billed Cuckoo	.00	0	.02	1
Chimney Swift	.06	3	.02	1
R. T. Hummingbird	.02	1	.00	0
Flicker	.10	14	.30	17
Y.-bellied Sapsucker	.06	3	.00	0
Hairy Woodpecker	.02	1	.00	0
Downy Woodpecker	.02	1	.00	0
Eastern Kingbird	.10	8	.10	6
Crested Flycatcher	.02	1	.16	8
Phoebe	.00	0	.02	1
Least Flycatcher	.06	5	.08	4
Wood Pewee	.04	2	.02	1
Tree Swallow	.04	2	.12	8
Barn Swallow	.04	2	.16	14
Cliff Swallow	.02	4	.08	6
Purple Martin	.02	1	.02	2
Blue Jay	.08	18	.20	15
Raven	.02	1	.06	5
Crow	.16	12	.28	22
B. C. Chickadee	.10	13	.02	2
W. B. Nuthatch	.02	1	.02	1
House Wren	.06	4	.04	2
Winter Wren	.04	4	.00	0
S. B. Marsh Wren	.02	1	.00	0
Catbird	.02	1	.02	1
Robin	.08	13	.36	26
Wood Thrush	.C6	3	.00	0
Hermit Thrush	.12	10	.04	3
Veery	.08	10	.16	9
Bluebird	.04	3	.02	1
Cedar Waxwing	.10	17	.02	2
Starling	.04	2	.20	65
Solitary Vireo	.02	1	.00	0
Red-eyed Vireo	.14	35	.22	12
Warbling Vireo	.00	0	.02	1
Bl. and Wh. Warbler	.02	1	.00	0
B. Throat. Bl. Warb.	.02	2	.00	0
Nashville Warbler	.04	4	.00	0
B. Throat. Gr. Warb.	.06	5	.00	0
Chestnut-s. Warbler	.02	1	.04	2
Pine Warbler	.00	0	.02	1
Ovenbird	.10	15	.04	2
Mourning Warbler	.02	1	.00	0
Yellowthroat	.06	3	.10	6
Redstart	.02	1	.02	1
English Sparrow	.00	0	.08	9
Bobolink	.02	1	.04	7
Eastern Meadowlark	.00	0	.02	1
Western Meadowlark	.00	0	.04	2
Redwing	.04	3	.12	15
Bronzed Grackle	.00	0	.08	14
Br. Headed Cowbird	.04	16	.12	6
Scarlet Tanager	.02	5	.00	0
R.-Br. Grosbeak	.06	4	.08	4
Indigo Bunting	.04	4	.08	4
Purple Finch	.02	1	.02	1
Goldfinch	.10	19	.10	13
Rufous-sided Towhee	.06	4	.10	5
Savannah Sparrow	.06	5	.10	6
Vesper Sparrow	.02	1	.04	2
Chipping Sparrow	.08	15	.20	11
Clay-col. Sparrow	.02	1	.04	3
W. T. Sparrow	.12	8	.02	1
Song Sparrow	.10	8	.32	19

were represented by a single individual. Twelve species (20%) were represented by 10 or more individuals. Together they accounted for 191 (59%) of all individuals seen. The crow was the species recorded at the greatest number of stops; the red-eyed vireo had the largest number of individuals recorded. On Transect A the number of species per stop ranged from 0 to 15, with an average of 5.2; individuals recorded per stop ranged from 0 to 22, with an average of 7.5.

On Transect B a total of 54 species and 383 individuals was recorded. Of these, 14 (26%) were represented by a single individual. Twelve species (22%) were represented by 10 or more individuals. Together they accounted for 243 (63%) of all individuals seen. The robin was the species seen at the greatest number of stops; the starling had the greatest number of individuals recorded. On Transect B the number of species observed per stop ranged from 0 to 12, with an average of 5.3; individuals recorded per stop ranged from 0 to 46, with an average of 8.1.

In general it may be said that the Pine–Popple watershed has the typical bird life of northern Wisconsin.

Hypothetical List

The following group of 47 species would be expected to occur in the study region according to distributional maps (Gromme 1963) and correspondence with Robbins (1971), but have not been recorded in the literature for this specific area, and were not observed during the project. Forty (85%) of these are transient visitants; only 7 supposed breeders have not been recorded. Also, almost forty per cent of the species on the hypothetical list are shore birds, most of which had moved farther north by the time the observers reached the study area.

If all species on this hypothetical list do in fact occur in the Pine–Popple watershed, the total species list is raised to 216, suggesting that our efforts resulted in the recording of about 78% of the species probably found in the area. Those not yet recorded are listed below.

Horned grebe (*Colymbus auritus*), pied-billed grebe[3] (*Podylimbus podiceps*), double-crested cormorant (*Phalacrocorax auritus*), whistling swan (*Olor cygnus*), sandhill crane (*Grus canadensis*), Sora[3] (*Porzana carolina*), semi-palmated plover (*Charadrius semipalmatus*), golden plover (*Pluvialis dominica*), black-bellied plover (*Squatarola squatarola*), ruddy turnstone (*Arenaria interpres*), common snipe[3] (*Capella gallinago*), greater yellowlegs (*Totanus melanoleucus*), lesser yellowlegs (*Totanus flavipes*), pectoral sandpiper (*Erolia melanotos*), white-rumped sandpiper (*Erolia fuscicollis*), Baird's sandpiper (*Erolia bairdii*), least sandpiper (*Erolia minutilla*), dunlin (*Erolia alpina*), stilt sandpiper (*Micropalama himantopus*), semipalmated sandpiper (*Ereunetes pusillus*), sanderling (*Crocethis alba*), short-billed dowitcher (*Limnodromus griseus*), long-billed dowitcher (*Limnodromus scolopaceus*), Wilson's phalarope (*Steganopus tricolor*), Bonaparte's gull (*Larus philadelphia*), Forster's tern (*Sterna forsteri*), Caspian tern (*Hydroprogne caspia*).

Snowy owl (*Nyctea scandica*), long-eared owl (*Asio otus*), short-eared owl (*Asio flammeus*), brown creeper[3] (*Certhia familiaris*), long-billed marsh wren[3] (*Telmatodytes palustris*), gray-cheeked thrush (*Hylochichla minima*), water pipit (*Anthus spinoletta*), Bohemian waxwing (*Bombycilla garrulus*), northern shrike (*Lanius excubitor*).

Orange-crowned warbler (*Vermivora celata*), Cerulean warbler (*Dendroica cerulea*), Connecticut warbler (*Oporornis agilis*), Wilson's warbler (*Wilsonia pusilla*), yellow-headed blackbird[3] (*Xanthocephalus xanthocephalus*), rusty blackbird (*Euphagus carolinas*), common redpoll (*Acanthis flammea*), grasshopper sparrow[3] (*Ammodramus savannarum*), sharp-tailed sparrow (*Ammospiza caudacuta*), white-crowned sparrow (*Zonotrichia leucophrys*), Lincoln's sparrow (*Melospiza lincolnii*).

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THE AMPHIBIANS AND REPTILES OF FOREST, FLORENCE AND MARINETTE COUNTIES WITH SPECIAL REFERENCE TO THE PINE, POPPLE AND PIKE WATERSHEDS[1]

William E. Dickinson

INTRODUCTION

Some of the factors that probably influence the amphibian and reptile population of the watersheds under consideration are the temperature (mean: 39° to 40° Fahrenheit), rainfall (36–40 inches annually), soils (some peat, sand and Kenon Loam) and the soil chemistry (acid to slightly acid). The area in general has a gently rolling aspect without drastic dispersal barriers. In general it is not being cleared for agriculture to the extent that the reptiles and amphibians are much disturbed. Food is not a primary concern: there seems to be an abundance.

The 44 collecting sites in the three counties involved in the survey vary in types of soil, vegetation, habitats and moisture. Previous collecting in the areas considered has been generally sketchy. The first records were apparently those of vacationers. They came mainly from certain limited lake areas, and this resulted in wide gaps in the data. Intensive collecting has been done by Howard Suzuki, 1945–47 (908 specimens), Dr. C. A. Long (400 specimens), and Dr. George Becker and his students, of Wisconsin State University at Stevens Point, Wisconsin, 1966–67 (338 specimens). Edgren and Levi also worked in the region.

When the present survey committee was formed, the available records of species and subspecies (12) for the area appeared quite small, but subsequent collections and research have added several more. In all, there are now some 35 species and subspecies recorded or observed for this area.

Many records, though outside the actual watersheds involved, are nevertheless included (see Table I). These extraneous species and subspecies have been listed because of similarity of habitats, and because their range may well be found, in the future, to include the watersheds of the Pine, Popple and Pike rivers.

A great deal of collecting has been done in Vilas and Oneida counties by vacationers. Some of the species thus obtained might be expected to get into the watersheds of the three rivers here con-

[1] This is paper No. 6 in the series, "Studies on the Pine-Popple Wild Rivers Area of Northeastern Wisconsin."

sidered. However, most streams in the two counties mentioned above are in the Mississippi drainage basin, rather than in the Great Lakes watershed, which is the area under discussion here.

Despite intermittent rumors of poisonous species seen by some visitors or even residents of the area, *no* poisonous species have up to the present been deposited in collections or reported by expert observers.

Species Collected or Observed

In the following list certain items of information are given for each animal, and in the order stated: (1) the name of the species; (2) the collector; (3) date of collection or observation; (4) the station or locality at which the specimen was taken or observed; (5) the catalog number of the specimen in the museum where it is deposited; (6) the name of the museum where it is deposited. To save space the following abbreviations will be used: *Sta,* station or locality of collection or observation; *Cat. No.,* catalog number under which the specimen is stored in the museum; *MPM,* Milwaukee Public Museum; *WSUSP,* museum of the Wisconsin State University, at Stevens Point, Wisconsin; *UW,* museum of the University of Wisconsin, at Madison, Wisconsin; *CMNH,* Chicago Museum of Natural History, at Chicago, Illinois. For the location of the collecting stations, listed by number, consult Table I.

Class Amphibia

Order Caudata (tailed amphibians).

Mudpuppies. *Necturus maculosus maculosus* (mudpuppy): range shown by Bishop (1943, Map 1) and by Conant (1958, Map 154) as including the Pine–Popple–Pike area. A subspecies, *N. m. stictus* is also reported by Conant (1958, Map 154) as ranging into this area.

Salamanders. *Ambystoma laterale* and *A. jeffersonianum* (Jefferson salamander): Kuony, 8/10/36, Sta. 29, Cat. No. 2568, MPM; Burant, 7/8/69, Sta. 44, Cat. No. 3274, MPM. *Plethodon cinereus cinereus* (red-backed salamander): Kuony, 8/10/36. Cat. No. 2569, MPM; Strelitzer, 7/5/69, Sta. 44, Cat. No. 3273, MPM. *Hemidactylium scutatum* (four-toed salamander): Lindstrom, 5/29/49, Sta. 15, Cat. No. 2667, MPM. *Diemictylus viridescens* (newt): Suzuki, 9/7/49, Sta. 42, Cat. No. 2793, MPM.

Order Salientia (jumping amphibians).

Toads. *Bufo terrestris americanus* (common American toad): Long, 7/21/67, Sta. 9, Cat. No. 203, WSUSP; Becker, 6/15/66, Sta. 19, Cat. No. 3198, MPM; Suzuki, 10/30/66, Sta. 37, Cat. No.

TABLE I. COLLECTION AND OBSERVATION STATIONS: FOREST, FLORENCE AND MARINETTE COUNTIES.

Stations 1–11 and 13 are in the Pine River watershed; Station 14 in the Popple drainage basin; Stations 12, 16, 19, 21, 24–27, 30, 32 and 37 are in the Pike River watershed; the remainder are in adjacent areas within the three counties involved.

STATION	TOWN. NORTH	RANGE EAST	SECTION AND QUARTER	COLLECTOR	LOCATION	NEAREST TOWN
1	40	14	14 SE¼	Becker	Lily Pond Lake	Tipler
2	40	14	26	Becker	Stevens Lake	Tipler
3	40	15	28	Levi		Tipler
4	40	13	25 W½	Becker		Tipler
5	40	12	14	Becker	Howell Lake	Tipler
6	40	12	16 NE¼	Becker	Franklin Lake	Tipler
7	40	12	12 SE¼	Becker	Franklin Lake	Tipler
8	40	12	34 SW¼	Becker	Butternut Lake	Tipler
9	39	15	11	Long		Long Lake
10	39	15	19	Dickinson		Long Lake
11	39	12	12 NW¼	Becker	McDonald Creek	Newald
12	39	12	27 E½	Becker	Kimball Creek	Newald
13	39	19	4 SE¼	Clowes	Spread Eagle L.	Spread Eagle
14	38	14	26 SE¼	Becker		Newald
15	37	17	6	Lindstrom	Lake Hilbert	Goodman
16	37	17 &	6, 17 SE¼	Becker		Goodman
		18	1, 2 NE¼	Becker		Goodman
17	37	12	10 NE¼	Becker		Hiles
18	37	12	28 SE¼	Becker		Hiles
19	37	17	2 NE¼	Becker	McIntire Creek	Goodman
20	37	17	20 W½	Riker		Goodman
21	36	17	19 SE¼	Becker	Pike River	Goodman
22	36	12	4	Becker	Pike River	Crandon
23	36	13	29	Cooper		Crandon
24	36	19	9	Becker		Dunbar
25	36	18	36 SE¼	Becker	Pike River	Dunbar
26	36	19	14	Becker	Mud Lake	Dunbar
27	36	21	32 SW¼	Becker		Pembine
28	35	12	29 NE¼	Becker		Crandon
29	35	13	6	Kuony	Metonga Lake	Crandon
30	35	13	30	Becker	Hemlock Creek	Crandon
31	35	14	14 SE¼	Becker	Glen Lake	Crandon
32	35	19	5 N½	Becker		Athelstane
33	35	20	6 NW¼	Becker		Athelstane
34	34	13	14 SE¼	Becker	Sawyer Quarry	Wabeno
35	34	14	6 SE¼	Becker	Roberts Lake	Wabeno
36	34	14	29 NE¼	Becker	Bog Brook	Wabeno
37	34	21	3	Suzuki		Wausaukee
38	32	18	8 NW¼	Suzuki	Sand Lake	Caldron Falls
39	32	18	9 N½	Suzuki		Caldron Falls
40	32	20	21	Suzuki		Crivitz
41	32	21	9 N½	Groh, Ziebel	Lake Noquebay	L. Noquebay
42	31	19	9	Suzuki		Beaver
43	30	22	1–2	Suzuki		Peshtigo
44	35	17	14 NE 40, SE¼	Several collectors	Camp Le Feber Boy Scout Camp	Athelstane

2841, MPM; Groh, 7/7/69, Sta. 44, Cat. No. 3277, MPM; also observed by Dickinson, 7/7/28, at Sta. 10.

FROGS. *Pseudacris triseriata triseriata* (3-striped chorus frog): listed by Conant (1958, Map 235) as including the Pine–Popple–Pike area in its range, as does also the subspecies *P. t. maculata* (Conant, 1958, Map 235). *Hyla crucifer crucifer* (spring peeper): Surges and Schmidt, 7/9/69, Sta. 44, Cat. No. 3272, MPM. *Hyla versicolor versicolor* (tree frog): Clowes, 9/12/07, Sta. 13, Cat. No. 789, MPM; Kuony, 8/6/35, Sta. 29, Cat. No. 2562, MPM; Suzuki, 8/24/47, Sta. 40, Cat. No. 2873, MPM. *Rana catesbiana* (bullfrog): Suzuki, 8/24/47, Sta. 40, Cat. No. 2892, MPM. *Rana clamitans melanota* (green frog): Long, 7/21/67, Sta. 9, Cat. No. 205, WSUSP; Becker, 7/23/66, Sta. 11, Cat. No. 3250, MPM; Becker, 6/23/66, Sta. 7, Cat. No. 3263, MPM; Becker, 6/17/66, Sta. 24, Cat. No. 3257, MPM; Becker, 6/16/66, Sta. 33, Cat. No. 3267, MPM; Kuony, 8/1/35, Sta. 29, Cat. No. 2567, MPM; Suzuki, 8/12/48, Sta. 38, Cat. No. 2996, 2997, MPM. *Rana palustris* (pickerel frog): Becker, 6/23/66, Sta. 6, Cat. No. 3255, MPM; Suzuki, 8/21/48, Sta. 43, Cat. No. 2894, MPM. *Rana pipiens* (leopard frog): Long, 7/21/67, Sta. 9, Cat. No. 206, WSUSP; Kuony, 8/6/35, Sta. 29, Cat. No. 2565, MPM; Suzuki, 9/2/49, Sta. 39, Cat. No. 2947, MPM; Suzuki, 8/12/48, Sta. 38, Cat. No. 2946, MPM; Becker, 6/30/65, Sta. 17, Cat. No. 3194, MPM; Becker, 7/12/66, Sta. 28, Cat. No. 3195, MPM. *Rana septentrionalis* (mink frog): Becker, 6/5/66, Sta. 19, Cat. No. 3221, MPM; Becker, (date?), Sta. 36, Cat. No. 3222, MPM; Becker, 6/15/66, Sta. 16, Cat. No. 3223, MPM; Becker, 6/24/66, Sta. 21, Cat. No. 3224, MPM; Becker, 8/24/66, Sta. 4, Cat. No. 3226, MPM, Becker, (date?), Sta. 1, Cat. No. 3278, MPM; Becker, 7/11/66, Sta. 35, Cat. No. 3232, MPM; Long, 7/21/67, Sta. 9, Cat. No. 207, WSUSP; Becker, 6/23/66, Sta. 12, Cat. No. 3266, MPM; Becker, 6/23/66, Sta. 6, Cat. No. 3254, MPM; Becker, 6/16/66, Sta. 26, Cat. No. 3259, MPM; Becker, 6/14/66, Sta. 32, Cat. No. 3260, MPM; Becker, 6/24/66, Sta. 34, Cat. No. 3268, MPM; Becker, 6/23/66, Sta. 8, Cat. No. 3261, MPM; Becker, 6/29/66, Sta. 5, Cat. No. 3262, MPM; Becker, 6/23/66, Sta. 7, Cat. No. 3264, MPM; Becker, 6/30/66, Sta. 18, Cat. No. 3197, MPM; Becker, 6/13/66, Sta. 25, Cat. No. 3265, MPM; Becker, 6/21/66, Sta. 27, Cat. No. 3258, MPM. Strelitzer, 7/9/69, Sta. 44, Cat. No. 3276, MPM. *Rana sylvatica* (wood frog): Long, 7/21/67, Sta. 9, Cat. No. 204, WSUSP.

CLASS REPTILIA

ORDER CHELONIA (TURTLES). *Chelydra serpentina* (snapping turtle): Becker, 7/3/66, Sta. 30, Cat. No. 3216, MPM; Suzuki observed this species on 8/26/48 at Sta. 42, and on 8/26/48 at Sta. 39. *Chrysemys picta belli* (Western painted turtle) : Long, 7/21/67, found one dead on Hwy. 8, Forest Co. *Chrysemys picta marginata* (Midland painted turtle) : Becker, 6/10/66, Sta. 31, Cat. No. 3218, MPM; Witman, 7/11/69, Sta. 44, Cat. No. 3279, MPM. *Clemmys insculpta* (wood turtle) : Johnson collected one in the Pine-Popple-Pike area, date not recorded, Cat. No. 2689, MPM. *Emys blandingii* (Blanding's turtle) : shown by Conant (1958, Map 29) as occurring in the area of this study.

ORDER SAURIA (LIZARDS). *Eumeces fasciatus* (5-lined skink). Smith (1946, Map 26) indicates that the range of this lizard includes the area of this study; Pelzer collected one in this area in 1939, Cat. No. 2653, MPM.

ORDER SERPENTES (SNAKES). *Diadophis punctatus edwardsii* (ringneck snake) : Ziebel, Sept./1954, Sta. 41, Cat. No. 3059, MPM. *Elaphe vulpina* (fox snake) : Long, 7/21/67, Sta. 14, Cat. No. 208, WSUSP (snake was dead when found) ; Riker, 6/21/66, Sta. 20, Cat. No. 3219, MPM; Grow, 10/17/32, Sta. 41, Cat. Nos. 2432–2435, MPM; Kuony, Aug. 1936, Sta. 29, Cat. No. 2558, MPM. *Heterodon contortrix* (hognose snake) : Pelzer, 1940, Popple R., Cat. No. 2606, MPM; Grow, 10/17/32, Sta. 41, Cat. Nos. 2430–2431, MPM; Fullerton, 9/10/56, Marinette Co., Cat. No. 3075, MPM. *Lampropeltis doliata triangulum* (milk snake) : (Schmidt, 1941, p. 190). *Opheodrys vernalis* (green snake) : Long, 7/21/67, Sta. 9, Cat. No. 210, WSUSP; Levi, July 1949, Sta. 3, UW; Suzuki, 8/30/49, Sta. 39, Cat. No. 2775, MPM; Cooper, 1927, Sta. 23, Cat. No. 2200, MPM. *Pituophis catenifer sayi* (bull snake) : Dickinson observed this snake 7/5/28 at Sta. 30; Conant (1958, Map 123) indicates that its range includes this area. *Storeria dekayi dekayi* (brown snake) : Suzuki, 9/2/49, Sta. 42, Cat. No. 2773, MPM. *Storeria occipitomaculata* (red-bellied snake) : collected by Reinhard, 8/31/07, in this area of study, Cat. Nos. 763, 788, 812, MPM; Long, 7/21/67, Sta. 9, Cat. No. 209, WSUSP; collected by Archbald, undated, in area of this study, Cat. No. 3312, CMNH; Suzuki, 9/3/49, saw this snake at Sta. 42. *Thamnophis sauritus proximus* (ribbon snake) : Suzuki, 9/2/49, Sta. 39, Cat. No. 2777, MPM. *Thamnophis sirtalis sirtalis* (common garter snake) : Becker, 10/28/66, Sta. 2, Cat. No. 3214, MPM; Levi, July 1949, Sta. 3, UW; Becker (date?), Sta. 19, Cat. No. 3215, MPM; seen by Suzuki, 9/4/49 at Sta. 39, and by Dickinson, 6/6/28, Sta. 3; Witman, 7/11/69, Sta. 44, Cat. No. 3278, MPM; *Natrix sipedon sipedon* (water snake) : this snake is indicated by Conant (1958, Map 850), Schmidt (1941, Map 219), and Wright and Wright (1942, Map 42) to have a range including the area of this study.

Remarks on Distribution

Perusal of the above records reveals that only two species have been reported officially from the Popple River watershed: *Elaphe vulpina* (the fox snake) and *Heterodon contortrix* (the hognose snake). The Pine River watershed is represented by ten species: American toad (*Bufo terrestris*), tree frog (*Hyla versicolor*), green frog (*Rana clamitans*), pickerel frog (*Rana palustris*), leopard frog (*Rana pipiens*), wood frog (*Rana sylvatica*), mink frog (*Rana septentrionalis*), green snake (*Opheodrys vernalis*) and garter snake (*Thamnophis sirtalis*). The Pike watershed has only five representatives: the toad, the green frog, the mink frog, the snapping turtle (*Chelydra serpentina*) and the garter snake.

The fact that so few common species have so far been found in these drainage basins is not because they are not there, but because so little collecting has been done in these wild areas. In fact many of them have been found in the adjacent county areas. A great deal more collecting must be done in the whole wild rivers area of northeastern Wisconsin before any adequate idea can be formed regarding the distribution, abundance and range of amphibians and reptiles in this remote area.

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ANNOTATED LIST OF THE FISHES OF THE PINE–POPPLE BASIN[1]

George C. Becker[2]

Introduction

Perhaps the first systematic survey of fishes of the Pine–Popple basin occurred in the late 1920's when E. Willard Greene (1935) made his survey of the fishes of Wisconsin. From some 20 collections he recorded the following 19 species: rainbow trout, brook trout, white sucker, blacknose dace, longnose dace, creek chub, pearl dace, northern redbelly dace, finescale dace, common shiner, bluntnose minnow, central mudminnow, yellow perch, johnny darter, Iowa darter, smallmouth bass, largemouth bass, mottled sculpin and brook stickleback.

For many years the Wisconsin Department of Natural Resources has surveyed the waters of the Pine–Popple basin in both their research and management programs. Aside from the game and panfish species there appeared to be little interest in fish systematics until Mason (1966) listed all of the species he encountered at 92 different locations. Several additional species were listed in an expanded paper (Mason & Wegner 1970).

In the present survey 34 species of fish were collected from the Pine River drainage and 29 species from the Popple River drainage. Examples of these have been placed in the collections of the Museum of Natural History at the University of Wisconsin—Stevens Point.

Materials and Methods

The fish were captured by seines 10 to 25 feet long with ¼″ bar mesh, or with electrofishing equipment. Two complete electrofishing units were used (one for each collecting crew). One unit was a C & H alternating current generator rated for 1000 watts and 120 volts at 8.5 amperes. The other was a Sears Alternator Portable light plant rated for 900 watts and 115 volts at 7.8 amperes. These were used from a boat or from the bank. One hundred-foot electrode cords enabled shocking in particularly brushy or

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inaccessible areas. The electrodes themselves were fashioned from heavy gauge copper wire forming long oblong hoops upon which ½-inch hardware cloth had been sweated.

The method of capture was determined upon arrival at the collection site. Frequently both seines and shocker were used. Collection time at a site averaged two hours. All possible niches were sampled and the captured fish placed in jars containing 10% formalin. Most game fish and large non-game forms were returned to the water, but a record was kept of all fish captured. Station data were placed on cards and then were inserted into the jars long with the fish.

All the preserved fish were brought back to the laboratory at Stevens Point where they were rinsed, sorted and identified to species. Examples of all species were placed into the collections of the Museum of Natural History at Stevens Point.

Physical and chemical data of each stream site were taken during or immediately following the fish collections. These are recorded in Tables III and IV.

DISTRIBUTION OF FISHES

Collection sites are listed in Table I (Pine River basin) and in Table II (Popple River basin). All collection sites are numbered on Map 1. When used in the annotated list they are coded as follows:

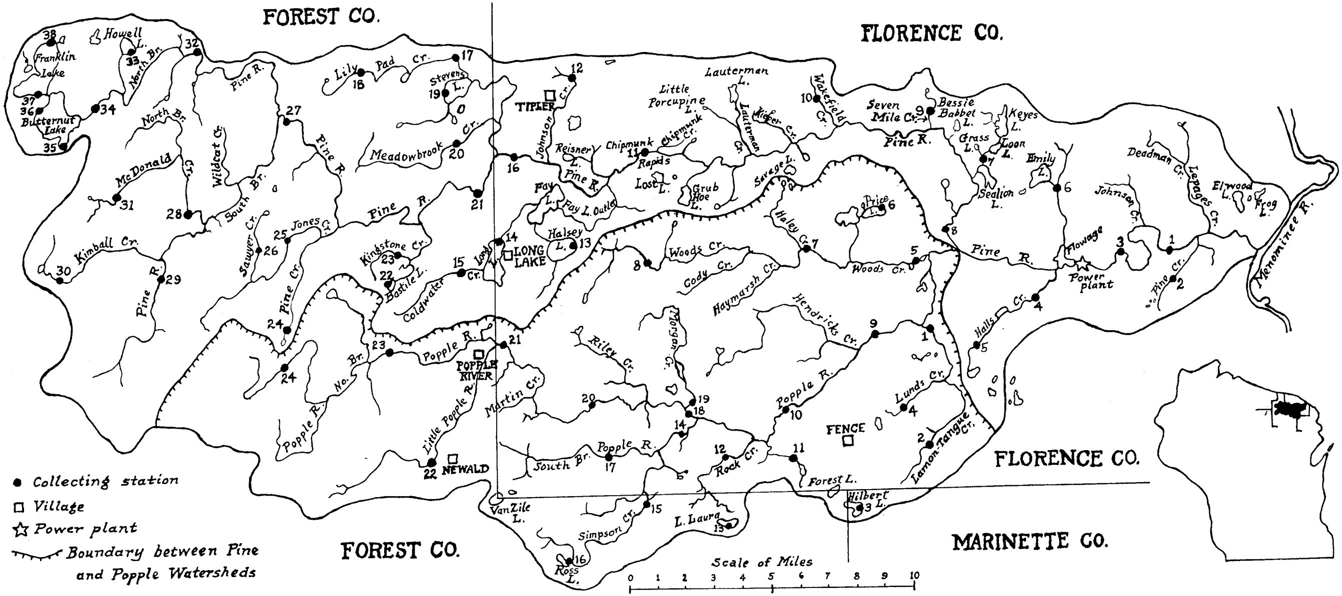
Pi—Pine River basin
Po—Popple River basin

Each basin has a separate numbering system. After the name of each species I have indicated by code and numbers all of the stations where it was captured. If one species appeared at several consecutive collecting sites, the first and the last are separated by a hyphen; e.g., Pi 23-26 represents capture at sites 23, 24, 25 and 26 within the Pine River basin.

Frequency represents percentage of stations within the basin at which that species of fish appeared. E.g., the bluntnose minnow appeared at 8 out of a total of 38 stations in the Pine basin with a frequency of 21%.

Forty-two species of fish are known from the Pine–Popple basin. These are listed below. Another 6 species have been captured near the Pine–Popple basin and may—with more intensive study—be shown to occur there. These are listed under PROBLEMATICAL SPECIES.

The common and scientific names used follow Bailey (1970).



MAP 1. PINE-POPPLE RIVER BASIN FISH SURVEY

This map shows the location of the stations at which fish were collected in the Pine and Popple River basins. The collecting stations that were selected are in two series, one for each basin, numbered consecutively from the mouth of each river toward its headwaters. A special line on the map marks the divide between the watersheds of the two rivers. The location of the Pine-Popple Wild Rivers Area in the State of Wisconsin is shown in the small inset map at the right.

TABLE I. PINE RIVER BASIN COLLECTIONS.

Information regarding each collecting station listed below is given in the following sequence: (1) site number, (2) river, creek or lake from which collection was taken, (3) location of station by section, town and range, (4) county in which station is located, (5) date of collection, (6) collecting technique used, (7) names of collectors. Map 1 shows location of stations.

Pi 1 Pine R., Sec 24 T39N R18E, Florence Co., June 24, 1965, 25 ft. seine, K. and D. Becker, J. Copp.

Pi 2 Pine Cr., Sec. 25 T39N R18E, Florence Co., June 25, 1965, electrofishing, K. and D. Becker, J. Copp.

Pi 3 Pine R., Sec. 22 T39N R18E, Florence Co., June 22, 1965, 25 ft. seine K. and D. Becker, J. Copp.

Pi 4 Halls Cr., Sec. 31 T39N R18E, Florence Co., July 2, 1965, electrofishing, K. and D. Becker, J. Copp.

Pi 5 Halls Cr., Sec. 11 T38N R17E, Florence Co., July 2, 1965, electrofishing, K. and D. Becker, J. Copp.

Pi 6 Small tributary of Pine R., Sec. 8 T39N R18E, Florence Co., June 23, 1965, electrofishing, K. and D. Becker, J. Copp.

Pi 7 Creek connecting Sealion and Grass L., Sec 2 T39N R17E, Florence Co., June 22, 1965, electrofishing, K. and D. Becker, J. Copp.

Pi 8 Pine R., Sec. 15 T39N R17E, Florence Co., June 25, 1965, electrofishing, K. and D. Becker, J. Copp.

Pi 9 Seven Mile Cr., Secs 27 & 33 T40N R17E, Florence Co., June 23, 1965, electrofishing, K. and D. Becker, J. Copp.

Pi 10 Wakefield Cr., Sec. 25 T40N R16E, Florence Co., June 22, 1965, electrofishing, K. and D. Becker, J. Copp.

Pi 11 Pine R., Sec. 1 T39N R15E, Florence Co., June 13, 1965, 25 ft. seine, K. and D. Becker, J. Copp;—July 22–23, 1967, seines, C. Long.

Pi 12 Johnson Cr., Sec. 21 T40N R15E, Florence Co., June 14, 1965, electrofishing, K. and D. Becker, J. Copp.

Pi 13 Halsey L., Sec. 21 T39N R15E, Florence Co., June 15, 1965, 10 ft. and 25 ft. seines, K. Becker and J. Copp.

Pi 14 Long L. outlet, Sec. 19 T39N R15E, Florence Co., June 14, 1965, 25 ft. seine, K. Becker and J. Copp.

Pi 15 Coldwater Cr., Secs. 25 & 26 T39N R14E, Forest Co., June 27, 1966, G. Becker team.

Pi 16 Pine R., Secs. 5 & 6 T39N R15E, Florence Co., June 14, 1965. K. Becker, J. Copp.

Pi 17 Lilypad Cr., SE¼ Sec. 14 T40N R14E, Forest Co., June 27, 1966, E. Peters team.

Pi 18 Lilypad Cr., NW¼ Sec. 20 T40N R14E, Forest Co., June 27, 1966, E. Peters team.

Pi 19 Stevens L., Secs. 23 & 26 T40N R14E, Forest Co., June 28, 1966, G. Becker team.

Pi 20 Meadowbrook Cr., SE¼ Sec. 35 T40N R14E, Forest Co., June 28, 1966, electrofishing and seining, G. Becker team.

Pi 21 Pine R., NE¼ Sec. 12 T39N R14E, Forest Co., June 28, 1966, G. Becker team.

Pi 22 Bastile L., S½ Sec. 28 T39N R14E, Forest Co., June 29, 1966, E. Peters team.

Pi 23 Kingstone Cr., NE¼ Sec. 21 T39N R14E, Forest Co., June 27, 1966, G. Becker team.

Pi 24 Pine Cr., Secs. 35 & 36 T39N R13E, Forest Co., June 27, 1966, G. Becker team.

TABLE I. PINE RIVER BASIN COLLECTIONS. (Continued)

Pi 25 Jones Cr., Secs. 13 & 24 T39N R13E, Forest Co., June 24, 1966, G. Becker team.
Pi 26 Sawyer Cr., SW¼ Sec. 14 T39N R13E, Forest Co., June 24, 1966, G. Becker team.
Pi 27 Pine R., Secs. 25, 35, & 36 T40N R13E, Forest Co., June 24, 1966, E. Peters team.
Pi 28 McDonald Cr., NE¼ Sec. 17 T39N R13E, Forest Co., June 27, 1966, E. Peters team.
Pi 29 South Branch Pine R., NW¼ Sec. 30 T39N R13E, Forest Co., June 24, 1966, E. Peters team.
Pi 30 Kimball Cr., Secs. 27 & 28 T39N R12E, Forest Co., June 23, 1966, G. Becker team.
Pi 31 McDonald Cr., NW¼ Sec. 12 T39N R12E, Forest Co., June 23, 1966, G. Becker team.
Pi 32 Pine R., NW¼ Sec. 21 T40N R13E, Forest Co., June 25, 1966, E. Peters team.
Pi 33 Howell L. and outlet, Sec. 13 T40N R12E, Forest Co., June 29, 1966, G. Becker team.
Pi 34 Pine R. (outlet of Butternut L.), N½ Sec. 26 T40N R12E, Forest Co., June 23, 1966, G. Becker team.
Pi 35 Butternut L., SW¼ Sec. 34 T40N R12E, Forest Co., June 29, 1966, gill nets (100 ft. 1 in. bar, 100 ft. 1½ in. bar) set at depth of 25–30 ft., 60–80 yds. off southwest shore, G. Becker, P. Holden.
Pi 36 Butternut L., SW¼ Sec. 28 T40N R12E, Forest Co., June 23, 1966, seines, G. Becker team.
Pi 37 Franklin L., SW¼ Sec. 21 T40N R12E, Forest Co., June 23, 1966, seines, E. Peters team.
Pi 38 Franklin L., NE¼ Sec. 16 T40N R12E, Forest Co., June 23, 1966, seines, E. Peters team.

TABLE II. POPPLE RIVER BASIN COLLECTIONS.

The sequence of items in each of the site entries listed below are in the same order as in Table I: site number; stream or lake being surveyed; location by section, town and range; county in which station is located; date of collection; collecting technique used; names of collectors. See Map 1 for location of each site within the Popple River drainage basin.

Po 1 Lamon–Tangue Cr., Sec. 4 T38N R17E, Florence County, July 1, 1965, 10 ft. seine, K. and D. Becker, J. Copp.
Po 2 Lamon–Tangue Cr., Sec. 28 T38N R17E, Florence Co., June 20, 1965, K. and D. Becker, J. Copp.
Po 3 Hilbert L., NW¼ Sec. 8 T37N R17N, Marinette Co., June 21, 1966.
Po 4 Lunds Cr., Sec. 21 T38N R17E, Florence Co., July 1, 1965, electrofishing, K. and D. Becker.
Po 5 Woods Cr., Secs. 28 & 29 T39N R17E, Florence Co., June 30, 1965, electrofishing, K. and D. Becker.
Po 6 Price L., Sec. 17 T39N R17E, Florence Co., June 28, 1965, electrofishing, K. and D. Becker, J. Copp.
Po 7 Woods Cr., Sec. 23 T39N R16E, Florence Co., June 28, 1965, electrofishing, K. and D. Becker, J. Copp.
Po 8 Woods Cr., Sec. 25 T39N R15E, Florence Co., June 21, 1965, electrofishing, K. and D. Becker, J. Copp.

TABLE II. POPPLE RIVER BASIN COLLECTIONS. (Continued)

Po 9	Popple R., Sec. 5 T38N R17E, Florence Co., June 30, 1965, electrofishing, K. and D. Becker.
Po 10	Popple R., Sec. 23 T38N R16E, Florence Co., June 21, 1965, electrofishing and 25 ft. seine, K. and D. Becker, J. Copp.
Po 11	Artificial L., Sec. 26 T38N R16E, Florence Co., June 18, 1965, 25 ft. seine, K. Becker, J. Copp.
Po 12	Rock Cr., Sec. 29 T38N R16E, Florence Co., June 18, 1965, electrofishing, K. Becker, J. Copp.
Po 13	Laura L., NW¼ Sec. 9 T37N R16E, Forest Co., June 30, 1966, G. Becker team.
Po 14	South Branch Popple R., Sec. 19 T38N R16E, Florence Co., June 18, 1965, electrofishing, K. Becker, J. Copp.
Po 15	Simpson Cr., NW¼ Sec. 1 T37N R15E, Forest Co., June 30, 1966, 25 ft. seine, G. Becker team.
Po 16	Ross L. and outlet, SW¼ Sec. 16 T38N R15E, Forest Co., June 30, 1966, G. Becker team.
Po 17	South Branch Popple R., Sec. 26 T38N R15E, Florence Co., June 16, 1965, 10 and 25 ft. seines, K. Becker, J. Copp.
Po 18	Popple R., Sec. 19 T38N R16 E, Florence Co., June 17, 1965, electrofishing and 10 ft. seine, K. Becker, J. Copp.
Po 19	Morgan Cr., Sec. 19 T38N R16E, Florence Co., June 17, 1965, electrofishing, K. Becker, J. Copp.
Po 20	North Branch Popple R., Sec. 22 T38N R15E, Florence Co., June 16, 1965, 25 ft. seine, K. Becker, J. Copp.
Po 21	Popple R., Sec. 6 T38N R15E, Florence Co., June 16, 1965, seine, K. Becker, J. Copp.
Po 22	Little Popple R., SE¼ Sec. 27 T38N R14E, Forest Co., June 29, 1966, E. Peters team.
Po 23	Popple R., Secs. 4 & 8 T38N R14E, Forest Co., June 29, 1966, E. Peters team.
Po 24	Popple R., NW¼ Sec. 12 T38N R13E, Forest Co., June 24, 1966, G. Becker team.

Salmonidae—trouts, whitefishes

Lake Whitefish—*Coregonus clupeaformis* (Mitchill).

Reported from Keyes L. (DNR files—Woodruff).

Cisco—*Leucichthys artedii* Lesueur.

Reported from Butternut, Franklin, and Keyes lakes (Wis. Cons. Dept. 1964).

Rainbow trout—*Salmo gairdneri* Richardson.

Pi 11; Po 9, 10, 14. These rainbows were taken in 1965. According to Mason (1966) 1,900 fingerlings were stocked in Pine R. during the summer of 1966. Between September and October 1967 he captured 32 by electrofishing in the mainstem between the Pine R. flowage and the juncture of the North and South Branches (Mason and Wegner 1970). Reported from Keyes and Anna lakes (DNR files—Woodruff).

Brown trout—*Salmo trutta* Linnaeus.

Pi 11; Po 9, 10, 22, 24. Brown trout distribution and incidence of marked and unmarked trout is documented by Mason (1966) and Mason and Wegner (1970).

Brook trout—*Salvelinus fontinalis* (Mitchill).

Pi 4, 11, 21, 23–26, 28, 30; Po 1, 2, 4, 5, 7-9, 14, 19, 22, 24. Our only native trout, the brook trout, occurred in 21% of the stations sampled in the Pine R. basin and 49% in the Popple R. basin. See Mason (1966) and Mason and Wegner (1970) for additional information. Reported from Sand and Patten lakes (DNR files—Woodruff).

Umbridae—mudminnows

Central mudminnow—*Umbra limi* (Kirtland).

Pi 2 4-6, 8, 9, 15, 18, 19, 23-25, 27-30, 34; Po 1, 4, 9, 12, 14, 24. Frequency in the Pine basin was 45%; in the Popple basin 25%. Reported from McKinney and Two Sisters lakes (DNR files—Woodruff).

Esocidae—pikes

Northern pike—*Esox lucius* Linnaeus.

Pi 1, 7, 8, 15, 21. Frequency in the Pine basin was 13%. Eight individuals were captured at Pi 1. Reported from Pine, Butternut, Bastile, Stevens, Two Sisters, Harriet, Lilypad, Long, Fay, Lost, Lauterman, Sealion, Keyes, Emily, Pine R. flowage, Halsey, Reisner, Lake of Dreams, Bessie Babbett, Loon lakes (DNR files—Woodruff). Also reported from Forest, Halsey, Seidel, Cosgrove, Hilbert lakes (Wis. Cons. Dept. 1964).

Muskelunge—*Esox masquinongy* Mitchill.

Reported in Sealion and Emily lakes and from the Pine R. flowage (Wis. Cons. Dept. 1964). Report from Quartz L. (DNR file—Woodruff).

Cyprinidae—minnows

Brassy minnow—*Hybognathus hankinsoni* Hubbs.

Pi 3-6, 14, 18, 20, 25, 28, 30, 31, 37; Po 1, 4, 11, 12, 15, 17, 19-21, 23, 24. Frequency in the Pine basin was 32% in the Popple basin 46%. Largest numbers were captured at Pi 18 (80) and Po 21 (153).

Hornyhead chub—*Nocomis biguttatus* (Kirtland).

Pi 1, 3-5, 7, 8, 11, 14, 16, 17, 21, 27, 32, 34, 38; Po 1, 9, 10, 14, 18-21, 23. Frequency in the Pine basin was 39%; in the Popple basin, 38%. Largest numbers captured were 180 and 131 at Po

TABLE III. PINE RIVER BASIN—STATION DATA.

Station No.	Air Temperature (°F)	Water temperature (°F)	Percentage of bottom occupied by								Dissolved oxygen (ppm)	H-ion concentration (pH)
			Mud	Silt	Sand	Clay	Detritus	Gravel	Rubble	Boulders		
Pi 1	73	69		7	45		3	45				
Pi 2	70.5	58			50		10	38	2			
Pi 3	65	67		5	20			40	30	5		
Pi 4	71	68		5	80		3	10		2		
Pi 5	73	67		80	10		10					
Pi 6	71	62.5		10	75		5	10				
Pi 7	72	73		10	80		10					
Pi 8	68	73		5	70		5	20				
Pi 9	64	65		+	+		+	+				
Pi 10	65	57		1	60		1	35	3			
Pi 11	-	63		1	15			70	10	4		
Pi 12	-	51		80	19			1				
Pi 13	-	69		60	10			18		2		
Pi 14	-	72		10	60			30				
Pi 15	73.5	73	+	+				+	+			
Pi 16	-	67		1	15			24	50	10		
Pi 17	79	77									8	7.5
Pi 18	71.5	70		25	30		25	20			5	7.5
Pi 19	82	80									8	6.4
Pi 20	79	73	75		25		tr.				8	7.3
Pi 21	71	72	10		75			15			8	7.4
Pi 22	76	78	75							25	8	6
Pi 23	76	70	15	5	80							
Pi 24	69	58	20				80					
Pi 25	83	78	15	65	tr.				10	10		
Pi 26	72	61	40	40	10			10				
Pi 27	82	72	30		35			35			7.5	7.6
Pi 28	70	61	25		69		tr.	3	3		9	7.5
Pi 29	84	82	85	15					tr.		7	7.6
Pi 30	78	66		10	50			40				
Pi 31	82	81		95		5						
Pi 32	78	74		60	40						7	7.4
Pi 33	-	-										
Pi 34	82	78		10	80			10				
Pi 35	-	-									8	7.6
Pi 36	82	72										
Pi 37	80.5	77									8	7.2
Pi 38	86	77			100							

20 and 23 respectively. Condition of both sexes at Pi 1, 7, and 34 indicates spawning toward the end of June 1965 and 1966.

Two hornyhead nests were observed just above the outlet of Butternut L. (Pi 34) on June 23, 1966. One nest was constructed in 1 ft. of water, the other in 3 feet. Both nests were of pebbles ½ to 1 inch in diameter, diameter of nests 18 inches and mounds up to 3 inches in height. Two females give the following data: total weight 25.22 and 23.87 gms., ovarian weight 3.00 (11.9%) and 2.10 gms. (8.8%) respectively.

Common shiner—*Notropis cornutus* (Mitchill).

Pi 1, 3-8, 11-14, 16-18, 20, 21, 27-29, 31-38; Po 1, 5, 9-12, 14, 15, 17-24. Frequency in the Pine basin was 71%; in the Popple basin, 67%. A lake as well as a stream inhabitant in this sector of the state. Largest numbers taken at Pi 3 (368), Po (603), Po 21 (637). This is the most abundant species in the Pine–Popple basin and over 5300 were collected in this survey.

Blackchin shiner—*Notropis heterodon* (Cope).

Pi 5, 13, 14. This species is generally taken in lakes or lake outlets. Twenty-four specimens were captured at Pi 5; 17 at Pi 13; 1 at Pi 14.

Blacknose shiner—*Notropis heterolepis* Eigenmann & Eigenmann.

Pi 4, 5, 8, 9, 12-14, 18, 20, 31, 33, 37; Po 1, 3, 10, 11, 15, 16, 19, 20, 23. Frequency in the Pine basin was 32%; in the Popple basin, 38%. This species is associated with lakes or slow-moving streams. Largest numbers were taken at Pi 13 (186) and Po 11 (605). At the latter site a gravid female with loose eggs appeared ready for spawning.

Golden shiner—*Notemigonus crysoleucas* (Mitchill).

Pi 4, 11, 13, 14, 29, 33, 37, 38; Po 6, 10, 11. Frequency in the Pine basin was 21%; in the Popple basin, 13%. Largest numbers captured were 77 (Pi 14) and 319 (Po 11). Terry McKnight, DNR biologist, reports individuals 6 to 8 inches long from Patten L.

Bluntnose minnow—*Pimephales notatus* (Rafinesque).

Pi 5, 6, 13, 14, 32, 34, 37, 38; Po 3, 5, 10, 15, 20, 21, 23. Frequency in the Pine Basin was 21%; in the Popple basin, 29%. Largest numbers were captured at Pi 14 (138 plus), Pi 37 (276), Pi 38 (566), Po 3 (126). Reported from Patten L. (DNR files—Woodruff).

Fathead minnow—*Pimephales promelas* Rafinesque.

Pi 6, 8, 11, 13, 18, 20, 25, 29, 31; Po 1, 8, 10, 11, 14-17, 19, 21, 23. Frequency in the Pine basin was 24%; in the Popple basin, 46%. Largest numbers were captured at Pi 31 (36) and Po 16 (48). The fathead and bluntnose occurred together only infrequently: twice in the Pine basin samples and four times in the Popple basin samples. Reported from Frog. L. (DNR files—Woodruff).

Northern redbelly dace—*Phoxinus eos Cope.*

Pi 4-6, 8-10, 13, 14, 18, 20, 28, 30, 32-34, 37; Po 1, 2, 4, 10-12, 14, 15, 17-24. Frequency in the Pine basin was 42%; in the Popple basin, 67%. Largest numbers were taken at Pi 10 (137), Po 15 (411), Po 19 (358). A female, 2.52 gm., taken at Pi 33 (June 29, 1966) had ovaries weighing 0.13 (5.1% of body weight). Deep red flanks were noted on 3 males taken June 28, 1966 (Pi 20) from Meadowbrook Cr.

TABLE IV. POPPLE RIVER BASIN—STATION DATA.

Station No.	Air Temperature (°F)	Water temperature (°F)	Percentage of bottom occupied by								Dissolved oxygen (ppm)	H-ion concentration (pH)
			Mud	Silt	Sand	Clay	Detritus	Gravel	Rubble	Boulders		
Po 1	69	56		+	50		+	30		+		
Po 2	74	58		51	38		10	1				
Po 3	82	76									9	7.6
Po 4	72	63		+	+		+	+				
Po 5	66.5	58		5	5			90				
Po 6	74	74		35	60		5					
Po 7	81	62.5		5	30			5				
Po 8	67	54		40	59		tr.	1				
Po 9	72.5	65.5		2	5			60	30	3		
Po 10	78	71		15	60		1	5		19		
Po 11		75		60	38			2				
Po 12		68		30	65			5				
Po 13	80	80										
Po 14		61		2	15			50	23	10		
Po 15	88.5	89	40	10	40		5	5				
Po 16					+		+					
Po 17		61		89	10			1				
Po 18		65.5	2		3			40	40	15		
Po 19		61.5		9	85			5		1		
Po 20		65		20	70			10		tr.		
Po 21		59		60	30			9	1			
Po 22	90.5	82										
Po 23	85	86	45					50	5		8	7
Po 24	81	76	30	20	20			20		10	7.0	6.4

Finescale dace—*Phoxinus neogaeus* Cope.

Pi 2, 6, 9, 10, 12, 18, 20, 26, 31, 34; Po 1, 4, 11, 12, 14, 15, 17, 19-22, 24. Frequency in the Pine basin was 26%; in the Popple basin, 50%. Stations at which 25 or more were captured are Po 1 (26), 11 (25), 19 (35), 21 (38). Prefers slow-moving water over a wide variety of soft bottoms. The 10 collection sites in the Pine basin can be summarized as follows:

3 sites stream width 2′ to 7′, water depth 2″ to 13″
5 sites stream width 1′ to 13.7′, water depth 3″ to 36
2 sites—bog ponds

This species appears to be best represented in the state of Wisconsin in the counties of Florence, Forest and Marinette.

Blacknose dace—*Rhinichthys atratulus* (Hermann).

Pi 4, 5, 8-12, 15-18, 20, 21, 23, 25, 27-30; Po 1, 5, 8-10, 12-15, 17-24. Frequency in the Pine basin was 50%; in the Popple basin, 71%. Largest numbers captured were 106-plus (Pi 10) and 81 (Po 22). On June 18, 1965, males from the So. Branch Popple R. (Po 14) were still in breeding color and all the females had not spawned as yet. On June 28, 1966, two females taken from Meadowbrook Cr. (Pi 20) were gravid and eggs loose, showing spawning readiness.

Longnose dace—*Rhinichthys cataractae* (Valenciennes).

Pi 8, 11, 16, 20, 21, 25, 28; Po 5, 8-10, 14, 18. Frequency in the Pine basin was 18%; in the Popple basin 25%. Largest numbers captured were 41 (Po 15) and 35-plus (Po 18)

Creek chub—*Semotilus atromaculatus* (Mitchill).

Pi 2, 4-6, 8-10, 12, 14-18, 20, 21, 23-25, 27-32, 34, 37; Po 1, 5, 9, 10, 12, 14, 15, 17, 18, 20-24. Frequency in the Pine basin was 68%; in the Popple basin, 58%. Largest number captured was 67 (Pi 20). Breeding tubercles present on males from Pi 6 (June 23, 1965) although the females were no longer gravid.

The range and average number of lateral line scales in creek chubs from northeastern Wisconsin is high. A Wakefield Cr. sample of 35 ranged from 52 to 64 with an average count of 58.43. Of these, eight individuals (23%) had lateral line scale counts of more than 60. A Popple R. sample of 61 ranged from 50 to 65 with an average of 58.48. Of these, 18 individuals (30%) had lateral line counts of more than 60. For comparison, a central Wisconsin (Portage Co.) sample had a range of 55 to 63 with an average of 58.03. A southern Wisconsin (LaFayette Co.) sample had a range of 49 to 62 with an average of 55.1.

Pearl dace—*Semotilus margarita* (Cope).

Pi 6, 9-12, 17, 20, 25, 26, 29-32; Po 1, 4, 6, 10-12, 14, 15, 17, 19-24. Frequency in the Pine basin was 34%; in the Popple basin 63%.

Largest numbers captured were 186 (Po 22) and (Pi 20). A February, 1968, DNR collection indicated this species from Patten L.

Catostomidae—suckers

White sucker—*Catostomus commersoni* (Lacépède).
Pi 3-7, 9, 13, 14, 16-21, 25, 27, 29, 32, 34-37; Po 1, 5, 7, 9-12, 14-24. Frequency in the Pine basin was 58%; in the Popple basin, 75%. The young-of-the-year taken June 22, 1965, at Pi 3 had total length of 17–23 mm. Largest numbers of suckers captured were 157 (Po 23) and 92 (Po 24). Reported from Butternut, Franklin, Three Johns, Quartz, Fay, Lost, Perch, Emily, Frog, Elwood, Patten, and Hilbert lakes (DNR files—Woodruff).

Ictaluridae—freshwater catfishes

Black bullhead—*Ictalurus melas* (Rafinesque).
Pi 5, 7, 9, 37; Po 9-12, 16, 20, 23. Frequency in the Pine basin was 11%; in the Popple basin, 29%. No more than 3 individuals were taken at any station.

Yellow bullhead—*Ictalurus natalis* (Lesueur).
Pi 7, 9. One individual was captured at Pi 7 and 4 at Pi 9.

Brown bullhead—*Ictalurus nebulosus* (Lesueur).
Pi 7, 14. Three individuals were captured at Pi 7 and 1 at Pi 14. This species is frequently found in inlet or outlet streams near lakes.

Tadpole madtom—*Noturus gyrinus* (Mitchill).
Pi 8, 13, 14. Ten individuals were captured at Pi 8 and singles at the other two sites.

Gadidae—codfishes

Burbot—*Lota lota* (Linnaeus).
John Mason (letter, June 18, 1969) reports that he had recently captured 4 or 5 individuals from the lower Pine river SW ¼ Sec. 23 and SE ¼ Sec. 23 T39N R18E.

Gasterosteidae—sticklebacks

Brook stickleback—*Culaea inconstans* (Kirtland).
Pi 2, 6, 9, 10, 12, 18, 20, 23-25, 28-31; Po 1, 4, 8, 10, 12, 14-17, 19-21, 23, 24. Frequency in the Pine basin was 37%; in the Popple basin, 58%. Largest numbers were captured at Pi 25 (24), Pi 31 (24), Po 17 (64), Po 20 (25), Po 21 (32), Po 24 (87).

Centrarchidae—sunfishes

Rock bass—*Ambloplites rupestris* (Rafinesque)
Po 5. Reported from Sealion, Keyes, Pine R. flowage, Cosgrove, Anna, Elwood, Patten lakes (DNR files—Woodruff).

Green sunfish—*Lepomis cyanellus* Rafinesque.

Reported from Lost, Emily, Cosgrove, Anna, Bessie Babbet, Grass, Bass (Sec. 15 T40N R17E), Oneata lakes (DNR files—Woodruff).

Pumpkinseed—*Lepomis gibbosus* (Linnaeus).

Pi 4, 6-8, 11, 14; Po 3, 6, 11. Reported from Franklin, Lost, Perch, Emily, Halsey, Reisner, Lake of Dreams, Patten, Hilbert lakes (DNR files—Woodruff).

Bluegill—*Lepomis machrochirus* Rafinesque.

Pi 7-9, 14, 16, 33, 37, 38; Po 3, 6, 12. Reported from Franklin, Three Johns, Quartz, McKinney, Fay, Porcupine, Lauterman, Keyes, Emily, Cosgrove, Anna, Halsey, Reisner, Lake of Dreams, Loon, White Bass, Elwood, Savage, Price, Oneata, Patten, Hilbert lakes (DNR files—Woodruff).

Smallmouth bass—*Micropterus dolomieui* Lacépède.

Pi 35, 36, 37. The smallmouth is an important game species in Butternut and Franklin lakes. Also reported from Quartz, Keyes, Cosgrove and Elwood lakes (DNR files—Woodruff). The Wisconsin Department of Natural Resources (1968) reports it in the Pine R. from La Salle Falls downstream to its juncture with the Menominee R.

Largemouth bass—*Micropterus salmoides* (Lacépède).

Pi 5, 16, 19, 37; Po 3, 5, 12. Reported from Butternut, Franklin, Three Johns, Stevens, Harriet, Harmony, Indian Camp, Howell, Ritter, Rogers, Wapoose, Long, Fay, Lost, Porcupine, Lauterman, Keyes, Cosgrove, Anna, Morgan, Halsey, Reisner, Lake of Dreams, Bessie Babbett, Grass, Loon, White Bass, Bass (Sec. 15 T40N R17E), Elwood, Nona, Savage, Price, Oneata, Patten, Hilbert lakes (DNR files—Woodruff).

Black crappie—*Pomoxis nigromaculatus* (Lesueur).

Pi 14, 33. Reported from Stevens, Fay, Porcupine, Perch, Lauterman, Keyes, Emily, Halsey lakes (DNR files—Woodruff).

Percidae—perches

Iowa darter—*Etheostoma exile* (Girard)

Pi 6-9, 13, 14; Po 2, 11, 16, 23. Twenty were captured at Pi 13. Recorded from Patten L. (DNR files—Woodruff). Shallows of lakes and slow-moving streams.

Johnny darter—*Etheostoma nigrum* Rafinesque.

Pi 1, 8, 11, 13, 17, 18, 20, 21, 25, 28, 29, 32, 33, 36, 37; Po 5; 9, 10, 14, 15, 17-24. Frequency in the Pine basin was 39%; in the Popple basin, 54%. Largest numbers were captured at Pi 37 (24) and Po 22 (35). Recorded from Patten L. (DNR files—Woodruff).

Yellow perch—*Perca flavescens* (Mitchill).

Pi 1, 3, 11, 13-15, 17, 19, 22, 27, 33, 34, 36-38; Po 6, 10, 11, 13, 14. Frequency in the Pine basin was 39%; in the Popple basin, 21%. Common at most sites where found. Reported from Butternut, Franklin, Bastile, Three Johns, Stevens, Quartz, McKinney, Two Sisters, Harriet, Lilypad, Indian Camp, Howell, Wapoose, Fay, Lost, Porcupine, Perch, Lauterman, Keyes, Emily, Pine R. flowage, Cosgrove, Halsey, Reisner, Lake of Dreams, White Bass, Bass (Sec. 15 T40N R17E), Elwood, La Fave, Oneata, Patten, Hilbert lakes (DNR files—Woodruff).

Logperch—*Percina caprodes* (Rafinesque).

John Mason (letter, June 18, 1969) reported recently taking "quite a few" from below the Pine River power dam in Secs. 22 and 23 T39N R18E.

Walleye—*Stizostedion vitreum vitreum* (Mitchell).

Pi 35. Reported from Butternut, Stevens, Laura, Long, Forest, Halsey, Fay, Sealion, Keyes, Emily, Cosgrove, Hilbert lakes (Wis. Cons. Dept. 1964). Reported from Harmony, Howell, Wapoose, Pine R. flowage, Frog, Patten lakes (DNR files—Woodruff).

Cottidae—sculpins

Mottled sculpin—*Cottus bairdi* Girard.

Pi 2, 4, 5, 8, 11-13, 15-21, 22-30, 32, 34; Po 2, 4, 5, 7-10, 14, 15, 17, 22, 24. Frequency in the Pine basin was 66%; in the Popple basin, 67%. Largest numbers were captured at Pi 20 (88), Pi 28 (75), and Po 5 (43). An individual 4⅛″ total length from Pi 28 had a 2-inch fish (mudminnow?) in its stomach.

PROBLEMATICAL FISHES

Following are species not recorded from the Pine–Popple basin but which may be expected on the basis of proximity.

Northern brook lamprey—*Ichthyomyzon fossor* Reighard & Cummins.

An adult was taken June 21, 1966, near the mouth of the Pike R., Sec. 4 T34N R21E, Marinette Co.

Silver lamprey—*Ichthyomyzon unicuspis* Hubbs & Trautman.

On July 19, 1970, several adults were taken from fish in the Menominee R., T34N R21E, Marinette Co., by Terry McKnight, DNR biologist.

Lake sturgeon—*Acipenser fulvescens* Rafinesque.

This species is a common inhabitant of the Marinette Co. sector of the Menominee R. into which the Pike R. empties. The range map by Priegel and Wirth (1971) shows this species in the Menominee R. through its entire contact with Florence Co. If the sturgeon still occurs in the Menominee R. at the point where the Pine R. enters, it may be expected in the lower Pine R. between the Pine R. flowage and its mouth.

Longnose sucker—*Catostomus catostomus* (Forster).

This species is present in Kentuck L., Forest Co., less than a mile from the Pine–Popple drainage. A specimen was given to the Univ. of Wisconsin—Stevens Point Museum by Terry McKnight, DNR biologist. It was netted in May, 1970.

Rosyface shiner—*Notropis rubellus* (Agassiz).

Greene (1935) recorded this species at the juncture of the Pike and Menominee rivers in Marinette Co.

Blackside darter—*Percina maculata* (Girard).

In 1966 I captured this species from near the mouth of the Pike R., Marinette Co.

THE FISHERY,—PAST, PRESENT, FUTURE

Although much of the area is wild and both the Pine and Popple rivers have been designated "wilderness rivers", there is much evidence that many profound changes have taken place in the basin which detract from their wildness. These changes have altered the fish composition of the basin.

In discussing the trend in trout fishing with a number of residents who have fished these waters over the years, it has become evident that trout fishing has fallen off. Within recent years trout fishing for good-sized trout was excellent at LaSalle Falls. This is no longer the case.

After the first few weeks of trout fishing in spring the fishing drops off rapidly. Water temperatures of the mainstem, especially the Pine River, respond readily to the rising air temperatures (Table 3 & 4). With a few days of warm spring weather fly fishing for trout ends. Water temperatures become critical for the brown trout and especially the brook trout.

Both the Pine and Popple rivers begin as slow-moving non-trout streams. With the increase in gradient and the admixture of numerous springs and spring-fed tributaries the mainstems soon become trout water. Originally the only trout were native brook trout. Later the temperature-tolerant brown was introduced.

At the turn of the century the Pine–Popple basin became cutover. There are many openings visible from the Pine River which are still reminiscent of this activity. Old abandoned farms provide additional open areas. Cottages, summer homes, campsites, road bridges, and canoe landings pushed back the vegetation and let in the sunlight. Man-made dams on mainstem and tributaries do the same while allowing the water behind the dams to warm up sharply.

Opening the forests provided an important wedge for the beaver which became abundant in many Wisconsin trout streams in the 1930's:

> ". . . Their ponds caused warming of waters, chemical changes, siltation, blocking of spawning runs, and decreased spring flow, according to those people making investigations." (Christenson et al. 1961)

The same source showed that in 1936 203 beaver dams were removed from Jones Creek of the upper Pine River basin alone. One hundred and ten dams were removed in Florence county with 58 from La Montagne Creek. Although La Montagne Creek lies just north and outside of the Pine River basin the numbers are indicative of the pressure which the beaver were placing on the trout streams in this region of the state.

From 1945 to 1952 beaver reached their all-time peak of abundance. Special trapping seasons reduced their numbers but "by 1958 and 1959, the beaver problem on trout streams had again reached such proportions that NEA fisheries personnel became concerned and requested a policy directive to cope with the situation." Beaver activity was high on the South Branch Popple River, Popple River (main), McDonald Creek, Meadowbrook Creek, South Branch Pine River, North Branch Pine River, Pine River (main), and Kimball Creek.

The upshot of man's activities combined with that of the beaver was to put the trout fishery in jeopardy. The result is summarized by Mason and Wegner (1970):

> "Warmwater fish predominated in the lower Pine. Trout were found in all three rivers (Pine, Popple, Pike), but productivity is restricted by low water fertility, high summer temperatures and cold winter temperatures."

We may be dealing with wild rivers; however, fish species composition has changed with the use of fish poisons on a number of waters within the basin. According to Department of Natural Resources files at Woodruff, the following lakes in the Pine–Popple basin have been poisoned: Three Johns (1965), McKinley (1968), Two Sisters (partially treated, 1964), Harriet (treated for perch, 1966), Sand (1962), and Morgan (1962). Treated lakes frequently show little diversity in fish speciation. After treatment the Department stocks only a few game fishes, panfish, and one or two species of forage fishes. The natural complement of fishes has been removed through the poisoning program. Disadvantages in such a program are summarized by Becker (1971).

That fish poisoning programs should continue in a wild river system is inexcusable unless there is built into the system a well-designed preliminary research program followed by a well thought-out management program. Fish poisons are useful tools, but they are a last-ditch measure. Effects upon the aquatic environment are devastating and could lead to serious ecological imbalance. I should like to suggest that the use of fish poisons be entirely banned in wild river basins. Poisons produce problems, and, unfortunately there are too many possible side effects to the solution of which we have not even begun to direct ourselves.

The Pine and Popple are not free from airborne chemical contaminants. Pesticide contamination in the form of DDT and dieldrin residues have been detected in trout taken from these rivers (Kleinert et al. 1967). Recent reports indicate that DDT tests may be confused with PCB's (polycholorinated biphenyls) which also are highly persistent industrial chemicals of widespread distribution.

The point is that although the contamination of fish with these toxic chemicals is low, civilization's pollutants are reaching into our most isolated wilderness areas. Our concern must extend beyond mere provision for wilderness vegetation strips along the banks. If at all possible, the technological crunch should rightfully be stemmed well behind the wilderness Maginot line.

Continued pressure is being placed by landowners and organizations upon the Department of Natural Resources to allow damming up of tributary streams in the Pine and Popple basin. Justification for such action is cited as "recreational area, waterfowl resting and nesting area" and the like. Several permits for such impoundments have been granted with the Department agent stating that such action will constitute no damage to the fishery on the mainstem. Such reasoning is questionable when we consider the damaging effects of ponds on increasing the temperature of outlet waters. Beaver ponds are an example. A number of these warmed-up tributaries are bound to raise the water temperature of the mainstem Pine and Popple. It is inadvisable to allow further damming even in the lower Pine River below the La Salle Falls area which is considered non-trout water until adequate study has been made of water conditions necessary to support the fishery desired.

When the Pine, the Popple and the Pike were declared wild rivers under Wis. Statute 30.26, Chapt. 363, Laws of 1965, the Wisconsin Conservation Commission was empowered to draw up a plan for its administration. On November 3, 1967, the Wis. Conservation Commission (1967) adopted its policy on wild and scenic rivers "In order to afford the people . . . an opportunity to enjoy natural streams" and because "it is in the interest of this state to preserve some rivers in a free-flowing condition and to protect them from development. . . ."

The preamble goes on to state that a wild river area

> "is a stream or section of a stream, tributary, or river—and the related adjacent lands—located in a sparsely populated, natural and rugged environment where the river is free-flowing and unpolluted or where *the river should be restored to such condition, in order to promote sound water conservation,* and *promote the public use and enjoyment* of the scenic, fish, wildlife, and outdoor recreation values."

I have italicized the items in the above statement with which I would take issue. If this means that we are going to allow the river to revert to its wild or primitive state, if it means that we are going to pull man and his devices back from the banks, that we are going to remove as much as possible things such as buildings, roads, campsites, power and telephone lines, then I can go along with the statement. If pulling man back is synonymous with "restoring," then I can see eye-to-eye with the statement. But, "to promote sound water conservation, and promote the public use and enjoyment . . ." imply man stepping into the act and "improving" on what nature can do herself. Stabilizing eroding banks and restoring bank cover are measures which promote sound water conservation. A trained technician knows this and he has been hired for exercising his expertise.

Do we want this kind of manipulation on a wild river? And, by promoting the public use and enjoyment, by encouraging more use by the public, are we protecting the wild river, the "natural and rugged environment." The more people using such a river, the more evidence there will be of human presence, and, in fact, the less "wild" it will be.

The State Department of Natural Resources, in order to provide solace for purists has designated a zone known as the Primitive Zone:

> "A true natural wilderness zone devoid of *ALL* man-made efforts, developments or improvements of any type, in the water, or within 400 feet of the stream bank or to the visual horizon, whichever is greater, except for statutory requirements of an emergency nature."

Unfortunately only small fragments of the Pine and Popple are so zoned.

The other zones are: Scenic and Aesthetic Management Zone, Roadside Public Use Zone, Timber Management Zone, Agricultural Zone, Developed Recreation Zone, Developed Zone. All of these unfortunately allow wide latitude for manipulation by man.

Even more disappointing is the wild river plan adopted by the Forest Service (U.S. Dept. of Agric. 1969). That portion of the Pine River from its origin downstream to a point seven miles east of State Hwy. 139 lies within the Nicolet National Forest. Within the Forest, 65% of the land adjacent to the Pine River is in National Forest ownership. Hence, what happens on Forest lands will pretty much determine what happens to the river.

In the Federal plan for this wild river we read (italics are mine):

> "Every effort will be made to maintain enjoyable visual conditions within this Zone by perpetuating, *restoring, or improving vegetative cover* to reflect a pleasing Forest environment. Within this Zone, the goal will be to present *a vegetative condition that appears undisturbed by man.*"

Cannot nature "restore" or "improve" on her own? Is a wild river one that simply "appears undisturbed by man?"

> "*Canoeable stretches* of the Pine *will be maintained* to allow relatively free passage. Maintenance will include the *removal of fallen trees* which block the movement of canoes, and *selective moving of key boulders.*"

Does the canoeist, seeking out a wild river, want a manicured river bed or would he prefer a true wilderness stream with all of its hazards? How will such landscaping help the fishing for trout? Don't down logs and key boulders provide trout cover already?

The Pine River will be managed "to increase the likelihood of observing wild animals. . . . Ruffed grouse, and especially deer observations, will be greatly increased by enlarging and improving existing wildlife openings along the River." Do we need a Disneyland of nature just because a river has been declared wild? Won't opening up the landscape also accelerate warming of the waters, thereby cancelling out hope of returning to primitive trout and aquatic conditions?

The plan calls for blasting waterfowl potholes "in suitable marsh areas in and adjacent to the Water Influence Zone." Has any study been made as to what effect this will have on the groundwater temperatures next to the potholes and the ultimate effects on the temperature of the water in the river?

The plan calls for possible use of "natural-appearing structures to improve the fish habitat. . . ." There is no question that water conditions for trout production can be improved through the use of management devices. This has been well documented (White & Brynildson 1967). However, won't this foresake completely the concept of a wild river?

In the plan there is no such thing as a no-cut zone along each bank, except through the approval of the Forest Supervisor "if needed to protect the Wild River character of the Pine." Indeed, logging will be permitted right up to the bank of the stream and "All timber cutting and cultural work will be designed for the primary purpose of improving the present and future aesthetic value of this zone." Just recently this regulation was violated by a logging contractor. The matter was reported to the Forest Service who admitted that the contractor was in error, that he had violated the cutting principles and that accordingly he was to be fined up to $100.

From the plan we learn that "Stabilization of eroding stream banks and existing road ditches and back slopes will be top priority work within the zone." Also "Conifers and shrubs can be planted along the Pine to stabilize the banks of the River." Are we managing a wild river or a trout stream in rural southern Wisconsin?

In all fairness, there are many excellent features of the Nicolet National Forest Wild River Plan for the Pine River. I would advocate adoption of many of these in future wild river planning. But I am concerned with those features mentioned above which disrupt and interfere with the mechanisms which nature uses for establishing the primitive. I am disturbed by a federal logging policy which will forever keep a managed forest lining most of the banks of the Pine River. Primeval wilderness with downed trees and large decaying logs play no role in the Forest Service's wilderness program, at least none as it affects the Pine River.

It almost appears that in setting policy for managing a wild river, both the state and federal plans call for *more* management. The federal plan is expanding its multiple-use program for forest lands—meaning more activities for more people. The mentality operating is one which equates wildness, the wilderness and the primitive with "restoration." We appear to be headed for another Quetico–Superior wilderness slum. The Pine–Popple wilderness streams will through over-management and overuse lose much of their wilderness quality.

Sixty-nine percent of the trout captured by Mason and Wegner (1970) were stocked brook, brown and rainbow trout, many of them recently stocked fingerlings. At least some natural reproduction in brook and brown trout occurs each year. Water temperatures which readily fluctuate in accordance with the air temperatures are undoubtedly the limiting factor in trout reproduction in the mainstem.

The Forest Service's wild river policies, many of which will open rather than close the vegetative canopy, will operate against the trout fishery in the mainstem. This is certain to happen unless the mainstem is heavily managed for improving trout habitat. There is little likelihood that management for improving trout habitat will be extensive enough to improve the character of the river for trout production and to offset the affects of the anticipated multiple uses.

In summation I look for no improvement of fishing—rather a gradual deterioration. This will continue until a radical change in state and federal policy is instituted. At this time there appears little hope that such a change will occur.

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