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TRANSACTIONS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

LXIV—1976

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ELIZABETH McCOY

TRANSACTIONS OF THE WISCONSIN ACADEMY

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Contributors are asked to submit *two copies* of their manuscripts to the Editor. The manuscripts should be typed double-spaced on 8½ x 11″ bond paper. The title of the paper should be centered at the top of the first page and should be typed in *capital letters throughout.* The Author's name and brief address should appear below the title and toward the right hand margin. They should be typed with capitals and lower case and the address underlined for italics. Each page of the manuscript beyond the first should bear the page number and author's name for identification, e.g. Brown-2, Brown-3, etc. A note on separate sheet should identify the author with his institution, if appropriate, or with his personal address to be used in *Authors' Addresses* at the end of the printed volume.

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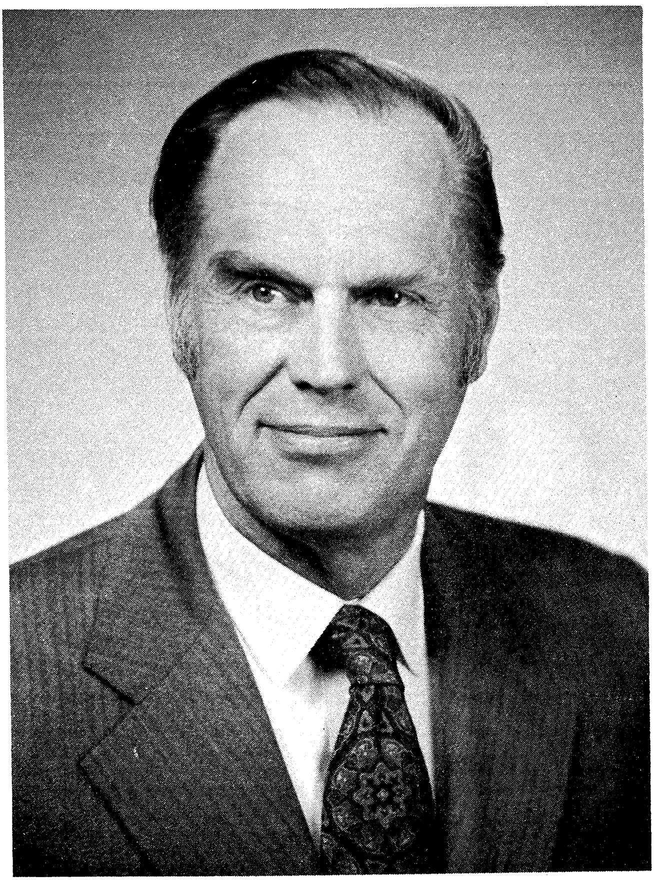


ROBERT P. HANSON

53rd President 1974-1975
WISCONSIN ACADEMY OF SCIENCES,
ARTS AND LETTERS

FROM ONE OF TWO WORLDS: VIROLOGY AND HUMAN AFFAIRS

Robert P. Hanson
Presidential Address
Waukesha, April 19, 1975

Almost everyone, perhaps everyone, innately resents it when he finds himself being stuffed into some categorical pigeonhole. A label has an imprisoning effect—we see a pacing lion behind a name on an iron-barred door. Labeling gives a seal of finality—we see an iridescent dragonfly neatly pinned on a plastic tray beside the name of its genus and species, as if that were all that need be said. But we are not ready for someone else's taxonomic judgment of ourselves, however well-meaning the judge may be.

We feel that the label tells us more about the label-giver than about ourselves. The University administration defines me as a member of the tenured staff, and my laboratory associates consider me a virologist. Other folks I know have no idea what a member of the tenured staff may be, or what a virologist does or looks like, and they feel little need to know. It does not matter, for they also have me identified. Nels believes I am a cog in the bureaucratic apparatus and fellow passengers on the Northwest flight to Washington may suspect that too. One biographical indexer and several presses think that I am an author. But in Burr's book, I drive a station wagon and stop in for gas at 7:45 AM, which makes me a morning-only customer. There are other concepts. To Marvin I am the one who calls him when one of his heifers has dropped a calf in the pasture that he rents from me. Pete knows me as the guy who comes to the mill to have alfalfa ground. My list, like yours, could go on and on. We each know that we are, in part, all these contradictory things, so how could anyone put us in a neat categorical box?

Much of the resentment of blacks and women is against labeling by race or sex—a labeling that by its restrictive implications puts the individual down, denies his or her individuality. Eventually, we will go beyond those movements as some of the women activists have been saying, to battle for the rights of all individuals to be their individual selves.

Benjamin Franklin succeeded, as have few others, in frustrating the many labelers. One thinks of him as being at once a printer, writer, inventor, scientist, diplomat, administrator, patriot and humanist—not any one of these things alone, but all of them. Yet, he remains in the minds of most of us as an approachable man, an individual with whom we could go to dinner, engage in small talk or in deep and challenging conversation. It is intriguing that a many-sided genius is viewed as quite normal and comfortable and that the individual who has exceptional talents to which he subjects his entire life like Fischer, the chess wizard, is viewed as odd and most of us would feel quite ill at ease, if we found ourselves in his presence. I suspect that we clearly understand our own complexity, and find any other many-sided individual to be quite normal. It is not the genius that we find peculiar, however brilliant, but the individual who rejects his own diversity to perfect a single talent. Such dedication may fascinate us in a morbid way. We become more interested in the story that the ballerina practices fourteen hours a day and has a list of things that she denies herself, than in the grace of her performance. We become more interested in the preoccupation of the mathematician who fails to recognize his brother on the street than in the elegance of his equation. We make such individuals into objects and drain them of their humanity.

Individuals, when we first meet them, are an apparition of the moment, creatures without a past. In a city they appear and vanish among its streets and corridors. About such passing images we can not care. They are merely images. We know that we have a past that conditions us, but we judge faces of others in the context of the moment.

I am sitting with a group of bankers and government officials, a group of faces around a heavy walnut table that is elegantly carved and oiled. My feet press into the deep pile of the carpeting and momentarily the scene fades back to a bibb-overalled boy rubbing his toes in the tall grass, as he gives directions to a well-dressed man at the wheel of a 1930 Buick. The boy knows that well-dressed people are rich, possibly bankers, and wonders what that is like—another kind of a world than his, and another kind of people. Now years later sitting at the walnut table the boy inside still wonders about himself and others. What sorts of boys are hidden in these bankers? Does a boy sit behind each of the man-costumes, now deciding things that control other peoples' lives and sometimes subconsciously trying to fulfill boyhood wants and to right boyhood hurts?

Images and labels—what do they mean? Early in my graduate training Carl Brandly, my advisor, argued against one using the word scientist to refer to oneself. To his thinking it is an accolade to be given by one's peers, if at all. One uses for oneself a more precise and descriptive term. An individual who studied bacteria is a bacteriologist, one who studied viruses is a virologist. Therefore, I was to be and am a virologist. Because of my affiliation and associations I have received two other titles that are variously defined. By virtue of the fact that I am an honorary member of the American Veterinary Medical Association, and spend much of my professional time with veterinarians and possess a doctorate in science, I am sometimes addressed as Doctor. I find Doctor used more frequently, and perhaps precisely, to keep the proper professional distance between the physician or veterinarian and his client. In Europe, my title becomes Professor, never Doctor since the former has a higher social connotation than the latter, and to give one less than his due is a rather serious matter. In many circles in this country titles can be socially inhibiting, a cold draft in a warm room. Fortunately, one does not have to wear a title upon the sleeve, as one must in the military.

Taxonomists are the people who not only label things but also classify things into a hierarchy of categories. Hugh Iltis assures me that taxonomists are by necessity a bit crazy and I must admit that some of them whom I have known do seem so to me. I believe, however, that he was really telling me that taxonomists possess the irrationality characteristic of the human race and are therefore human. The taxonomist that concerns me is not the one who classifies things but the one who classifies people and, particularly, the one who separates the learned community into two categories—the scientist and the humanists, a scientist being the individual who is concerned about things and the humanist, the one who is concerned about values. To some thinkers this means two philosophical approaches to life and two views of the world, which would make ours a schizophrenic civilization.

This, like all classifications, has reality only in the mind of the classifier. There may exist scientific humanists and humanistic scientists and unscientific scientists or unhumanistic humanists. To those of us less taxonomically inclined, human kind consists of individuals who live in a world of things and values and who deal more or less imperfectly with both.

As one who has been pushed forcefully into the box called scientist, I would like to tell a story of two individuals, coming from two different civilizations as they labored to acquire the tools and the processes of science. It is a story of how individuals learn to ask questions susceptible to scientific testing. I suspect that humanists have another system for asking questions and of evaluating the answers, but more important than any system is the recognition, by both scientist and humanists, that the art of asking significant questions is the basis of our civilization and that our future lies in how relevant to our needs we find answers by the systems that we use.

Before I can introduce my two subjects, I must sketch the background for their studies. That account starts with a three year old girl who lived in a little valley branching from the Mississippi River above its confluence with the Wisconsin. One August day almost two decades ago she became feverish and fretful and then was seized by intermittent convulsions. Rushed to a La Crosse hospital, she received supportive care but her condition worsened and she lapsed into coma and died. The physician told her parents that she had died of viral encephalitis of unknown etiology.

Unknown things that reach from out of nowhere to snuff out lives, particularly suddenly and violently, have filled man with dread for centuries. Since the rise of modern medicine such happenings have been subjected to systematic and intensive search for causes.

In this instance investigators from the University of Wisconsin isolated from the child a virus now known as LaCrosse encephalitis. Viruses are the ultimate of parasites. Unlike lice that infest unkempt scalps and round-worms that wander in human bowels, the submicroscopic virus lives *inside* selected cells somewhere in the body and subverts those cells to its exclusive use. LaCrosse encephalitis virus lives in critically important cells of the brain and destroys them. In the laboratory, it remains equally fastidious, growing only in brain cells of suckling mice or in special gardens of cells that can be cultured in glass dishes.

Isolation of the disease agent was an important step, but more important questions remained. How did the little girl become infected and will other children become infected in the same way? Where does the virus hide when it isn't infecting children? Can the disease be prevented? To discover the answers to those questions took more than 15 years; it challenged staff and students, and stimulated the writing of a series of ten scientific papers and ten theses.

The first thing that was done was to set down educated guesses or scientific hypotheses as to what might account for the appearance of the disease and then to devise ways of testing which of the several guesses was correct or most nearly correct. Wrong guesses are much more frequent than right ones. One does not complain if only one guess in ten or one in fifty is correct.

Since LaCrosse encephalitis virus was discovered to be related taxonomically to a group of mosquito transmitted viruses, it was guessed that a mosquito must have infected the little girl. But which mosquito? There are many kinds, differing in behavior and often requiring a different breeding place. To control a mosquito one must know it and its habits.

Were other children or adults being infected? Did death often occur, did some children recover from the acute illness only to remain paralyzed or mentally retarded, or did most children recover without any lasting effects? How widespread was the disease? Was it limited to places near La Crosse? Was it present throughout Wisconsin or the entire Midwest?

Rather quickly it became clear that there were many cases of the illness, almost exclusively in children and limited to children from the southwestern parts of Wisconsin and the adjoining areas of Minnesota and Iowa. Death was rare and occurred in only the youngest children. Older siblings recovered, some with impairment but most often without permanent ill effects. Adults suffered no apparent clinical illness.

The establishment of this information took some sleuthing as well as experimental tests of hypotheses. Rather odd things were discovered. The affected children were from families at the two ends of the socioeconomic scale, those of tenant farmers and professional people. Affected boys outnumbered affected girls more than 5 to 1.

Fascinating to me was the dearth of information in the literature of the kind that an ethologist is first to seek, when tracing a disease in, say the white tailed deer; i.e., its home range and behavior patterns. What is the home range of a six-year old boy? And is that of a girl different? In what ways do the circadian rhythms of children change in the span of a year? It was vitally important for us to know where the afflicted and non-afflicted children played. Neither child experts nor parents were of much help. Fortunately, the children had neither preconceived notions of what we were ultimately seeking or pretenses about life that they had to hide, so they showed us where they played and how they came and went. All children were at the stage when forts and tree houses, simple or elaborate, were retreats from parental authority, secret places of which they were shyly proud. The children from elegant suburban houses and dilapidated rural dwellings had identical playgrounds.

The children led us to the mosquito. Its name is *Aedes triseriatus*, a very close cousin of the notorious yellow fever mosquito *Aedes aegypti*. The culprit mosquito lives on the dry, oak-clad hillsides where the hot afternoon sun is partially filtered and where tree houses and forts are easy to build. There, in July and August in the late afternoon and evening after supper but before the shadows lengthen, the mosquito feeds and feeds again until the children leave for bed. At that point feeding stops for *Aedes triseriatus;* unlike most mosquitoes, it prefers to feed in day light.

In July and August the hillsides were dry, the nearest creeks had long since ceased to run and even the pools in the creek bed had dried. Since the larvae of all mosquitoes must live in water and the adults of most mosquitoes survive for only a few weeks after hatching, the source of these mosquitoes was puzzling.

The answer was on the hillside, although we failed at first to see it. At the base of some of the oaks, particularily those with several trunks, were depressions formed by the rotting away of wood where a long dead trunk had been. Now encircled by buttresses of sister trunks the cavity could hold a cup or a gallon of water shed by the bark above. These miniature pools contained water even in August and each teemed with microscopic life. Preying upon it, were the tiger-like larvae of *Aedes triseriatus,* safe here from the larger predators of streams and ponds.

We found LaCrosse encephalitis virus in these mosquitoes and we learned that the mosquitoes fed on people and chipmunks and squirrels. Tests soon revealed that the chipmunks and squirrels also became infected and that the virus increased in their blood until it was sufficient to infect susceptible mosquitoes that fed on the blood. The chipmunks and squirrels always survived the infection, became immune, eliminated the virus and showed no ill effects.

A student from Equador learned that the first mosquito larvae hatched in April from eggs laid the autumn before. At first the larvae grew slowly in the cold water of the tree hole, then as the weather became warmer, they pupated and finally the male and female mosquitoes emerged from the pupae about the middle of June. Within hours they mated and the male flew off to feed on flower nectar. The female, now driven by a need to provide sustanence for her developing eggs, sought warm blood. In late afternoon she sought out chipmunks, squirrels and children, to land, to probe and to draw blood. A female would live three to five weeks, alternately feeding and laying eggs, again and again. Once infected with the virus she would transmit it for the rest of her life.

Studies showed that *Aedes triseriatus* was the mosquito that transmitted the virus to children; that it lived on the hillsides of the many small valleys branching from the Ohio and upper Mississippi rivers. Hundred of encephalitis cases in children were disovered and additional deaths were recorded.

The seasonal sequence, from emerging of the mosquito to subsequent appearance of the infection, the disappearance of mosquitoes and the subsequent disappearance of infection fitted nicely. Each part of the story became a study for a student as he sought to establish its essential subcomponents.

A major gap remained—where did the virus come from each spring? All infected female mosquitoes died in the fall. All chipmunks and squirrels had become immune even before the first snow had fallen. The disappearance of many other arboviruses each fall and their reappearance each spring had puzzled investigators, since their discovery. It did not appear likely that an inexperienced student working on LaCrosse virus would find the answer.

Somsak Pantuwatana, like all Thais, was a quiet young man, respectful of elders, rather solemn in appearance but not without a low-keyed sense of humor. His thesis problem concerned the growth of the virus in chipmunks and, particularly, the effect of winter hibernation upon the antibody and virus. He came in one afternoon with some agitation evident in his passive features. His request was simple and I did not get the full implication at first, as an American student would not have asked what Somsak did or even thought of asking it.

He merely asked permission to test mosquito larvae from the tree hole for virus, knowing that virus would be there if it had passed from the mother mosquito through the egg to the larvae by transovarian transmission. The text books were unanimous in saying arboviruses were *not* transmitted through the egg of the mosquito. His lecturers had all said the same thing. He knew this but had come to doubt it. Somsak was asking permission to disagree with authority, with the text books, with his other professors and with me and with the Thai tradition and the Oriental culture of his forefathers that had taught him respect for his elders. Somsak had become an experimentalist; like the *avant guarde* in art and the revolutionary in politics, he wanted to test his ideas against the world.

I told him that his chances were poor; that he was probably asking to do a lot of unproductive work, but I carefully did not say no. He went off happy. And he did isolate the virus from a mosquito larva. The first isolate came easy. Then he slaved all summer long to repeat his feat as doubters teased him for being a windmill tilter. In the fall he did repeat the isolation and in doing so he convinced Douglas Watts, another student, of the validity of his hypothesis.

Doug grew up in the mountains of Kentucky where the boys only sometimes go to high school and never go to college. Doug went to Berea, the college that expects students to work while they study, to run the college farm and to operate the hotel in order to pay their way. He managed to graduate but not with grades that would win a scholarship. From Berea he went into the army and chance placed him in a laboratory working for an officer who later saw that he got an opportunity to go to graduate school. The mountain boy did well in his graduate studies.

He had a natural methodological approach to a problem that fitted well with Somsak's tenacity and visionary idea. Before they were done they together convinced the doubters. Doug grew the mosquitoes in the laboratory, induced them to feed and to lay eggs. He hatched the eggs, carried the mosquito through cycle after cycle. He fed the virus to the female mosquito, found the virus in the eggs she laid after he had carefully washed and disinfected them, and in the larvae that hatched from the eggs, then in the pupae that developed from the larvae and finally in the adults that emerged from the pupae.

Before the task was complete, Somsak had returned to Thailand and it fell to Doug to go to the national meeting of the Society of Tropical Medicine and Hygiene and present their findings. His paper was a highlight of the meeting. The Dean of arbovirology from the School of Public Health at Berkeley congratulated him for an outstanding paper. For a graduate student, an acknowledgment of this kind is close to a Nobel Prize and he was pleased. While Somsak would have enjoyed being there, he had another reward — he knew that the most important tenet of science was real — that the authorities could be challenged, and that questions properly asked by people like himself could change things.

By describing the process of scientific awakening in a boy from southeast Asia, and a boy from southeast Kentucky as they jointly solved a biological problem, I have hoped to show that scientific innovation involves an increased awareness of self, and a testing of self against all human kind. It is a contest with excitement, keen disappointment and high elation. There is nothing cold or impersonal in the search or the discovery whether the individual is labeled scientist or artist.

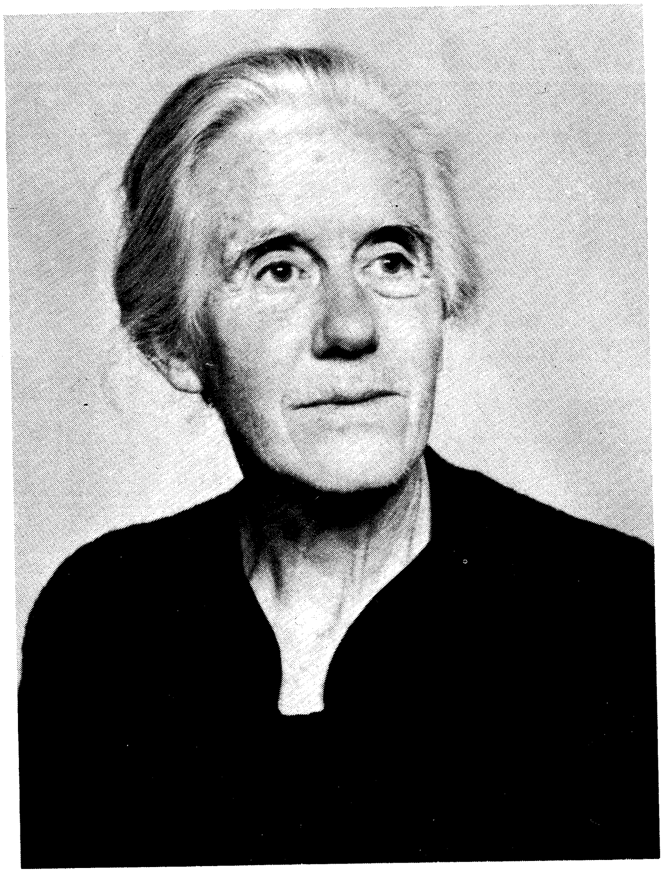
I am not claiming that science, arts and letters are alike. Science is demonstrably different from art in one key aspect. Its truths are verifiable and may be discovered simultaneously by several individuals, or if not discoverd now, will be discovered later. If

Somsak and Doug had not discovered transovarian transmission of virus in mosquitoes, someone somewhere else would have found it eventually. But no painting or poem has ever been reported to be created by two painters or by two poets. I know of no one who claims that another individual, in another place or at later time, would have written Shakespeare's plays.

The creative process in science, arts and letters, however, has one rather disconcerting similarity that is seldom recognized. This is, that the creative process is, itself, amoral. New insights are neither good nor bad. By asking the right questions we discovered the cause of a frightening disease of children. We learned how it is transmitted, even how it persists in nature. We can use that knowledge to prevent the disease. We could use that same knowledge to spread LaCrosse encephalitis to human populations and some people have used scientific knowledge and will continue to use it in that way. Rather than evil science there is evil use of science, just as there is evil use of art and evil use of history and philosophy.

Most creators are aware that their creations like children can be kidnapped or subverted and by evil design used to bring untold misery to the world. Is infanticide the way to prevent kidnapping, or prohibition of research the way to prevent the misuse of science? I doubt that the answer can be that simple. It is more difficult to recognize that every individual shares a responsibility for making decisions affecting the future of man and that he or she shares responsibiities for seeking the information and gaining the understanding of values needed to make those decisions.

Perhaps, it is trivial to say so but in giving and accepting labels we abdicate some of that responsibility. We say that it was the fault of the soulless scientist, the pornographic artist, the grasping banker, and we hope this way to escape the blame. We can no longer afford scientists who are not humanistic and humanists that do not recognize the laws of gravity or biological inheritance, if we are to avoid the fire in which a schizophrenic world would surely end.



ELIZABETH McCOY

54th President 1976
WISCONSIN ACADEMY OF SCIENCES,
ARTS AND LETTERS

TOWARD A PERSUASIVE PRESENCE: THE WISCONSIN ACADEMY IN 1976

Elizabeth McCoy*
Presidential Address
Madison, May 8, 1976

Sometimes a chance word, or phrase catches the attention and sets up a train of thought that otherwise might never have opened. You know our brains have a myriad of possible synapses between nerve cells, and which we use and where they lead us in thought very much depend upon the triggering stimuli. My stimulation came a few months ago, when I read the newsletter of my professional bacteriological society, the American Society for Microbiology. The Executive Director in the Washington office of ASM was asking the question whether our society should be a "periodic probe" or a "persuasive presence." The same might be asked concerning the Academy.

In the early days of the Academy our Founders undertook certain programs to meet perceived needs of the State at that time, but they provided for a wonderfully wide range of Academy functions in their stated purposes. They took the "periodic probe" technique as the way to begin, and in truth they accomplished a great deal. Anyone who looks at the titles of early programs and papers published in TRANSACTIONS can only marvel at the range and quality of much that was published.

But have we a choice of position of either/or for the Academy today? I think not and, as you see from my title tonight, I think the Academy has passed the point of choice and should be committed to the "persuasive presence" position. I think we are ready for a more "persuasive presence" and there are signs that we are already on that track. Let me trace for you tonight indications that we are achieving a recognized "presence" in our State of Wisconsin. Hopefully then you, the members, can join with your officers and the Academy committees in identifying new "presence" opportunities to the benefit of our Academy program and our State citizens.

*Uniquely this year there are two presidential addresses for record in TRANSACTIONS. The reason is that the Academy changed from July 1 to January 1 for its fiscal year with the result that the address no longer is given at the end of the presidential term but near its beginning. Thus both addresses fall within the timing of this Volume LXIV.

Let us start with the *Charter* and the first *Constitution*, because they are the bases of our very being as an Academy, and also because they should be a matter of nostalgic pride in this Bicentennial year. The Founders of the Academy, like to founders of our Country, were remarkable men! They had prophetic insight into the role that the Academy could have in the lives of citizens of Wisconsin. If interpreted broadly, the stated purposes of the Academy, as worded by the Founders, give us the mandate to do what we are now doing and much more.

The *Charter*, Section 2, states that the Academy shall . . . "encourage investigation and disseminate correct views of the departments of science, literature and the arts." They probably meant "true", "valid", and perhaps "proven" in the sense of tested and found genuine. Nevertheless I am amused by the expression, "correct views", and can only say that TRANSACTIONS tries to avoid the *incorrect* in the opinion of the reviewers and every year we have at least one occasion to save some author from publishing an incorrect view.

Why should the Academy encourage investigations and disseminate correct views? A reading of the letters of those who responded to the Call for a Meeting to Organize provides clues to their concepts of the place the Academy should have in the cultural and material growth of Wisconsin. From the phrases used one can conclude that the Founders expected *benefits* to ensue from their investment of time at the founding and from continued efforts of the members through the years. For example, as Lewis O. Thompson of Whitewater put it, *"Its [the Academy's] influence on general information and education throughout would be marked and signal."* D.W. Jones of Mineral Point stressed that the Academy would *"add to the material wealth of the State"* and was *"certain, at no distant day, to become a matter of State pride."* But perhaps the strongest endorsement of the Academy role came from the first President, John Wesley Hoyt. Upon assuming the chair at the first meeting, he is reported by Increase Lapham to have said of the academy concept: *"Academies devoted to original research were the forerunners of higher civilization."* In another place, the benefits to be expected from a Wisconsin Academy were said to *"lead to a more fruitful intellectual activity among the people and to a wider diffusion of useful knowledge."*

From the outset the Academy was to consist of three parts, then called Departments — Sciences, Arts and Letters. This is a bit unusual. Wisconsin is one of three state Academies so endowed, the others being Academies of Sciences. The broader composition of our Academy was clearly intended in the Call for a Meeting to Organize, wherein it is stated;

> "It would awaken a scientific spirit in inquiring minds . . . and lead to a more fruitful intellectual activity among the people at large.
>
> "It would associate artists of every class, establish higher standards of execution of works of art.
>
> "It would bring together men of letters and promote advancement of every department of language, literature and philology.
>
> "It would tend to promote literacy and aesthetic culture of the people . . . and . . . largely contribute to social progress of the state and thus earlier insure to Wisconsin an advanced position among the most enlightened communities of the world."

Surely an ambitious assignment for the Academy! How was all this to be accomplished?

The Department of Science was to:

1. Encourage general *Scientific Research* which its members would report at meetings.
2. Conduct a "progressive and thorough *Scientific Survey*" which mandate lead to the Academy's role in the Wisconsin Geological and Natural History Survey, and, if I may claim so, to many important papers in TRANSACTIONS, which document the biota and physical features of Wisconsin today.
3. Establishment of a *Scientific Museum*. This was apparently a plan to receive specimens and make them available to scholars and to schools. But this plan was not carried out, probably because other established museums served these purposes.

The Department of Arts was apparently conceived to comprize:

1. *Useful Arts* for applications of Science, including encouragement of invention
2. *Fine Arts* for the "improvement of Public taste" — encouragement to be by means of "awards and honors for works of superior merit."
3. An *Art Museum* was contemplated but this too was never realized.

The Department of Letters was to:

1. Encourage Philological and Historical Research
2. Improve the English language
3. Collect and preserve Historical Records

4. Form a General Library.

Contrary to the plans for the Museums, that for the Library has been implemented. The Academy Library now numbers over 50,000 items with a valuation of approximately $1 million dollars. It is housed in the U.W. Memorial Library and is added to yearly by exchange of our TRANSACTIONS for the transactions of Academies world-wide. There are now some 600 participating academies and their names by country are inscribed on a chart, which is framed and hanging on display in the Steenbock Center hallway.

In recognition of our library we have a Librarian, Mr. Jack Clarke of the University Library School, who is appointed yearly by the Academy Council. We owe especial thanks to him recently for his supervision of indexing the TRANSACTIONS. Working with Mrs. Edith Jones, he has improved earlier indices and brought up to date both author and subject indices for greater convenience of scholars and librarians who use TRANSACTIONS. Speaking of indexing, I wish also to acknowledge and thank Mr. Eugene Engeldinger, the reference and loan librarian at U. W. Library-Eau Claire, for his volunteer services in the indexing of the Academy REVIEW. This is, I think, an example of how a member, with a specialty of which the Academy is in need, can make a personal contribution and thus advance the Academy effectiveness. In this connection and perhaps as a further call for all members to come to the aid of the Academy, I can do no better than to quote the Plan of Operation as stated by President Hoyt:

> "The measure of accomplishment, in other words the efficiency and degree of usefulness of the Academy will, of course, be determined by the competency and zeal of its members, the wisdom, energy and devotion of its officers and the cordiality and liberality with which their plans and efforts for the public good are seconded and sustained by the people and the State."

OPPORTUNITIES FOR THE ACADEMY IN 1976 AND THE FUTURE

With such lofty ideals to spur us, what are we now doing to fulfill the hopes of our Founders? I will not attempt to mention all we *have* done in the 106 years of our existence—much of that you know from the 1970 Centennial Celebration. Rather I will turn to current programs which offer new and exciting opportunities for the

Academy to advance its "persuasive presence" position in Wisconsin.

Junior Academy and Related Matters

For about thirty years now the Junior Academy has been a source of pride to the senior Academy. LeRoy Lee is the present Director of the Junior Academy program and we owe much to him for the pre-eminence our Junior Academy enjoys. As you know, the program is oriented to the high school age youth, at first in the sciences but now in the arts and letters also. The program is handled through a statewide network in seven districts, cooperative with the public and private high schools. In fact, 24 per cent of all Wisconsin high schools and some 1200 students are involved. Creative work by the students is encouraged and rewarded by the opportunity to participate in a Spring Festival in each District. To quote from the brochure:

> "The festivals are not intended to be highly competitive... instead it is a day of sharing and observing what other students have done. Workshops, where students can sharpen their skills and learn from professionals, are also conducted in such areas as creative writing, sciences, art, multimedia, dance and film."

Summer Institutes offer experiences in arts, anthropology, plus travel within the State and also out-of-state to important national areas in Maine, Colorado, Montana. Another particularly worthwhile program is called *Wordworks*, a week-long experience in creative writing for 20 selected students, who benefit hugely from the volunteer staff of professional writers—poets, novelists, journalists, editors. This year, if I may be so bold as to say in advance of its happening, there is a plan for each student to have year-long contact with his own mentor. You may well ask—how is all this Junior Academy activity financed? Largely by self-generated funding, by high school membership, by student-paid fees for the major trips, by special grants. And we are justifiably proud of the agencies which have been so impressed as to make these grants—the Atomic Energy Commission, Wisconsin Arts Board, National Endowment for the Arts, National Science Foundation, Wisconsin American Revolution Bicentennial Commission and private foundation, like the Johnson Foundation and the Kohler Foundation.

With all of this success in programming for the high school youth, we felt the need to extend to the college youth, but had not yet taken such a step, when a very nice thing happened. We were approached by a young Honors student, Dan Russler. He had, I believe, had some conversations with Dean Chester Ruedisili and then with Dean Chandler Young (a WASAL past-president and now a Councilor-at-large). Dean Young referred him to us in the Academy. We met the challenge and a joint committee of Honors students, Assistant Dean Barbara Peterson, and Academy representatives was formed.

The request was for us in the Academy to provide a mature and critical audience to listen to presentation of student papers, based upon their Honors theses. Under the enthusiastic leadership of H. Clifton Hutchins, our Associate Director for Programs and himself a volunteer, the collegiate program was developed. Several meetings were held; three seminars were arranged to better inform the students of professional writing standards and techniques; and finally an Undergraduate Research Forum was held, where the student presentations were judged by invited professionals, who passed their critical comments privately to each participant. Out of some 80 odd students in the program originally, two were the finalist and, as you know, we have today had the pleasure of meeting them and hearing their papers at our noon luncheon. Very appropriately, we are able to reward them and record their success by giving the Edwin B. Fred Awards to Developing Scholars. The students today are the first recipients; their names will be inscribed on a plaque to be hung in the Steenbock Center. We have the intention to continue to recognize finalist each year in a similar manner. Incidentally, the program this year was limited to the College of Letters and Science at UW-Madison but we plan to open it more widely within the University System and private Colleges as well.

If this program does become a broad and on-going one statewide, the Academy would have the chance to develop a "Collegiate Academy", if so desired, but whether or not that is done, we can take pride in the initial fact—the students came to us as the appropriate source of the help they needed, i.e., to listen to them and to offer constructive criticism. I assure you the benefits are mutual. Incidentally, Dan Russler who first approached us, has joined the Academy and why should he not? I heard his paper at the Forum and I assure you that his work and his presentation were worthy of a professional. We also plan to encourage these Honor students to submit their papers to TRANSACTIONS, if they so desire. Why then would we need a Collegiate Academy? Should we not welcome these young people for what they are—Developing Scholars as worthy of our esteem as any Academy member?

Critical Issues

During the Robert Hanson administration a beginning was made on what we like to call our Critical Issues programming. I am not certain whether the concept arose during Hanson's presidency or during his previous service to the Academy on the so-called Long Range Planning Committee. It does not really matter. What does matter is that the Academy now recognizes its duty in relation to the State somewhat as the National Academy relates to the Federal Government. The very nature of the Academy and its diverse membership offers a resource to which state government can turn for analysis and disinterested (impartial) interpretation of issues of technological and social impact upon its citizens. What are such critical issues and are they of a nature that the Academy can effectively handle? Should the Academy wait to be asked, i.e., be merely a resource agency, or should it be ready by its own efforts to call attention and to develop the factual bases for assessment of one or more critical issues? President Hanson took the latter position and appointed an *Ad Hoc* Critical Issues Committee, chaired by Meredith Ostrom. This Committee was doing very well at the time of change of presidents and so I took the liberty to reappoint the same committee. It had, as you will remember, circulated the Academy members to develop a list of critical issues. From some 80 responses (some of them overlapping) 40 definitive issues were selected and three were viewed so urgent as to warrant initial study with a view of defining possible Academy action. They are:

1. Energy Production Systems for Wisconsin
2. Highest and Best Use of Land
3. Responsiveness of Government.

There is no significance in this order, except that the Energy issue is receiving first exploratory planning by the *Ad Hoc* Committee (and, I may add, from C. Hutchins. Only he knows how many hours of effort he has invested!). For a time it seemed not one issue but so many-faceted that it was a puzzle to see any phase that the Academy could tackle. Just recently there came a call from Mr. Charles Cichetti, Energy Director for the State of Wisconsin. This call, by the way, was in answer to our inquiry—in what way could the Academy serve the state in the Energy issue? Mr. Cichetti then met with the *Ad Hoc* Committee on April 13. Ways and means were thoroughly discussed and it does appear that the Academy can make a significant contribution. Mr. Cichetti left with the intention of informing the Governor of our willingness and we are waiting more specific planning. We who listened that day are convinced that we have here a prime opportunity to show the State the nature and capability of the Academy. And remember—this is only one of the identified critical issues. This could be a substantial start on a newly recognized "presence" of the Academy in State service.

Other Examples of the Importance of the Presence of the Academy 1976

I wish to list briefly several recent instances of Academy service to the State:

1. Our cooperation with the Wisconsin Art Education Association and the Wisconsin Department of Public Instruction in the planning of a Youth Art Month, which has culminated in the recent opening by Governor Lucey of a statewide student art exhibition at the State Capitol.

2. The leadership of our Junior Academy in providing the Governor with recommendations for 2 students to represent Wisconsin at the West Virginia Science Camp (and, I might add, we were instrumental in opening this particular program to young women as well as young men).

3. The Academy and the Junior Academy have also helped to keep alive the program known as the Governor's Youth Awards. This project, which provides recognition for acts of bravery and special achievement on the part of young Wisconsin citizens 18 years of age or younger, was in danger, because the state agency which administered it (the Governor's Advocacy Committee on Children and Youth) ceased to exist when its federal funding was eliminated. The Academy, in cooperation with the Office of the Governor, provided the administrative operation of the program this year and is now developing recommendations which will, it is hoped, assure the continuation of this important mechanism for honoring these deserving young people of Wisconsin.

4. I should also make mention of the opportune efforts of the officers and staff in claiming a rightful place for the Academy in the cultural life

of Wisconsin. When Assembly Bill 1345, which calls for a Joint Legislative Committee on the Arts, was proposed during the last Session, it listed two state agencies which would serve in advisory capacities. The author of the bill, which is now expected to be taken up in the next Session of the Legislature, was approached and he readily agreed to include the Academy as one of the agencies with which the Legislative Committee would confer in regard to all state legislation pertaining to the arts.

Another instance of recognition of the Academy by the State came in a request for the Academy to participate in appointing three persons to expanded Scientific Areas Preservation Council.

5. Very recently, we have undertaken talks with administrators from the University of Wisconsin-Extension as to how our two organizations might cooperate to better serve certain constituencies which we have in common. We are exploring at this time the area of youth programming, and we have agreed to assume, through a one year arrangement with UW-Extension, the administration of the highly successful Regional Arts Program. This will provide needed administrative assistance to Extension and will, through funding provided to the Academy, allow us to develop in an area in which we have historic interest but little programming as yet, i.e., the area of the visual arts.

6. I would be remiss if I did not point out, also, that the visibility and impact of your Academy is being spread through participation of its officers and staff as Academy representatives on boards or committees of important cultural groups. Our Executive Director, for example, currently serves as a member of the Wisconsin Humanities Committee, the Wisconsin Arts Council, and, by appointment of the Governor, the Wisconsin American Revolution Bicentennial Commission. Both Mr. Batt and I—and other officers and staff—have made a number of speeches throughout the past year to organizations of a variety of types; we invariably manage to put in our pitch for the Academy, you may be certain.

7. For a number of years now we have encouraged other groups, whose purposes relate to those of the Academy, to affiliate with us, somewhat as we are affiliated with the American Association for the Advancement of Science. Often such alliance strengthens the program and efficiency of both partners. Given our present concern for advancing in the fields of Arts and Letters, we are especially appreciative of affiliates like the Wisconsin Regional Writers, Wisconsin Arts Council, Fellowship of Poets, and the Wisconsin Art Education Association. In the Sciences too we have in this very meeting an example of mutual strength of the Academy and two of its affiliates, Nature Conservancy (Wisconsin Chapter) and the Botanical Club of Wisconsin, who helped materially in organizing the colloquia today and the nature trips tomorrow.

Affiliates were provided for in the Charter, Section 7, but it was left open whether they should "become a department" of the Academy or be "otherwise connected therewith on terms mutually satisfactory to the governing bodies of the said Academy and such other society or institution." We have evidently taken the latter approach and so far there is "satisfaction" on our part, and we hope also on the part of our affiliates. But perhaps we now should think about this—we have raised the number of affiliates from three to nine within the last three years and have done so without looking farther ahead than the good credentials of the affiliates applying. How far should we extend our invitations to new affiliates? Should we be known as an Umbrella for affiliates? What may we expect *from* them in exchange for what we do *for* them? These are some of the questions our Long Range Program Planning Committee has been asked to consider. I am confident that they will provide the Council and officers with a thorough analysis of our relations to our affiliates.

I think you have every right to feel a large measure of pride in the many programs, publications and activities in which your Academy is now engaged. That pride can only be enhanced by the knowledge that we are accomplishing all this on a budget, which the last Treasurer and Council recognized as a "bare bones" budget.

I only wish it were possible to lay to rest the notion that the Academy is "filthy rich" because we "came into" a million dollars, thanks to the generosity of our late colleague, Dr. Harry Steenbock. We did, indeed, inherit a most valuable stock portfolio from Dr. Steenbock—a fact that has made an enormous difference in the development of the Academy. We have, however, restricted ourselves to use of only interest and dividends of this endowment—an amount which makes up slightly less than one-half of our total operating budget. Were we to spend the principal of these funds in our annual operations, we would jeopardize our very future.

The dual effects of the depressed stock market, which was experienced until recent months, and the high rate of inflation, to be quite candid, very nearly caused a state of financial crisis where we found it necessary to reduce our base budget in the face of rising costs. This included the necessity in the current fiscal year to withhold all staff salary increases, to drop maintenance contracts on our office equipment, and to cut back on supplies and program expenses drastically.

I am told, however, that the Chinese character for *crisis* contains two symbols one which represents danger and the other which represents opportunity. In avoiding the former, we have experienced something of the latter. Remarkably enough, the officers and staff have been able to effect certain efficiencies which have allowed us, despite the reduced budget, to maintain and, in some instances, even to expand our programming. In this we have also been very much assisted by the generous gift support of members and friends and by the favorable response on the part of foundations to our grants proposals.

This does, however, touch upon one of the challenges which we now face. If we are to maintain financial stability, it will be necessary for us to find new sources of funding or to call more heavily upon those we now have. It will, I am sure, be of utmost importance to increase the size of our membership so that membership dues, without increasing them, can account for a greater portion of our operating income. At the same time, we must continue to seek additional income in gifts and grants from members, friends, business, industry and foundations. We may also want to explore our legal and historic ties with State Government and what this might mean in terms of support from that source.

This "challenge of dollars" is, of course, important only to the extent that we must continue to progress toward meeting the mission and charge given us by our Charter—to which I referred at the outset.

We must continue to strive toward these goals. We must continue to seek to be a *truly* statewide organization in membership representation, in program *around the state*, and in total and positive impact through a rich and balanced mix of activities in the sciences, arts and letters.

Now to end upon this positive and optimistic note—your Director shared with me two letters that came to him recently. They must have brightened his day considerably, because they were both dated April 14 and probably arrived on the 15th or 16th. One is from a member, who dropped out ten years ago but now intends to rejoin. Of the Academy ten years ago he says, *"it seemed to me to be missing the mark. Now it is a good organization, no question about that."* The other letter is from a twenty-year member, who like many of us was a dues-paying but rather silent member. We are all impressed by the Academy's new birth and we should be quick to give credit where credit is due—namely to our Executive Director! As the letter says, *"you . . . have made something of the Academy that it never was."* And to that I say for the Academy, "I agree. Thank you, Jim." And now I close by adding, "Thank you all for listening."

ALDO LEOPOLD'S *A SAND COUNTY ALMANAC* AND THE CONFLICTS OF ECOLOGICAL CONSCIENCE

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Few books do more than Aldo Leopold's *A Sand County Almanac*, in themselves and in the history of their publication, to illustrate the complexities of ecology as it has appeared on the American scene in the late nineteen sixties and early nineteen seventies.[1] Few books satisfy the conceptions of ecology of more readers than does *Sand County*. Few books come so close to containing the rhetoric of ecology in all its meanings—ecology as science, ecology as subject matter, ecology as ethical and esthetic point of view, and even ecology as preferred environment.

Despite its popularity and reasonable longevity, however, no literary critic has as yet taken *Sand County* very seriously. Like all its ecological cousins, like all nature writing (with the single exception of *Walden*), *Sand County* has been read with rhetorical and conceptual blinders. No scientist has considered it much more than pleasant or moving material to be read at leisure. No philosopher has approached its ethics. No literary critic has suggested that it might be fruitfully examined with a systematic eye to style, metaphor, conception, or narrative.

Because it is written at the interfaces of conventional academic disciplines, *Sand County*, like other such creations, has lacked serious scholarly attention, while enduring woeful misinterpretation at the hands of a well-meaning and enthusiastic popular audience. The two historians who have examined *Sand County* in detail have been less interested in the book itself than in Aldo Leopold's place in American history and the place of *Sand County* in Leopold's life.[2]

Like almost all books written at the interfaces between the natural sciences, the social sciences, and the humanities, *Sand County* suffers when judged by the criteria of any one of the established disciplines. Like almost all nature writing, it partially dissatisfies all its readers. Yet, unlike many such books, *Sand County* has qualities that indicate why even its most critical readers have been at least tentatively appreciative. It is a surprisingly complex and intricate work, rewarding to anyone who would closely examine its overt argument, its covert questions and counterarguments, the relationships among them, and the methods used to present them.[3]

INDUCTIVE STRUCTURE AND PRIMARY ARGUMENT

The primary argument of *A Sand County Almanac*—the argument for which Aldo Leopold is famous—is a two-fold statement: a tripartite, descriptive illustration and explanation of land communities—what they are, how they work, and how they change; and a closely related, prescriptive declaration of needs served by maintaining certain kinds of land communities. This is the argument for which *Sand County* is much quoted, the overt argument from land community or ecosystem to conservation and preservation.

As the book develops, its primary argument moves logically, from the land community as empirical fact, through the recognition of man's place in land communities, to a plea for ethical standards of land use. It progresses inductively: from one, restricted land community; through a series of land communities; to a discussion of the concept of land community—from detailed description and narration of a single land community; through description, narration, and exposition of several diverse land communities; to a largely expository discourse on the esthetics, ethics, science, and culture of land communities. In essence, the relation of Part I, "A Sand County Almanac," to Part II, "Sketches Here and There," to Part III, "The Upshot," in *Sand County* is the relation of percept to generalized observation to concept.

Part I is basically an introduction to a land community, an introduction that establishes the land community as an empirical (i.e. descriptive and narrative) certainty. It presents a series of essentially mundane facts in the life of a Wisconsin land owner. It speaks, for example, of pasque-flowers, geese, chickadees, mice, grouse, deer, cornfields, high waters, and old boards, among other things. It is noticeably lacking in conceptual terms. Conceptions and concepts, when they appear, are colored, qualified, and finally overshadowed by perceptual terms. It is broken into what might be called perceptual situations. Even individual chapters are occasionally fragmented. "January," for example, opens with "the tinkle of dripping water" on a warm midwinter night and then proceeds to independent consideration of a meadow mouse, a rough-legged hawk, and a skunk. "October" begins and ends with grouse hunting but presents, in between, a deer, a chickadee, some geese, some ducks, and a marsh. "December" begins with a canine rabbit hunt and then jumps to more chickadees, deer tracks, grouse, pine trees, and finally to chickadee 65290. Through such a perceptual conglomeration, the members of a land community are introduced, and along with them another significant member of the community: a man perceiving, digesting, and pondering a set of basic materials and relationships in a restricted environment.

Of first importance to the methods and meanings of Part I are the perceptual raw materials that form the substance of the man's environment. Without meadow mice, old boards, and chickadees the man would amount to very little. Meadow mice, grouse, and deer tracks substantiate the man's experience, not to say his identity. Pine trees, high waters, and woodcock corroborate the existence of the land community. But the man and his reflections are also central to the environment, as they are to the primary argument of the book as a whole. Without the man and his reflections neither meadow mice, nor old boards, nor chickadees would amount to much.

Part I is made of more than perceptual raw materials, however crucial they may be to the major statement of *A Sand County Almanac*. The simple sense experiences of the man are occasionally crossed and complicated by symbolic reflections and interpretive analogies. Trout, as they rise to the man's brown miller and eventually land in his creel, call to his mind a similar human disposition "to seize upon" gilded morsels containing hooks. Grouse that thunder across narrow openings in tamarack swamps suggest to the man that "many thoughts, like flying grouse, leave no trace of their passing, but leave some clues that outlast the decades." And the long growth of pines in 1941 leads him to wonder whether these pines "saw the shadow of things to come" and "made a special effort to show the world that pines still know where they are going, even though men do not."

Sometimes the man in Sand County reads the book of nature rather heavily. At other times he only suggests symbolic intricacies to a perceptual situation. In "January," for example, a meadow mouse "darts damply" across a skunk track, leading the man to wonder:

> Why is he abroad in daylight? Probably because he feels grieved about the thaw. Today his maze of secret tunnels, laboriously chewed

through the matted grass under the snow, are tunnels no more, but only paths exposed to public view and ridicule. Indeed the thawing sun has mocked the basic premises of the microtine economic system!

> The mouse is a sober citizen who knows that grass grows in order that mice may store it as underground haystacks, and that snow falls in order that mice may build subways from stack to stack: supply, demand, and transport all neatly organized. To the mouse, snow means freedom from want and fear (p.4).

In situations like this one, the basic perceptual substance of the land community momentarily recedes into the background, as the narrator becomes a symbolist, in this case perhaps a satiric symbolist. The mouse becomes an analogue for the narrator's conception of economic man, and mouse tunnels become metaphors for the inroads that civilized man makes on the land. A midwinter thaw may be equivalent to the passage of time that exposes man's economic determinism. And, despite thaws, it may be that man, like the mouse, is a sober citizen who will continue to believe that grass grows to make haystacks (which may be fed to cattle, which may profitably be sold to men) — "supply, demand, and transport all neatly organized." Sometimes the man in Sand County reads the book of nature suggestively, so much so that, on occasion, his readings can only be said to have multiple meanings. At still other times, he does not seem to read the book of nature at all, but simply to present it, without interpretation.

As Part I develops, as the Sand County land community develops, so the personality of the man in that community develops, and vice versa. Through his symbolic interpretations of seemingly mundane events, the man becomes more than a recorder of details, more even than a personifier of animals and plants. With the meadow mouse he becomes a socio-economic critic of sorts. When he makes wood in "February" he becomes a historiographer—saw, wedge, and axe, in turn, becoming three distinct, if complementary, approaches to the past. When he interprets the "December" pine (which has its own "constitution" prescribing terms of office for its needles) he becomes yet another kind of ironist, a commentator on the relations of human language and the non-human environment.

The numerous episodes of Part I have the quality of developed perceptions. Their denotative and connotative impression is cumulative rather than progressive. The facts they present are a kind of sequential validation of the land community. The members of a land community are introduced. Their relations and attachments (including those produced by the man) are established—

in a prose that is basically descriptive, narrative, and dramatic rather than expository or imperative; from a point of view that is fundamentally personal rather than communal or impersonal.

If Part I of *Sand County* validates the land community, Part II extends that validation, taking it beyond personal experience and carrying it across conventional geobiotic and cultural boundaries. Where Part I concentrates on a single land community, a restricted psycho-biotic locus, Part II covers several geographically distinct land communities, several less-restricted and less-detailed loci in a much broader field of reference. Where the prose of Part I is basically narrative, the prose of Part II is narrative only in part. It is also expository, almost by half. Where, in Part I, explanations are the dramatized thoughts of a narrative character, in Part II they are also (and often) rendered independent of specific narrative occasions. The narrative "I," "my," and "me" of Part I often become, in Part II, expository "we," "our," and "us"; or generic "you" and "your." The largely psycho-biotic drama of Sand County becomes, in substantial part, the socio-biotic exposition of Wisconsin, Illinois, Iowa, Arizona, New Mexico, Chihuahua, Sonora, Oregon, Utah, and Manitoba. The largely personal and local history of Sand County tends to become generic, regional, American, and even Western. The personal narrative drama and description of Part I become less dramatic, more pointedly prescriptive, and more communal in Part II. In more senses than one, "Sketches Here and There" is an expansion of "A Sand County Almanac."

In fact, Part II of *A Sand County Almanac* is a hybrid of the styles that define Parts I and III; a stylistic amalgam of the concrete and the abstract, personal narrative and impersonal exposition, idiosyncratic perception and impersonal conception. As it extends the style of "A Sand County Almanac" it also leads into "The Upshot."

In "Manitoba," for example, one reads not only a past tense personal narrative about grebe-watching, but also an impersonal, present tense interpretation of grebes and grebe-watchers:

> I was starting to doze in the sun when there emerged from the open pool a wild red eye, glaring from the head of a bird. Finding all quiet, the silver body emerged: big as a goose, with the lines of a slim torpedo. Before I was aware of when or whence, a second grebe was there, and on her broad back rode two pearly-silver young, neatly enclosed in a corral of humped-up wings. All rounded a bend before I recovered my breath. And now I heard the bell, clear and derisive, behind the curtain of the reeds.

> A sense of history should be the most precious gift of science and of the arts, but I suspect that the grebe, who has neither, knows more history than we do. . . . If the race of men were as old as the race of grebes, we might better grasp the import of his call. Think what traditions, prides, disdains, and wisdoms even a few self-conscious generations bring to us! What pride of continuity, then, impels this bird, who was a grebe eons before there was a man (pp. 160-61).

Specific, narrative grebes become the archetypal grebe. The events of personal narrative experience are rendered exemplary and set in expository and communal context. Past tense personal narrative leads to self-reflection, and reflection leads to what "we" characteristically do, to what "we" might be, to a shared human condition. Personal narrative is explained and subsumed by impersonal exposition.

The chapter "Wisconsin" is almost entirely discursive and impersonal. Even its most personal and narrative segment, "Flambeau," ends in a brief historical account of "REA," "the Conservation Commission," and "the Legislature." The chapter "Oregon and Utah" is dedicated to an explanation of cheat grass and its effects on the American West, an explanation interrupted only once by a personal narrative that illustrates and corroborates prior, impersonal exposition, and leads directly into the conclusion: "We tilt windmills in behalf of conservation in convention halls and editorial offices, but on the back forty we disclaim even owning a lance" (p.158).

Of the six chapters in Part II, "Sketches Here and There," only the short chapter "Illinois and Iowa" maintains the unbroken personal narrative prose of Part I. In the other five, personal experience of and in land communities is rendered communal, generically human, and increasingly abstract.

The narrator (*qua* narrator), the "I" so central to Part I, often disappears in Part II of *Sand County*. In "Chihuahua and Sonora" the land community is presented in familial as well as personal terms, and the narrator's experience is frequently inseparable from his brother's. In "Arizona and New Mexico" the geobiotic environment is identified primarily in its relations to "*Homo texanus*," and the narrator becomes a horseman: an "undistinguished" member of a socio-historical and human community composed of cowmen, sheepmen, foresters, and trappers. As personal experience of land communities is generalized, so, of course, are the detailed events of the geobiotic environment. As the first-person singular of Part I gives way to the first-person plural (or the second-person), so it also gives way to the even less personal third-person:

> High horns, low horns, silence, and finally a pandemonium of trumpets, rattles, croaks, and cries that almost shakes the bog with its nearness, but without yet disclosing whence it comes. At last a glint of sun reveals the approach of a great echelon of birds. On motionless wing they emerge from the lifting mists, sweep a final arc of sky, and settle in clangorous descending spirals to their feeding grounds. A new day has begun on the crane marsh (p. 95).

The descent of sandhill cranes in "Wisconsin" gives rise to a discussion of their historicity; to notes and comments on a Holy Roman Emperor, Marco Polo, and Kublai Khan; and finally to historiographical ponderings: "Thus always does history, whether of marsh or market place, end in paradox" (p. 101).

The stylistic strategy of Part II of *Sand County* is to take the details of a man's relations to land communities (the kinds of details that are strictly narrative in Part I), to generalize them and lead them toward the major concepts and arguments of Part III; to move gradually away from the personal narrative drama of "A Sand County Almanac" toward the essentially impersonal explanations and ideas of "The Upshot"; to gradually withdraw the personal voice, turning ever more frequently to the materials of history and community, and increasingly to outright socio-economic criticism.

Arguments at best only implicit in Part I become increasingly explicit in Part II, even if they are still indirect:

> The highway stretches like a taut tape across the corn, oats, and clover fields; the bus ticks off the opulent miles; the passengers talk and talk and talk. About what? About baseball, taxes, sons-in-law, movies, motors, and funerals, but never about the heaving groundswell of Illinois that washes the windows of the speeding bus. Illinois has no genesis, no history, no shoals or deeps, no tides of life and death. To them Illinois is only the sea on which they sail to ports unknown (p. 119).

Judgments at best tentative in Part I become increasingly overt: "That the good life on any river may likewise depend on the perception of its music, and the preservation of some music to perceive, is a form of doubt not yet entertained by science" (p. 154).

As personal experience is generalized, as social and economic events become primary subjects of concern, so the disinterested personal observation and reflection of Part I tend to become discrimination and adjudication. Prescriptive terms, like "overgrazing" and "misuse," multiply. Cheatgrass is "inferior," and research is a "process of dismemberment." "The place for dismemberment is called a university," and professors are something less or something more than simple functioning parts of their environments.

As adjudication increases so, appropriately, does ratiocination: the formation and explanation of conceptions necessary to support normative judgment. The notion of the land pyramid, for example, becomes in Part II something more than the unnamed thought of a Sand County land owner, and yet something less than the "mental image" it will be in "The Upshot":

> Food is the continuum in the Song of the Gavilan. I mean, of course, not only your food, but food for the oak which feeds the buck who feeds the cougar who dies under an oak and goes back into acorns for his erstwhile prey. This is one of many food cycles starting from and returning to oaks, for the oak also feeds the jay who feeds the goshawk who named your river, the bear whose grease made your gravy, the quail who taught you a lesson in botany, and the turkey who daily gives you the slip. And the common end of all is to help the headwater trickles of the Gavilan split one more grain of soil off the broad hulk of the Sierra Madre to make another oak (pp. 152-53).

As the details of personal experience are rendered communal and abstract, as prescription and explanation take over from description and narration, so the unsifted percepts of Part I are gradually built into conceptions, conceptions that become concepts in Part III.

If Part I of *A Sand County Almanac* is about things like a meadow mouse, a Wisconsin land owner, and chickadee 65290; and Part II about things like horsemen, government trappers, and sandhill cranes; Part III is about things like wilderness, recreation, science, wildlife, conscience, esthetics, conservation, ethics, land health, the A-B cleavage, and the community concept. "The land pyramid," for example—a complex of oak, buck, cougar, and goshawk in Part II—becomes in Part III a "symbol of land," an "image," and "a figure of speech":

> Plants absorb energy from the sun. This energy flows through a circuit called the biota, which may be represented by a pyramid consisting of layers. The bottom layer is the soil. A plant layer rests on the soil, an insect layer on the plants, a bird and rodent layer on the insects, and so on up through various animal groups to the apex layer, which consists of the larger carnivores.
>
> The species of a layer are alike not in where they came from, or in what they look like, but rather in what they eat. Each successive layer

> depends on those below it for food and often for other services, and each in turn furnishes food and services to those above. Proceeding upward, each successive layer decreases in numerical abundance. Thus, for every carnivore there are hundreds of his prey, thousands of their prey, millions of insects, uncountable plants. The pyramidal form of the system reflects this numerical progression from apex to base. Man shares an intermediate layer with the bears, raccoons, and squirrels which eat both meat and vegetables (p. 215).

The oaks, jays, and bucks of Part II become in Part III more abstract plants, birds, and animals—logical components of "The biotic pyramid" rather than characteristic members of regional ecosytems. The individualized actors of Part I—the dog, the meadow mouse, and the Sand County land owner—give way to carnivores, herbivores, and mankind.

In more ways than one Part III is the upshot to A Sand County Almanac. In formal terms it is the ideational conclusion to a logical and stylistic order that moves inductively from the narrative raw materials of Part I through the generalized observations of Part II. It is a conceptual, and essentially impersonal, summation of man's relations to land, the kinds of relations made personal, dramatic, and narrative in Part I. It is a further formalization and exposition of the generalized experiences, notions, and judgments that characterize Part II. Its language and its substance are as conceptual as the language and substance of Part I are perceptual and imagistic. Its prose is as clearly expository as the prose of Part I is narrative.

As the land community of Part I and the regional communities of Part II become the concept of land community in Part III, so the Sand County land owner of Part I and the community member of Part II become the ethicist and moralist of Part III. Thoughts, impressions, and preferences that are functions of a first-person narrative character in Part I become theoretical constructs in Part III. Judgments and criticisms that are expressions of shared communal experiences in Part II become the reasoned end products of a formal normative system, a moral code for man's relations to the nonhuman environment.

As "The Upshot" to *A Sand County Almanac* develops, "mental images" and concepts become primary subjects of concern. Figures of speech—"the land community" and "the land pyramid"—become the philosophic corner posts to a land ethic. Symbols—"the biotic pyramid" and "the pyramid of life"—become necessary psychosocial conditions to developing an ecological conscience. In short, the primary argument of *A Sand County Almanac* is made explicit—the argument from ecosystem as fact and concept to the need for maintaining certain kinds of ecosystems.

In one sense, it is an easy argument to follow. Its descriptive or nomothetic elements are easy to understand, and its prescriptive or normative components seem to grow logically from systematic premises and historical evidence: Land is, and for a long time has been, a complex organism, a "highly organized structure" of interlocking food chains and energy circuits. The continuous functioning of land depends, and for a long time has depended, on "the cooperation and competition of its diverse parts," of which man is simply one among many. "The trend of evolution is to elaborate and diversify the biota." "Evolution has added layer after layer, link after link," to the pyramid of life; and man is but "one of thousands of accretions" to its height and complexity. Man, however, has often behaved as if he were an overlord rather than a citizen of the land community. Modern man especially has simplified (or oversimplified) the land pyramid. He has, in fact, been a counter-evolutionary force in the biota. He has had counter-evolutionary effects on the environments he has occupied. He had depleted soils and deranged the circuits of energy flow that sustain the land. He has upset the capacity of land for self-renewal. He has thought of land as property and of himself as property owner. He has applied to land a narrow system of strictly economic priorities and values. He has possessed the land rather than being possessed by it. As a result, both he and the land are in need of a new system of concepts and values: a system that will assure the continued existence of empirical norms for healthy land through the preservation, conservation, and restoration of lands that have not yet suffered the most disruptive inroads of civilization; a system of values and images that will restore, and then maintain, harmonious relationships between man and land.

To many people it is a satisfying, if not compelling, argument—the argument from land community as fact and concept to the land community as value. It derives not only from the intimate narrative experiences and personal preferences of Part I but also from the generalized observations and communal experiences of Part II. At the same time, it contains or encompasses its logical components. It explains the relations of man to land, both the relations of the individual man as they appear in "A Sand County Almanac," and the relations of human communities as they are expressed in "Sketches Here and There." It calls for "an internal change in our intellectual emphasis, loyalties, affections, and convictions"; an "extension of the social conscience from people to land." And it finally rests on the proposition that *Homo sapiens* must begin to think of himself as "plain member and citizen" of the land community rather than "conqueror" of it: "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise" (p. 224-25).

OVERT THESIS, COVERT ANTITHESIS, AND VICE VERSA: THE AMBIGUITIES OF ECOLOGICAL CONSCIENCE

Compelling and satisfying though it may be, intricate though it is, the primary argument of *A Sand County Almanac* is far more complex than any simple description of its development can suggest—in part because its descriptive and prescriptive components are at stylistic and conceptual odds with one another; in part because the dialectic of their relationship is typically covert; and in part because that dialectic changes form as point of view and prose style change.

Like virtually all nature writing, *Sand County* is dedicated to and defined by two mutually exclusive conceptions of man's relations to nature: one basically descriptive, synthetic, and holistic; the other essentially prescriptive, analytic, and dualistic. Man in *Sand County* is, and ought to be, a plain member and citizen of the land community. But he is also an exploiter and subverter of land communities, and ought not to be. He is, whether he likes it or not, an overseer and guiding force in the biotic community, a king "that will not leave the world . . . the same place that it was." Yet he is also but "one of thousands of accretions" to the pyramid of life, and cannot be otherwise. Nature, analogously, is the self-sustaining system of energy circuits that contains and absorbs all men and their artifacts. But it is also that which men naturally attempt (and must attempt) to contain and absorb, if not in supermarkets and power plants then in "mental images" and symbols. The land pyramid is a "mental image" in terms of which humans must conceive their actions. Yet it is also the contextual system, the "revolving fund of life," in which all those actions are taken, including actions leading to the creation of "mental images."

To be a part, yet to be apart; to be a part of the land community, yet to *view* or *see* one's self as a part of that community (and thus remain apart from it); to be a part of the biotic pyramid, yet to know the pyramid and the terms of one's position in it; to identify man in terms of his environment, yet to know the terms of that environment and the terms of man's place in it; to present the land pyramid as an accurate description of man's relations to his environment, yet to present the land pyramid as a "symbol" for land, a symbolic key to an ethical system created and held by men, and not very many men at that: both conceptions are as conventional in nature writing as they are definitive in *Sand County.* So, too, are the impulses they express and the needs they seek to satisfy. The one—an holistic conception of man's place in nature—aspires to a non-normative theory of the development and operation of the geobiotic environment, a disinterested account of the relations of organisms (including men) and their surroundings. The other—an atomistic conception—aims at a dualistic, and at least partially normative, theory of man and nature; a bilateral, and at least partially adjudicative, account of man's relations to the geobiotic environment; a conception of man and nature based on fundamental distinctions between the natural (i.e. geobiotic and, therefore, appropriate) actions of man and at least some of his civilized (i.e. social and economic) habits.

The holistic conception of man's place in nature is dedicated to the proposition that man's behavior—however distinctive, however cultural, however linguistic—is finally, and fully, explainable in the same basic terms as the behavior of other organisms. As a combination of ideas and impulses, the holistic perspective is, thus, geobiotic. It draws no fundamental distinctions between the natural and civilized actions of men. It identifies man as an integral part of the land community, and the other members of that community as integral parts of man's environment. It explains the actions of men, whatever their form, as functions in and of geobiotic systems. So, too, it explains geobiotic systems (and the behavior of their constituents) as functions in and of human communities. It represents evolution as a process subsuming human history and containing man, even as he foreshortens food chains and "deranges" the "normal" succession of nonhuman ecosystems. It emphasizes an integral, on-going connection of man and land, even as man "destroys" land, even as changing lands provoke changes in man—the whole to be traced through time. And it, therefore, expresses, and no doubt satisfies, man's traditional desire to be immersed in his surroundings.

The atomistic view of man and nature, by contrast, presupposes that some of man's relations to land are integral, and that some are not; that some members of the land community have integral relations to man, and that some do not. Resting on the proposition that "man-made changes" in the biotic pyramid "are of a different order than evolutionary changes," it represents evolution as a process in which man participates only imperfectly, a process in which he may early have participated but now, very often, does not. Taking essentially nonhuman biotic communities as norms, it explains the actions of men as functions in and of evolving geobiotic systems only when those actions are consonant with the needs of other elements in such systems, where "consonant" means conducive to the continued, healthy existence of all present species. The atomistic perspective identifies man as an integral part of the land community only as his actions perpetuate and sustain its component food chains and energy circuits. At the same time, it identifies man as *Homo sapiens*, as a knowing creature capable of altering or directing the course of evolution, a creature whose behavior can only be partially explained in geobiotic terms. As a complex of ideas and impulses, it is, thus, bio-social rather than geobiotic, dualistic rather than monistic. It assumes that man can do (and has done) inimitable things to the pyramid of life, but it also assumes that man has the capacity (unique among organisms on earth) to rectify his misdeeds, to become (or once again become) a plain member and citizen of the land community—only this time a knowing, self-conscious citizen. And it therefore effectively expresses, and perhaps satisfies, man's continuing need to be on top of his surroundings.

Taken together, these two conceptions of man's relations to nature are not only the logical antipodes to the world of *Sand County;* they are also its warp and woof, its constant stylistic threads. They intersect each other on almost every page of every chapter, and they make the book as a whole a composition of opposites, a fabric of coordinates converging from two radically different directions, a fabric of ironies, ambiguities, and paradoxes. Together they account not only for the frontside of *Sand County*—the overt argument from land community to land ethic—but also for its backside—the covert pattern of questions, doubts, and contrary impulses that runs just behind its primary surface and upon which its overt statements depend.

In Part III, of course, the dialectic cloth of *Sand County*, the web of relationships between holist and atomist, is more abstract and more open than it is in either Part I or Part II. In two or three short pages of "The Land Pyramid," for example, one hears both holist and critical dualist: Man is "one of thousands of accretions to the height and complexity" of the pyramid of life, and "the trend of evolution is to elaborate and diversify the biota." In short, man is a plain member and citizen of the evolving land community. "Evolution is a long series of self-induced changes" in the circuit of life, "the net result of which has been to elaborate the flow mechanism and to lengthen the circuit." And yet "man's invention of tools has enabled him to make changes of unprecedented violence, rapidity, and scope" in the biotic pyramid. He has simplified its flow mechanisms and shortened its circuits. His agriculture, industry, and transportation have produced an "almost world-wide display of disorganization in the land," a disorganization that "seems to be similar to disease in an animal, except that it never culminates in complete disorganization or death" (p. 219).

Loosely interwoven as they are in Part III, the perspectives of the holist and the dualist are comparatively easy to separate, and the contradictions between them are readily apparent and inescapable. If man *is* a plain member and citizen of the land community, "one of thousands of accretions" to the pyramid of life, then he cannot be a nonmember or conqueror of it; and his actions (like the actions of other organisms) cannot but express and affect his position within the pyramid of life. If "the trend of evolution *is* to elaborate and diversify the biota," and man is an inextricable part of the process, then man *cannot* be simplifying its flow mechanisms or shortening its circuits. If "evolution *is* a long series of self-induced changes" in the circuit of life, and man's actions are an inseparable part of evolution, then "man's invention of tools" cannot logically be said to have enabled *him* to make changes of "unprecedented violence, rapidity, and scope" in that circuit. Conversely, if man's technology *has* enabled him to make unprecedented changes in the circuit of life, then evolution is *not* simply a long series of self-induced changes in that circuit. It is in recent earth history, at least in part, a series of man-induced changes. If man *is* simplifying the flow mechanisms and shortening the circuits of the biotic pyramid, then the trend of evolution is *not* to elaborate and diversify the biota, at least not so long as man is a functioning member of it. If man is an exploiter and conqueror of the land community, then he is not a plain member and citizen of it, or at least he is a citizen only part of the time.

Because its composition is bold, direct, and expository; because its alternative conceptions and arguments are unmediated by narrative occasions or shared communal experiences; Part III of *Sand County* raises almost as many questions as it may seem to answer: Is man a plain member and citizen of the land community? Or is he a conqueror and exploiter of land communities? Or is he both? Is man a citizen of the land community only part of the time? If so, when? Under what conditions? Is he a citizen of the land community when he *thinks* of himself as such, when he consciously seeks to understand his place in the biotic pyramid? Do man's thoughts and language take him outside the land community? Or are his thoughts, conceptions, and ethics (like his search for shelter, food, and sex) simply expressions of his place in the pyramid of life? And, if so, can any fundamental distinction be drawn between his "land ethic" and any other ethic he may apply to land? Is evolution a long series of self-induced changes in the circuit of life? Or is it also man-induced? And, if so, to what extent, when, and under what conditions? If at least some man-made changes in the land are of a different order than evolutionary changes, how is a *man* to tell whether or not such a change (say the adoption of a land ethic) is evolutionary?

Questions such as these, lying just behind the surface of "The Upshot," produce a series of critical uncertainties for the serious reader of *Sand County*. Deriving, as they do, from the clash of disinterested geobiotic science and interested socio-biotic criticism, they create a pattern of critical doubts and ambiguities, a pattern that surrounds almost every important statement in the final, abstract section of the book. If, for example, "an ethic, ecologically, is a limitation on freedom of action in the struggle for existence," then an ethic (any ethic) is very much like a water supply, a windstorm, or a wheat field; like money, cancer, or language. Are any of man's ethics more than expressions of his geobiotic condition? Have they ever been? Can they ever be? In what sense is a "land ethic" or an "ecological conscience" more than an ecological event, to be understood (as are other such "ethics" and "consciences") as another in the series of "successive excursions from a single starting-point, to which man returns again and again to organize yet another search for a durable scale of values" (p. 200)? Does all history consist of "successive excursions from a single starting-point," successive searches after a durable scale of values? Or is history progressive? Can man find in the land ethic a *final*, durable scale of values? *Have* we learned "that the conqueror role is eventually self-defeating," because "the conqueror knows, *ex cathedra*, just what makes the community clock tick, just what and who is valuable, and what and who is worthless, in community life" (p. 204)? Can, or should, we learn?—"A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise." Is man to determine when the biotic community is stable and beautiful? Or must he take counsel from other citizens of the community— not only pines, deer, and wolves but cheat grass, algae, gypsy moths, and rats? Can man take anything more than *human* counsel with the other members of the land community? Can such counsel ever express more than the ecological interests of man and the species he most closely identifies with? Is the problem *we* face simply a matter of extending "social conscience from people to land"? Are *we* willing to extend to other members of the land pyramid the conscience and the consciousness that would make the notion of land community a working analogy? Or would that simply be another human imposition on the pyramid of life, another example of exploitive anthropocentrism?

Virtually every key word in "The Upshot" has two mutually exclusive meanings—one descriptive, the other prescriptive. "Evolution," for example, is the process of change that occurs over time in the geobiotic environment. But "evolution" is also the process by which the land sustains itself, the purpose of which is to preserve the life of *the* biotic pyramid. "Ecological situations," similarly, are networks of organisms and environments changing over time. But "ecological situations" are also the kinds of situations that men ought to seek, the kinds of relations among organisms and environments that must not be violated and which evolution is designed to foster. "The land pyramid" is both fact and value. So are "the pyramid of life," "the land community," and even "the land."

The conflicts between fact and value, description and prescription, in Part III of *Sand County* are both radical and unconditional, more radical and less conditional than they are in either Part I or Part II. Neither narrative occasions nor shared regional experiences are present to relieve the tension between them. "The biotic pyramid" both "is" and "ought to be." An "ecological conscience" involves both a conscious understanding of the biotic pyramid, a cosmogonic sense of what it is and how it changes, *and* a desire to discriminate its healthy and unhealthy states, a teleological need to indicate where it ought or ought not to go: "In all of these cleavages, we see repeated the same basic paradoxes: man the conqueror *versus* man the biotic citizen; science the sharpener of his sword *versus* science the searchlight on his universe; land the slave and servant *versus* land the collective organism" (p. 223). But is not man a conqueror when he thinks of himself as conqueror? Or even when he *writes* of himself as a plain citizen? Is not science (*scientia*) the sharpener of his sword even when he *styles* it a searchlight? Is not land a slave and servant even when, or perhaps especially when, men call it a collective organism? Is not man indeed a king, a king "that will not leave the world . . . the same place that it was"? Does any organism leave the world the same place that it was?

Logical and philosophical questions arise easily in "The Upshot" to *Sand County*. One might even say "The Upshot" is designed to raise such questions—by alternating conceptions of man's relations to nature, by juxtaposing competing theories of history, by rotating "is" and "ought," by interlacing fact and value. At the same time, however, "The Upshot" exposes the basic threads of the book as a whole, the elements that make up its imperative primary surface as well as its interrogative sub-surface in Parts I and II no less than in Part III.

Though they are less obvious in either Part I or Part II than in Part III, the ambiguities and uncertainties that underlie "The Upshot" are no less central to "Sketches Here and There" or "A Sand County Almanac." In both Part I and Part II, the web of relations between holism and ethical dualism is tighter than it is in Part III (though considerably more open in the second section than it is in the first). Fact and value are more closely related than they are in "The Upshot." Competing theories of history and evolution, alternative conceptions of man and nature, are more compactly interwoven. And conflicts among the dialectic elements of *Sand County*, conflicts often almost blatant in the last part of the book, are therefore less conspicuous, though by no means less crucial to its developing cloth.

In "Wisconsin" of Part II, "a new day has begun on the crane marsh":

> A sense of time lies thick and heavy on such a place. Yearly since the ice age it has awakened each spring to the clangor of cranes. The peat layers that comprise the bog are laid down in the basin of an ancient lake. The cranes stand, as it were, upon the sodden pages of their own history. These peats are the compressed remains of the mosses that clogged the pools, of the tamaracks that spread over the moss, of the cranes that bugled over the tamaracks since the retreat of the ice sheet. An endless caravan of generations has built of its own bones this bridge into the future, this habitat where the oncoming host again may live and breed and die.

> To what end? Out on the bog a crane, gulping some luckless frog, springs his ungainly hulk into the air and flails the morning sun with mighty wings. The tamaracks re-echo with his bugled certitude. He seems to know.
>
> *   *   *   *
>
> Our ability to perceive quality in nature begins, as in art, with the pretty. It expands through successive stages of the beautiful to values as yet uncaptured by language. The quality of cranes lies, I think, in this higher gamut, as yet beyond the reach of words (p. 96).

This passage, like so many others in *Sand County,* presents a divided picture of the natural world. On the one hand, it suggests that man is not a part of nature, that nature—the crane marsh and the events that go to make it up—is an essentially nonhuman phenomenon, a set of processes that man participates in only vicariously, however much he may wish otherwise. On the other hand, it also suggests quite the opposite: that man is indeed a part of nature, that nature—insofar as it is *known* and *appreciated*—is at least as human as it is nonhuman, at least as much the product of human ingenuity as it is the conditioner of man's "creative" impulses: an expression of his science, his language, and his needs for order as much as it is their basic substance.

Perhaps the greater part of the passage implies that nature is foreign to man, that nature is never more than inadequately understood by men. "A sense of time lies thick and heavy" on crane marshes, as it typically does not on man's farms and cities. "The cranes stand, as it were, upon the sodden pages of their own history." Men, by implied contrast, often seem to stand on the pages of a history not their own, their own history being, too frequently, thin and dry. Time, not man's time, is the time of the crane marsh. And, while man may, in one sense, know that time—know that lake, mosses, tamaracks, cranes, and peat have built the crane marsh, "this bridge into the future, this habitat"—man does not know, perhaps cannot know, "to what end," however much he may wish to. The crane, on the other hand, flailing "the morning sun with mighty wings" and bugling his certitude, "seems to know"—not only where he has come from but also where he and his marshes are going—a quality of knowledge man can perceive perhaps, but which he cannot capture in language.

In such a world (at least half the world of *Sand County)* man is a stranger to nature, a questing perceiver of natural processes, an outside observer attempting with little success to encompass and comprehend cranes, crane marshes, and their relations. As outsider observer, man only learns slowly to perceive quality in nature. His efforts to capture such quality in language are a never-ending, and seldom successful, struggle to reconcile his own needs and his own terms with the nonhuman world around him. His dilemmas are not the crane's dilemma. He tries to write and understand, while the crane simply goes on living. There is a world of difference between cranes and the man who seeks to know them.

Tellingly, ironically, and inevitably, man's desire to know, his needs to order, explain, and understand (to the extent his needs realized) set him apart from the very things he would know. In his questing, ordering hands, a complex of sounds and silence, cries and mists, arcs and spirals, becomes a crane marsh. The crane marsh, in turn, becomes a product of ecological succession—mosses, tamaracks, cranes, and peat—and more than that even. For the differences between man and marsh are apparent not only in his scientific propositions but also in his "poetic" figures of speech. Ecological succession becomes "an endless caravan of generations" building futuristic bridges, and the crane in his habitat becomes a phoenix, a mythic being with a capacity for self-renewal and a certitude that man can only envy.

In man's hands, the crane becomes considerably more than a plain member and citizen of the land community, more than a crane perhaps. For to be a crane in man's ordering hands is not just to be named. It is to be compared with other named things. It is to become a member of complex systems—energetic, genetic, morphological, and ecological—systems in which the thing you are swallowing (what men call a frog) is no longer a primary term, systems in which "frogs" are replaced by "heat," "waste," "structure," "energy," and "time." To be a "crane" is to be invested with man's hopes and doubts, with man's particular kinds of order.

Strangers though they may be in one sense, crane and man are in another and no less significant sense, not strangers at all, but rather acquaintances of the most intimate kind. As stylized products of ecological succession and evolutionary change, cranes and crane marshes express man's needs to know at the same time they pattern his knowledge. The crane marsh—the "bridge into the future," the "habitat" for the "oncoming host"—is a method for coming to terms with living, breeding, and dying—for man no less than for the crane. The crane, in turn—the bugling phoenix—is an assurance that life is self-renewing, a means to knowing that something or someone can answer the question "To what end?" even if man cannot.

Despite differences in their respective media, perhaps the crane's dilemma *is* man's dilemma. Still, it is no doubt only in man's power to say in words, while trying to capture the quality of cranes in words, that "the quality of cranes lies . . . as yet beyond the reach of words." It is no doubt only in man's power to conclude with paradox and yet, paradoxically, continue to seek resolutions to paradox—to say in quite civilized words, in sentences far from "wilderness incarnate,"

> Thus always does history, whether of marsh or market place, end in paradox. The ultimate value in these marshes is wildness, and the crane is wildness incarnate. But all conservation of wildness is self-defeating, for to cherish we must see and fondle, and when enough have seen and fondled, there is no wilderness left to cherish (p. 101).

Mutually exclusive views of history and evolution, alternating notions of man's relations to nature, are no less central to Part II of *Sand County* than they are to Part III. In Part II, however, history and evolution are only infrequently presented as theoretical constructs. Divergent views of man and nature are only occasionally treated as concepts or "mental images." And conflicts among the dialectic elements of *Sand County* are, therefore, only inadequately explained in logico-philosophic terms, tensions between man and land, "is" and "ought," are only partially represented as logico-philosophic problems.

In "Sketches Here and There," as one might expect, logico-philosophic problems are presented in regional, national, and cultural contexts. Ethical, metaphysical, and even scientific questions are raised in context of regional economics, national politics, and cultural traditions. History and evolution are embedded in regional development and ecosystematic change, in the details of cranes and crane marshes, or coyotes and abandoned logging camps. Man's relations to nature are the crane watcher's relations to cranes, or the government trapper's relations to the mountain, Escudilla. By the same token, the crane watcher's inability to capture the quality of cranes in words is less an epistemological dilemma than it is a shared, cultural difficulty. The paradoxes of wilderness preservation are less logical problems than they are communal concerns. And problems generated by competing ideas of conservation are less theoretical difficulties than they are "our" problems—emblematic problems that express "our" needs, national problems that "we" have created, regional problems that "we" must solve, if any solutions are to be found.

As one returns from "The Upshot" to "Sketches Here and There," the dialectic cloth of *Sand County* becomes, in a sense, more dramatic and more familiar. As the substance of *Sand County* changes, as cranes and crane marshes, or farmers and cornfields, replace concepts and symbols, so philosophic doubts become geo-historical ironies. As point of view changes (from a predominant third-person to a basic first-person plural), logical dilemmas become bio-cultural ambiguities. The basic elements of *Sand County* are held constant, while the patterns they form vary.

As one moves, in turn, from "Sketches Here and There" back to "A Sand County Almanac," the fabric of *Sand County* is further compressed, its dialectic threads are even more closely interwoven than they are in Part II. As the voice of communal experience—regional and historical experience—becomes a personal voice, the voice of the Sand County land owner, so socio-biotic ironies become psycho-biotic uncertainties. As the historical time and space of geo-cultural regions become the personal narrative time and space of a Sand County farm, so logical dilemmas become psychological dilemmas, and philosophical problems become personal problems. Alternative notions of man's relations to nature are absorbed in personal narrative. Competing conceptions of history and evolution are embedded in autobiographical experience. What had been "our" traditions and desires become "my" personal habits and needs, and "our" disagreement becomes "my" uncertainty. What ought to be the case is what "I" wish for; what is the case is what "I" see, and need to see; and any differences between the two are facets of "my" personality.

In "A Sand County Almanac" the dialectic elements of the book as a whole are fully dramatized. Both cultural traditions and philosophic questions are functions of an individual man's relations to his land:

> I find it disconcerting to analyze, *ex post facto*, the reasons behind my own axe-in-hand decisions. I find, first of all, that not all trees are created free and equal. Where a white pine and a red birch are crowding each other, I have an *a priori* bias; I always cut the birch to favor the pine. Why?
>
> Well, first of all, I planted the pine with my shovel, whereas the birch crawled in under the fence and planted itself. My bias is thus to some extent paternal, but this cannot be the whole story, for if the pine were a natural seedling like the birch, I would value it even more. So I must dig deeper for the logic, if any, behind my bias.

> The birch is an abundant tree in my township and becoming more so, whereas the pine is scarce and becoming scarcer; perhaps my bias is for the underdog. But what would I do if my farm were further north, where pine is abundant and red birch is scarce? I confess I don't know. My farm is here.
>
> The pine will live for a century, the birch for half that; do I fear that my signature will fade? My neighbors have planted no pines but all have many birches; am I snobbish about having a woodlot of distinction? The pine stays green all winter, the birch punches the clock in October; do I favor the tree that, like myself, braves the winter wind? The pine will shelter a grouse but the birch will feed him; do I consider bed more important than board? The pine will ultimately bring ten dollars a thousand, the birch two dollars; have I an eye on the bank? All of these possible reasons for my bias seem to carry some weight, but none of them carries very much.
>
> So I try again, and here perhaps is something; under this pine will ultimately grow a trailing arbutus, an Indian pipe, a pyrola, or a twin flower, whereas under the birch a bottle gentian is about the best to be hoped for. In this pine a pileated woodpecker will ultimately chisel out a nest; in the birch a hairy will have to suffice. In this pine the wind will sing for me in April, at which time the birch is only rattling naked twigs. These possible reasons for my bias carry weight, but why? Does the pine stimulate my imagination and my hopes more deeply than the birch does? If so, is the difference in the trees, or in me? (pp. 68-70).

"Is the difference in the trees, or in me?"—with that question the Sand County land owner gives the dialectic of *Sand County* as a whole perhaps its purest expression. On a November day, he poses the question implicit in virtually all the logico-philosophical dilemmas and socio-biotic inconsistencies of "The Upshot" and "Sketches Here and There." Is man a plain member and citizen of the land community? Or is he its conqueror? Or is he both? Why do I find man as plain member more attractive than man as conqueror? Does the notion of man as biotic citizen stimulate my imagination more than the notion of man as conqueror? If so, is the difference in man's actions, or is it in me and my notions? Am I citizen, or conqueror, or both? Is the biotic pyramid a fact? Or is it a figure of thought and value? Is the difference between fact and figure, or fact and value, a function of things in the pyramid of life? Or is it a function of needs in man, and in me? Is there a difference between what man knows and what the crane on the "Wisconsin" marsh knows? And, if so, is the difference in what each knows, or in me? Are man and nature both inextricable parts of a unified natural whole? Or are man and nature distinct? And, if so, are the distinctions in man and nature, in man, or in me?

Crucial though such questions (and their answers) are to the formulation of a land ethic in "The Upshot"; central though they are to the conception of regions in "Sketches Here and There"; in "A Sand County Almanac" they concentrate in one fleeting, reflective, November moment of a self-conscious land owner's life; they come back to earth, as it were, to the relations of an organism and its environment, the personal relations of a man and his surroundings.

In the land owner's almanac of Part I, the dialectic threads of *Sand County* produce an autobiographical cloth, a closely woven pattern of personal perceptions, individualized arbitrations, and self-conscious reflections. As one might expect, in Part I of *Sand County* epistemological and metaphysical dilemmas become matters of momentary self-interrogation, passing rhetorical queries of a man "wasting" his November weekends "axe-in-hand." Alternative approaches to history become idiosyncratic analogies for "saw, wedge, and axe" as the man makes wood in February. The events of history—a federal law prohibiting spring duck shooting, for example—become personalized analogues for the growth-rings on the oak he is cutting. Members of the human community—neighbors, tourists, and speeding grouse hunters—become the substance of occasional, and often self-gratifying, thoughts. And nonhuman elements of the geobiotic environment become configurations of singularly personal ideas and impressions.

A meadow mouse darts damply across a skunk track, provoking questions and reflections, complex figures of speech and developed conceptions, perhaps even concepts and mental images:

> Why is he abroad in daylight? Probably because he feels grieved about the thaw. Today his maze of secret tunnels, laboriously chewed through the matted grass under the snow, are tunnels no more, but only paths exposed to public view and ridicule. Indeed the thawing sun has mocked the basic premises of the microtine economic system!

Perhaps the mouse *does* suggest man in his current relationships to land, and perhaps some thaw will expose his habits of land use:

> The mouse is a sober citizen who knows that grass grows in order that mice may store it as underground haystacks, and that snow falls in order that mice may build subways from stack to stack: supply, demand, and transport all neatly organized.

But there is also a strong possibility that the mouse and his tunnels represent each member of the land community, each member of the land community (man included) soberly and selfishly pursuing the mouse-eat-grass, hawk-eat-mouse pattern that prevails in all ecosystems: "To the mouse, snow means freedom from want and fear." And, in the next paragraph, to the hawk " . . . a thaw means freedom from want and fear" (p. 4).

Perhaps the mouse, the hawk, and every other member of the land community (man included) will continue to see snows, thaws, and bio-economic organizations as meaning freedom from want and fear. Maybe it is natural for man, mouse, and hawk to use their surroundings in order to be free from want and fear. Perhaps it is necessary that man, mouse, and hawk attack and exploit other members of the land community—if not with underground haystacks and economic systems, then with scientific explanations and ethical judgments, with language and figures of speech. In short, just as there is evidence to support an ironic and satiric reading of the meadow mouse episode, so there is evidence to suggest that the episode is nothing more or less than a *picture* of the actions and habits of *one diminutive member* of the land community. Or, to put it another way, just as there is evidence for a prescriptive reading of the situation, so there is evidence to support a descriptive interpretation.

Such are the ways of analogies and analogues that both the figure and the thing figured are brought to the same end. Only the maker of figures perhaps is provided momentary freedom from want and fear, and even that kind of freedom seems terribly fleeting to the self-conscious ecologist. In the end, then, we return to the man in Sand County, to a man in a land community.

NOTES

1. In manuscript form at Aldo Leopold's death in 1948, *A Sand County Almanac* was prepared for publication by his second son, Luna. Published in 1949 by Oxford University Press, it was initially read and and admired primarily by devotees of nature writing, inveterate conservationists, ecologists, and foresters. Original reviewers and reviews of the book were utterly predictable—Joseph Wood Krutch in *The Nation*, Edwin Way Teale in *The New York Herald Tribune*, and Hal Borland in *The New York Times*—all sought to place *Sand County* in the popular tradition of Thoreau's *Walden*.

Between 1949 and 1952, *Sand County* proved successful enough for Oxford to consider publishing some more Leopold material. Accordingly, in 1953, *Round River* appeared—a selection of essays and notes from the Leopold family journals edited by Luna Leopold. This second book, however, did not enjoy the success of *Sand County*, and, in 1966, Luna and his wife, Carolyn Clugston Leopold, brought out an "Enlarged Edition" of *A Sand County Almanac*. A testament of sorts to the failure of *Round River*, the "Enlarged Edition" combined eight essays from *Round River* with a slightly emended text of the original edition of *Sand County.*

The "Enlarged Edition" proved surprisingly successful, perhaps beyond imagination—but not primarily because of its increased length or the material from *Round River;* rather because it happened to hit the market at the right time, just as the popular "ecology movement" was getting off the ground. In fact, Oxford was hard pressed to meet the new patterns of ecological consumption. In 1968 it reprinted the original edition of *Sand County* in paperback, and, in something less than two years (with precious little advertising), *Sand County* became what, for a university press, is a best seller, at 30,000 copies a year. So extreme did ecological demands become that Oxford and the Leopolds eventually sold the paperback rights to the "Enlarged Edition" of *Sand County* to efficient, mass-producing Ballantine Books (1970). Aldo Leopold's once unfinished draft was, thus, available in three versions, all selling well. Such have been the vagaries of "ecological conscience" in America that even its fondest advocates may occasionally wonder at its substantial commercial success.

2. For an "early" interpretation of Leopold's place in American history see Roderick Nash, *Wilderness and the American Mind* (New Haven: Yale Univ. Press, 1967). For the details of Leopold's life and the development of his thought see Susan L. Flader, *Thinking Like a Mountain: Aldo Leopold and the Evolution of an Ecological Attitude toward Deer, Wolves, and Forests* (Columbia, Missouri: Univ. of Missouri Press, 1974). For a brief, nicely written story of the man and his land see Susan Flader's essay in *The Sand Country of Aldo Leopold* (San Francisco: Sierra Club, 1973).

3. The analysis which follows is concerned solely with the original (1949) edition of *Sand County*, for at least two reasons: first, because it is the original edition; and, second, because the "enlargements" of the 1966 edition add nothing to the formal characteristics of the original. In stylistic terms, the "enlargements" of 1966 are a repeat of the original Part II, "Sketches Here and There." Page references to the 1949 edition are parenthesized in the text.

ACKNOWLEDGMENT

I would like to express my gratitude to the National Endowment for the Humanities for generous support that provided time to complete this study.

LIMNOLOGICAL RESPONSES OF CRYSTAL LAKE (VILAS COUNTY, WISCONSIN) TO INTENSIVE RECREATIONAL USE, 1924-1973

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ABSTRACT

Crystal Lake, in northeastern Wisconsin, has approximately 70% of its shoreline developed into camping sites and swimming beaches. Results of a 1973 limnological survey of the lake were compared with measurements taken by Birge, Juday, and associates (1924-1942) to assess physical, chemical, and biological changes. Secchi disc readings declined from 10.8 to 8.8 m. This decrease probably resulted from mechanical disturbances of human activity and increased rates of erosion and run-off from shoreline use. Standing crops of phytoplankton and zooplankton did not change, but bacterial concentrations in the water rose by 90%. The slight decrease in total phosphorus (13.5 to 5 μg/liter) probably resulted from regrowth of the vegetation in the drainage basin after the lumbering and clearing in the first decade of the 1900s. The carbon dioxide equilibrium has apparently shifted as evidenced by slight increases in alkalinity (1.0 to 2.6 mg/liter), specific conductance (10.0 to 13.2 μmhos), and pH (5.8 to 6.2) and a decrease in free carbon dioxide (1.7 to 1.3 mg/liter). The small magnitude of these changes could be accounted for by natural eutrophication processes.

INTRODUCTION

Recreational activities associated with natural water bodies are rapidly becoming a major American pursuit. The recreation experience is critically affected by water quality, and recreational water quality standards have been proposed (National Academy of Sciences and National Academy of Engineering, 1973). Scientists are also becoming increasingly aware that intense camping and recreational use can in itself drastically change the quality of natural aquatic systems (Worms 1965, Reigner 1966, Dotzenko et al. 1967, Barton 1969, and National Industrial Pollution Control Council 1971).

Crystal Lake, located in the Highlands Lake District of northeastern Wisconsin, receives intense camping and recreational use. It is an infertile seepage lake with acidic soft water and high transparency (Black et al., 1963). The lake occupies a depression in a glacial outwash plain between two recessional moraines. The saucer-shaped basin (see Fig. 1) is bordered with fine, light-colored quartz sand forming gradually sloping beaches around most of the edge. The geology of the Northeastern Highlands Region has been extensively reviewed by Thwaites (1929), Fries (1938), and Juday and Birge (1941). Historical data on the limnology of Crystal Lake are available from early studies by Birge, Juday, and their associates (Juday and Hasler 1946). Objectives of our study were to: (1) determine whether limnological conditions had changed significantly in the past 30 to 50 years; and (2) relate any changes to possible influences of heavy recreational use.

MATERIALS AND METHODS

Earliest literature on Crystal Lake comes from E. A. Birge and C. Juday, and from their students and associates who undertook a complete survey of the Highlands Lake District. In addition to published papers, their results were recorded and maintained in a card file available through the Laboratory of Limnology, University of Wisconsin, Madison. A list of publications on Wisconsin limnology, 1871-1945 (Juday and Hasler 1946), contains at least 42 publications with information on Crystal Lake. Data for Crystal Lake are thus extensive.

Characteristics were chosen for our 1973 study based on completeness of the historical record, an ability to replicate the data, and its importance as an indicator of the lake's trophic status. We used three sampling sites (Fig. 1): (C) lake center, (B) off the beach in 3.5 m of water, and (R) a relatively low use "reference" area in 3.5 m of water. Data from the center station only were compared with previous data.

Table 1 lists characteristics measured in 1973, the sampling frequency, reference for the 1973 method employed, and reference(s) for the 1924-1942 data used for comparison. We sampled from 23 May 1973 through 23 March 1974. However, sufficient 1924-1942 data were available for statistical comparisons with 1973 data only for the period from late June through September. To minimize variations in results owing to methodology, analytical techniques were modeled after those employed in the 1924-1942 analyses. Some difficulties arose in comparing 1973 data with previous data because sampling procedures during 1924-1942 were not consistent in method or water depths sampled. Comparisons were made on a weekly, biweekly, or monthly basis depending on frequency of the 1973 sampling (see Table 1). Because the number of data points available for each week of the year varied greatly for 1924-1942 data, the median for each week was used for comparisons with 1973 in Wilcoxan's signed rank test (Steel and Torrie 1960).

Groundwater flow rates through Crystal Lake were estimated from the equation Q = k m i L(Todd 1957), and the estimated permeabilities for glacial outwash sands in northeastern Wisconsin (Jaquet 1974).

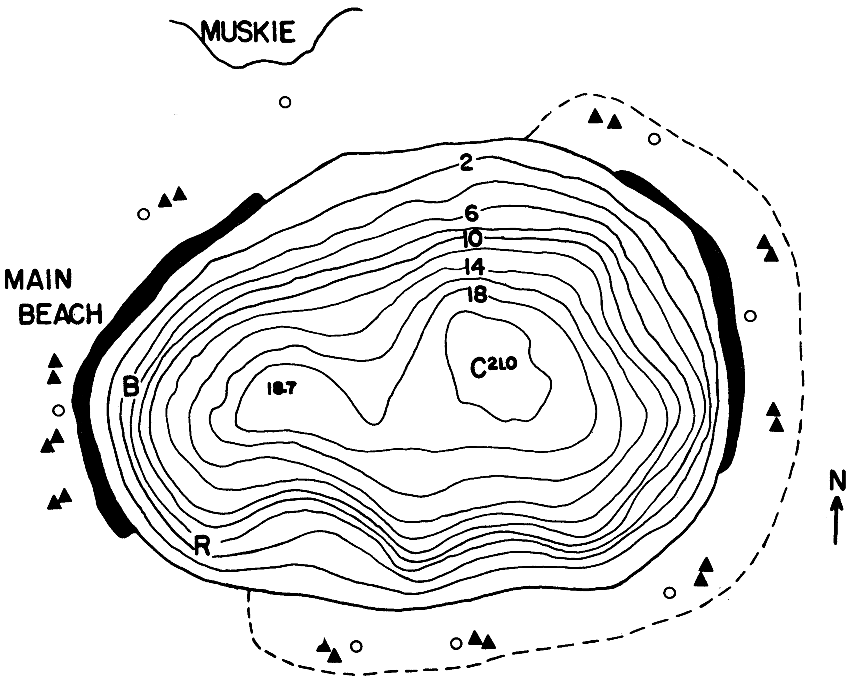

FIGURE 1. Contour map of Crystal Lake, at 2 m depth intervals (source: Star Map Services, P. O. Box 18633, Milwaukee, Wisconsin). Recreational development around the shoreline as it existed in 1973 and sampling areas are shown. Developed beaches are shaded. The area of the camping sites is enclosed by a dashed line. Triangles represent pit toilets; circles, hand-pump wells. Sampling sites, C = lake center site at about 20 m depth, B = beach station at 3.5 m depth, and R = reference station, also at about 3.5 m depth.

TABLE 1. LIMNOLOGICAL CHARACTERISTICS, SAMPLING FREQUENCY AT CRYSTAL LAKE IN 1973, PLUS METHOD REFERENCES FOR 1973 and 1924-1942

Characteristics	Summer Sampling Frequency	1973 Method	1924-1942 Method
Bacterial densities in the water column	twice weekly	American Public Health Association (APHA), 1971; Stark and McCoy, 1938 K. Crabtree and B. Frey.	Stark and McCoy, 1938
Water temperature	weekly	Whitney thermistor	N.A.[a]
Dissolved oxygen	weekly	APHA, 1971 azide modification	Juday and Birge, 1932
Carbon dioxide	weekly	APHA, 1971	Juday et al., 1935
Alkalinity	weekly	APHA, 1971	Juday et al., 1935
pH	weekly	Hach colorimeter	Juday et al., 1935
Specific conductance	weekly	APHA, 1971; Lab-line lectro mho-meter Mark IV	N.A.[a]
Secchi disc	weekly	10 cm diameter white and 20 cm black and white discs	Juday, 1929
Light penetration (light meter)	weekly	photocell CL 502 Type 2	pyrlimnometer Birge and Juday, 1929a Birge and Juday, 1929b Birge and Juday, 1930
Zooplankton counts	biweekly	Van Doren sampler	Juday, 1916

		filtered through No. 10	Juday, 1943
Phytoplankton counts	biweekly	Van Doren sampler centrifuged with Foerst centrifuge	Juday, 1916 Juday, 1943
Plankton dry weight and loss on ignition	biweekly	Van Doren sampler concentrated with Foerst centrifuge; A. D. Hasler, U. of Wisconsin, Madison, personal communication	Juday, 1926 A. D. Hasler, personal communication
Phosphorus (total and soluble)	biweekly	Juday et al., 1927 APHA, 1971	Juday et al., 1927
Nitrate-N, nitrite-N	biweekly	APHA, 1971 cadmium reduction	Robinson and Kemmerer, 1930 APHA, 1923
Nitrogen (total and ammonia - N)	monthly	Torrie, 1972 APHA, 1971	Robinson and Kemmerer, 1930 APHA, 1923
Bacteria in bottom sediments	monthly	Henrici and McCoy, 1938 K. Crabtree and B. Frey, personal communication	Henrici and McCoy, 1938
Total residue	1 per summer	APHA, 1971	N.A.[a]
Loss on ignition of bottom sediments - estimated organic content	twice in the fall	Frey, 1960	Twenhofel and Broughton, 1939

[a] N. A. - No reference available for analytical technique

RESULTS

Limnological Changes

Four limnological characteristics increased significantly, four decreased, and seven remained the same (summarized in Table 2). The magnitude of the change was slight for most characteristics (Figs. 2 and 3). However, Secchi disc depths (Fig. 4) decreased by 2 m, and total bacterial counts in the water column (Fig. 5)

TABLE 2. CHANGES NOTED IN LIMNOLOGICAL CHARACTERISTICS FOR CRYSTAL LAKE, 1973 MINUS MEDIAN VALUE 1924-1942 (SIGNIFICANCE LEVEL $p \leq 0.01$, UNLESS OTHERWISE NOTED). RANGES FOR VALUES MEASURED IN 1973 ARE ALSO INCLUDED

Increased	Decreased	No Change
Alkalinity all depths (0.5 - 4.3 mg/liter)	Light penetration with Secchi disc[a] (6.2 - 10m)	Soluble phosphorus (trace, 0.5 - 5.5 μg/liter)
pH at 10 m (5.5 - 6.8 units)	Total phosphorus (2.2 - 8.0 μg/liter)	Plankton dry weight (0.3 - 3.4 mg/liter) organic content (0.10 - 1.8 mg/liter)
Specific conductance all depths (12.4 - 14.5 μmhos)	Dissolved oxygen in the hypolimnion[b] (7.6 - 12.1 mg/liter)	Zooplankton numbers (32-311/liter)
Total bacteria in the water (33 - 48,000/ml)	Carbon dioxide[a] at 5 and 10 m (0.3 - 2.5 mg/liter)	Phytoplankton numbers (46.5 - 700.4 thousand/liter)
		Temperature, depth of thermocline (5-8m)
		Total residue (5 - 25 mg/liter)
		Organic content of sediments (40.8 - 53.0%)

[a]Significance level $0.01 \leq p \leq 0.05$

[b]Significance level at 15 m depth $0.01 \leq p \leq 0.05$; for 15 and 18 m combined $0.05 \leq p \leq 0.10$.

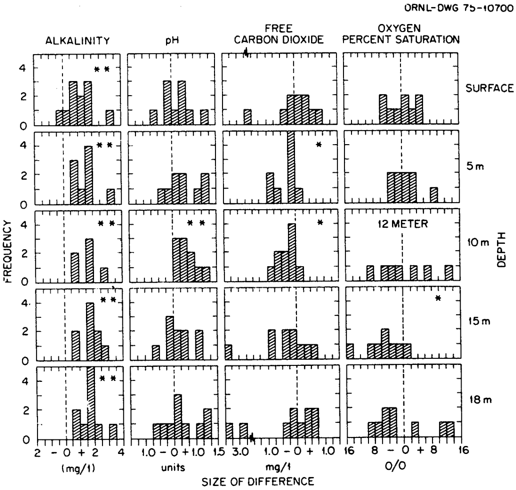

FIGURE 2. Frequency distribution of differences (1973 minus median value 1924 - 1942) for alkalinity, pH, per cent saturation of oxygen, and free carbon dioxide, at various depths. Significant differences indicated by * for $0.01 \leq p \leq 0.05$, or ** for $p \leq 0.01$.

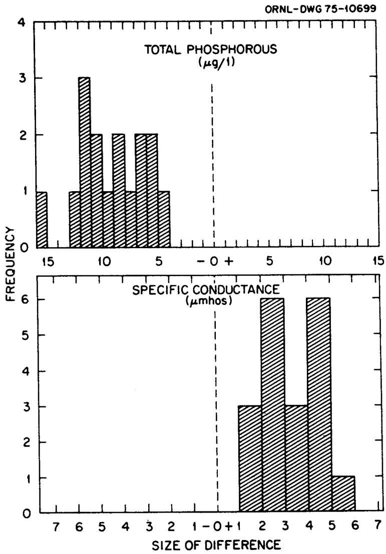

FIGURE 3. Frequency distribution of differences (1973 minus median value 1924 - 1942) in specific conductance and total phosphorus for all depths combined (0, 5, 10, 15, and 18 m). Differences significant at $p \leq 0.01$.

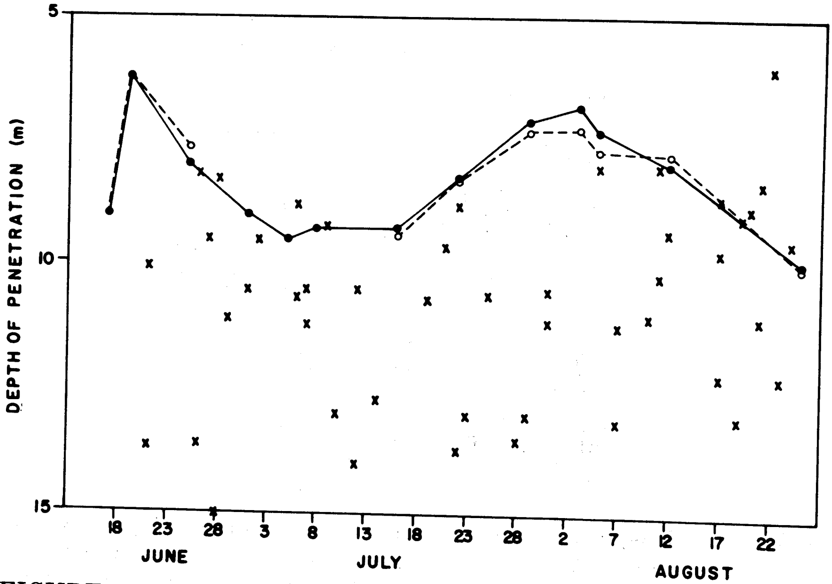

FIGURE 4. Light penetration as measured by Secchi disc. 1973 readings for 20 cm black and white disc are represented by the solid line. The dashed line indicates 1973 readings with the 10 cm all-white disc. Data from 1924 - 1942 (both size discs) appear as X's. 1973 data significantly different from 1924 - 1942 data at $p \leq 0.01$.

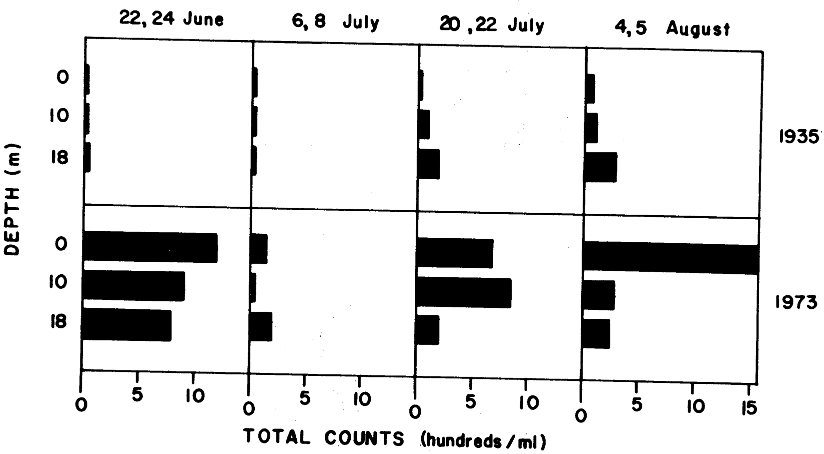

FIGURE 5. Total bacteria counts (per ml) at 0, 10, and 18 m; 22 June, 6 July, 20 July, and 4 August 1935, as compared with 24 June, 8 July, 22 July, and 5 August. 1973 data significantly different from 1935 data at $p \leq 0.01$.

increased greatly (about 90%). Nitrogen data (nitrate, nitrite, ammonia-N, and total-N) were not comparable owing to dissimilarities in methods of measurement. Nitrate values in 1973 ranged from 0.0003 to 0.0077 mg/1, organic-nitrogen levels from 0.13 to 0.47 mg/1.

No fecal coliform bacteria counts are available for Crystal Lake 1924-1942, so changes in relative coliform counts through the summer of 1973 were examined with respect to human use. Coliform counts ranged from 0 to 413/100 ml. With one exception, differences among the coliform counts at the three stations (C, B, and R) were not significant. Coliform counts at the surface (sum of three stations) were significantly greater on Sundays than during midweek (Table 3). Numbers of campers on the night previous to each of the coliform counts indicated more people present on weekends than during midweek. However, the regression of coliforms per 100 ml as a function of the number of persons at the campground the night before was not statistically significant.

Although total plankton counts per liter, 1973 versus 1924-1942, did not differ significantly at surface, 5, 10, or 15 m depths, the dominant genera of phytoplankton collected changed. In 1973, *Dinobryon* was by far the dominant phytoplankter, constituting 88.0% of the total count in samples in July 1973. The average proportion for *Dinobryon* for the years 1924-1942 in July was only 1.3%. Dominant genera in 1924-1942 collections were blue-green algae, particularly *Chroococcus*, *Oscillatoria*, and *Microcystis*. In 1973, these three genera composed only 1.3% of the phytoplankton collected compared with 42.3% in 1924-1942.

Groundwater flow calculated for Crystal Lake, using an average gradient of 2.6 m/km (Fries, 1938) and expected values for permeability (k) (Jaquet, 1974) ranged from 505,000 liters/day to 2,580,000 liters/day. Calculated from a volume of 29 x 10^8 liters for Crystal Lake, the range in flushing time is 3 to 16 years.

Development of Recreational Use

The exact date when camping around Crystal Lake became popular is not known. Between 1900 and 1912, the region was heavily logged. From approximately 1910 to the early 1950s, informal camping sites were located on the strip of land between Crystal Lake and Big Muskellunge Lake.

The first major development for camping came in 1957 when 102 individual camping sites around Crystal Lake and 60 around Big

TABLE 3. COMBINED (STATIONS C, B, AND R) SURFACE COLIFORM COUNTS/100ML, ON SUNDAYS VERSUS TUESDAYS (OR WEDNESDAY) IN 1973

Coliform Counts/100 ml Sunday	Tuesday	Difference	Dates
42	10	+32	3, 5 June
2	2	0	10, 12 June
40	60	-20	17, 19 June
63	46	+17	24, 26 June
276	85	+191	1, 4 July
281	29	+252	8, 10 July
162	108	+54	22, 17 July
167	93	+74	29, 24 July
301	75	+226	5 Aug., 31 July
281	223	+58	12, 22 August

Muskellunge Lake were established. Also in 1957, 20 open-bottomed pit toilets were installed. Six of the pit toilets are located up-gradient from the lake, the closest being 18 m from the shoreline. Calculated from the estimated maximum permeability for outwash sands in the Northern Highlands Region (Jaquet, 1974) of 500 liters per day per meter, a minimum of 2.6 years is required for the leachate to flow via groundwater from the toilets to the lake. Hand-pumped wells for water supply were drilled, and a beach 213 m long was developed, mainly by enlarging an already existing natural beach.

Renovations in 1962 added another 30 units around Big Muskellunge Lake. In 1965, the main beach area was expanded by 213 m. A 6.5 ha lawn and picnic area was also added at this time. In 1973, the combined campgrounds of Crystal and Big Muskellunge Lakes covered approximately 50% of the shoreline of Crystal Lake with 192 individual campsites, usually separated by 15 to 20 m (Fig. 1). The 427 m beach plus the lawn covered an additional 20% of the shore (F. F. Reinemann, Superintendent of the Northern Highlands State Forest, Trout Lake Forestry Headquarters, Wisconsin Department of Natural Resources, personal communication, 1973).

Peak campground use to date occurred in 1970. From 1 July to 20 August (the major camping period) Crystal-Big Muskellunge campground use averaged 99.1% of its maximum capacity of 192 units. Approximately 685 people were living in the watershed each night (assuming 3.6 people per unit as estimated by the Wisconsin Department of Natural Resources). In 1973, Crystal Lake campground was also visited by 313 dogs for a total of 1077 dog-days at the campground. Twenty-three other pets also stayed at Crystal Lake for a grand total of 1166 pet-days (unpublished data, Wisconsin Department of Natural Resources records).

Information gathered from interviews with 44 groups staying at Crystal Lake campground during the summer 1973 indicated that swimming is by far the major activity of the campers. Persons 15 years of age and under spend an average of about 4 hours in the water per day; those over 15, 2.5 hours per day. Counts of swimmers on the main beach (Fig. 1) in summer 1973 ranged from 32 to 470 on fair weather days. Despite the ban on washing in the lake since the late 1960s, we often witnessed persons applying shampoo and soap in the lake during 1973. No shower or bath facilities are supplied at the campground.

DISCUSSION

Several human activities might have affected the water quality of Crystal Lake—namely, seepage from pit toilets, swimming activities, presence of dogs and cats, and construction of the campground facilities. The major impacts of recreation on Crystal Lake have been to increase turbidity and densities of bacteria in the water. A secondary effect of the increased turbidity was a slight decrease in dissolved oxygen in the hypolimnion.

The average difference between 1973 and 1924-1942 Secchi disc readings was approximately 2 m. The median reading in 1973 was 8.8 m. Plankton total counts and biomass have not changed significantly and, thus, the decrease in light penetration must have resulted primarily from mechanical disturbances from human activity (principally swimming) and increased rates of erosion and run-off from shoreline use. Swimming activities have been hypothesized to increase turbidity of the water by stirring up of bottom materials (Quigley and Andrews, 1974). In the construction of the facilities at Crystal Lake, ground cover and trees were cleared, roads and outbuildings built, and lawns planted. Such activities could increase nutrient and particulate run-off into the lake. Dotzenko et al. (1967) found heavily used areas in Rocky Mountain National Park with areas trampled, soils compacted, and vegetation cover destroyed altering run-off rates and soil stability.

Bacterial increases probably resulted from bodily contact with the water during swimming and from stormwater run-off over soils and vegetation repeatedly contaminated with fecal wastes (primarily from pets). The main emphasis in research involving swimming has been related to increases in bacteria, as a result of bodily contact with the water. A number of studies indicate increased bacterial densities with recreational use of lakes (Symons, 1974).

Bicarbonates have increased slightly in Crystal Lake, more likely as part of a natural process than from human interference. Increases noted for alkalinity and specific conductance were both statistically significant, but the magnitudes of the differences were small—1.5 mg/liter for alkalinity and 3.2 μmhos for conductivity. The pH at 5 and 10 m depth generally increased by approximately 0.5 units. Dissolved carbon dioxide decreased by about 0.3 mg/liter at 5 and 10 m depth. Conductivity, alkalinity, pH, and carbon dioxide are all interrelated by means of the carbon dioxide cycle (Ruttner, 1953).

Total phosphorus content decreased in 1973 relative to 1924-1942 data to less than half the values obtained in the earlier years. Soluble phosphorus concentration did not change significantly. Apparently the open pit toilets, wastes from swimmers, bathers, and pets have not yet significantly added to the phosphorus load of Crystal Lake. Childs (1972) concluded that nitrates and chlorides may be transported via groundwater flows, whereas most soils are capable of fixing large quantities of phosphorus (Dudley, 1973). Decreases in total phosphorus and the shift from bluegreen algae in 1924-1942 as the dominant phytoplankton genera to *Dinobryon* in 1973 may have resulted from the redevelopment of a stable forest ecosystem after the earlier logging. *Dinobryon* is considered characteristic of low nutrient water (Hutchinson, 1967). Lawrie and Rahrer (1971) suggest that conditions in Lake Superior have become more oligotrophic since the days of clear-cutting and burning in the first part of the 20th century. The turnover time for water in Crystal Lake is between 3 and 16 years.

In order to improve the reliability of the above conclusions, the limnological survey of Crystal Lake, especially the Secchi disc readings, and light meter, total phosphorus, conductivity, and oxygen measurements, should be repeated in some future year(s). Since the use of the Crystal Lake campground has only become exceptionally heavy as of 1968, it is possible that processes of change have not had adequate time to express themselves. Also, the possiblity of future contamination, especially from the pit toilets, has not been eliminated.

ACKNOWLEDGMENTS

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THE OCCURRENCE, STATUS AND IMPORTANCE OF BATS IN WISCONSIN WITH A KEY TO THE SPECIES

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Bats are fascinating aerial animals belonging to the mammalian order Chiroptera. They migrate, hibernate, and show other interesting phenomena as well such as colonial behavior, echolocation, and sperm storage. Bats are important vectors of the dreaded rabies virus.

Only a few people north of Mexico have died from rabies transmitted to them by bats. However, one of these was a Wisconsin citizen from Grant County, who died in 1959 (Jackson, 1961). The importance of bats, in addition to their aesthetic attributes, will be discussed below, particularly the incidence and extent of confirmed rabies in recent years. The distributions of all the Wisconsin species are mapped and discussed, with comments included on seasonal occurrence, reproduction, and relative abundance. Finally, a key is provided for the identification of Wisconsin species and two other species which occur close to the southern border of the state.

METHODS

Bats were examined in the collections of the Museum of Natural History, University of Wisconsin-Stevens Point, and the Zoological Museum, University of Wisconsin-Madison. A few specimens were examined in the Milwaukee Public Museum, the River Falls University collection and the UW-Whitewater Museum. Specimens that were examined in the University of Wisconsin-Madison Zoology Museum are listed with the abbreviation UWZ, in the Milwaukee Public Museum with MPM. The uncatalogued bats in the University collection at Madison recently willed to that museum by A. W. Schorger are listed as UWZS. Whitewater specimens are denoted as UWW. Specimens in the University of Wisconsin-Stevens Point collection are not designated with an abbreviation. Dr. Daniel O. Trainer, Dean of the College of Natural Resources, University of Wisconsin, Stevens Point, provided the author with monthly reports of the Wisconsin State Hygiene Laboratory on positive tests for rabid mammals. These reports were available from 1974 to 1967, and other data compiled by Trainer extended back to 1952. Distribution maps show the occurrence of the bats, with black dots representing localities from which I examined specimens, and open circles representing localitites mentioned in the scientific literature. Small dots on one map (Fig. 1) stand for counties from which rabid bats were recorded. Information on the natural history of bats was obtained from my own field observations or specimen labels, unless cited from literature. Little information was known to me from banded bats; such bats should be reported to the Bird and Mammal Laboratories, U. S. National Museum of Natural History, Washington, D. C. Scientists there or this author can identify specimens of bats. They must be preserved (easily done) in alcohol or formalin, with the abdomen pierced or slit open to facilitate internal preservation, subsequently drained nearly dry after hardening a few days, and mailed moist in a thin plastic bag within a small box with locality and date of capture provided for each specimen. Hardly anything is known on the ecological requirements and natural history of Wisconsin bats. For con-

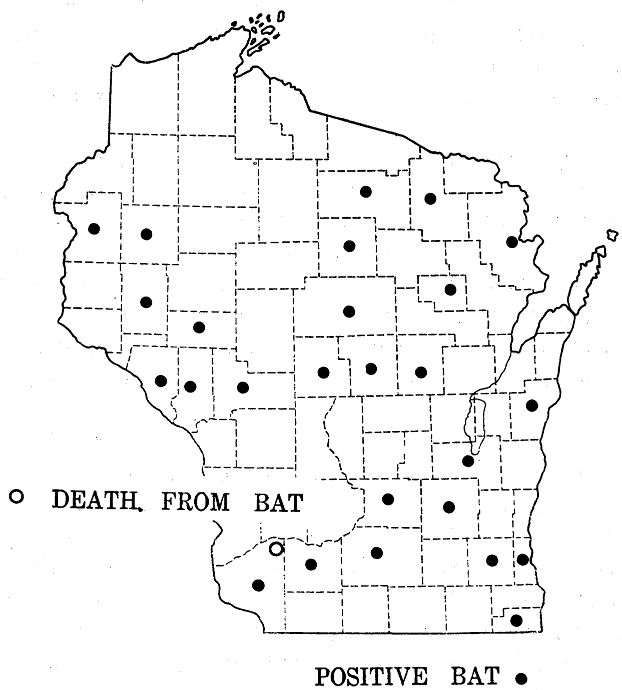


FIGURE 1. Rabid bats 1967-1974

venience, bats of Wisconsin are divided into two groups, the cave and tree bats. Eight species have been found in Wisconsin. One of these has not been taken more than once. Two other species may occasionally range into the state from the south but are unlikely to remain.

IMPORTANCE OF WISCONSIN BATS

The bats illustrate many interesting scientific phenomena, and are therefore aesthetically appreciated by some of us but generally feared by many citizens of Wisconsin. Bats are important members of the Wisconsin fauna (Long, 1974). By predation on aerial, nocturnal insects they render help to man in controlling pests. Whitaker (1972) has found that in Indiana the little *Myotis* bats and the red bats feed primarily on moths, the tiny pipistrelle on leafhoppers, the big brown bat on beetles.

In caves and abandoned houses bats, themselves, are preyed upon by owls (Beer, 1953), by fox snakes (personal observation of *Myotis lucifugus*, July 27, 1975 Big Summer Island, Michigan) and probably by foxes, skunks, raccoons and other den-dwelling carnivores. This valuable linkage in the food chain of furbearers is eroded by the contact it gives them to rabies virus communicated by the bats.

Bats are rightfully feared by man as vectors of rabies, and any sick bat should be handled with greatest caution. Unfortunately, these are the bats usually found by children. Whitaker (1969) has evidence that bats found in human communities show a higher incidence of rabies than those occurring in their natural habitats. Of 133 big brown bats collected in "normal wild" populations in Indiana all were negative, during a rabies outbreak in 1967. This does not mean that bats in nature present no risk. Of course local outbreaks of rabies can occur.

The counties from which bats tested positive for rabies (1974-1967) are numerous and are located throughout the state (Fig. 1). The highest incidence is found in Dane (seven positive tests), Milwaukee (four positive tests) and other densely populated counties, because the finding of infected bats depends on the density of humans as well as the density of bats. Furthermore, tests are more often made in the counties where testing is done (Trainer, correspondence). The danger of rabies seems to exist throughout the state, and shows no correspondence to the presence of caves, forests, or other ecological habitats.

The numbers of positive (rabid) bats are lower than of dogs, cows, and especially skunks (in which actual and relative numbers of cases seem to be increasing). Rabies in bats does not seem correlated with rabies in other species (Table 1); see also Whitaker, 1969, for Indiana bats. To dispute a recent news article written by a county health officer, bats are not constantly rabid. According to available reports on positive and negative tests, far more bats proved negative than positive. In Indiana about 7% of the bats proved rabid (Whitaker, 1969). Furthermore, as mentioned above, the bats testing positive for rabies virus may not represent their natural habitat populations.

TABLE 1. CONFIRMED RABIES IN WISCONSIN BATS AND OTHER MAMMALS (1952-1974)

	Positive Cases				Ratios			
	Bats	Skunks	Dogs	Total Cases	Bat/Skunk	Bat/Dog	Skunk/Total	Bat/Total
1974	2	68	17	107	.03	.12	.64	.02
1973	9	76	35*	154	.12	.26	.49	.06
1972	8	96*	24	163	.08	.33	.59	.05
1971	10*	46	15	91	.22*	.67*	.51	.11
1970	4	33	11	60	.12	.36	.55	.07
1969	4	21	6	46	.19	.67*	.46	.09
1968	6	21	13	54	.29*	.46	.39	.11
1967	1	28	11	61	.04	.09	.46	.02
Totals	51	389	132	736	Ave. .13	.39	.53	.07
1966	1	22	--	68	.05	--	.32	.01
1965	1	21	--	64	.05	--	.33	.02
1964	6	12	--	95	.50	--	.13	.06
1963	5	17	--	62	.29	--	.27	.08
1962	5	12	--	42	.42	--	.29	.12
1961	2	5	--	30	.40	--	.17	.07
1960	0	5	--	24	.00	--	.21	.00
1959	1	64	--	92	.02	--	.70*	.01
1958	3	184*	--	227	.02	--	.81*	.01
1957	6	37	--	74	.16	--	.50	.08
1956	0	13	--	41	.00	--	.32	.00
1955	0	19	--	39	.00	--	.49	.00
1954	0	36	--	90	.00	--	.40	.00
1953	0	25	--	49	.00	--	.51	.00
1952	0	27	--	56	.00	--	.48	.00
Totals	30	499	--	1053	Ave. --	--	.47	---

* High Values

The distribution of rabies by month shows that August ("dog days") is the most dangerous month. Bats migrate southward of Wisconsin or hibernate from late October until approximately late April, and hardly any bats were sent in for tests in these months (from 1974-1967). Evidently one person from Grant County was bitten by a rabid bat in January. This county is one of the warmest in the state and has large bat caves as well.

Although skunks bite people and dogs with very high frequencies, bats apparently seldom bite dogs and cats (two reports in eight years). Probably these pets are not inclined to pick up sick bats or remove them from attics and other hiding places. If a bat attacked a dog, as they occasionally attack men (Jackson 1961), the dense fur of dogs may protect them somewhat from the tiny teeth of bats. Humans may never know about some of these attacks.

A problem for future study is the possible transmission of rabies virus to skunks and raccoons via their digestive tracts. Aerosol transmission (Constantine, 1962) of rabies virus in bat urine droplets is unlikely even in caves of large colonies of *Myotis*, such as Beetown Cave, because of the relatively inactive condition of hibernating bats and their much lower numbers than in colonies of free-tailed bats which are dangerous in the southwestern United States.

The species of bats in Wisconsin that show the highest incidence of rabies are unknown because bats are difficult to identify. Laboratory reports mention only "bat". I myself have seen in summer a sick or nearly helpless hoary bat and a sick *Myotis keenii*, both likely rabid. Probably most bats that harbor rabies are *Eptesicus fuscus*, *Lasiurus borealis*, and *Myotis lucifugus* for they are the most abundant species. In Indiana *Lasiurus borealis* and *Eptesicus fuscus* showed the highest incidence (Whitaker, 1969). There is no evidence that rare species such as *Myotis sodalis*, *Pipistrellus subflavus*, *Lasionycteris noctivagans*, or *Lasiurus cinereus* have bitten humans in Wisconsin. A more serious threat to humans is the abundance of stray dogs and cats.

Rabies reports from doctors and veterinarians should contain standardized information not presently included. The reports should contain the following information: whether the bat attacked in flight or was picked up, whether taken from a tree, house, cave, or the surface of the ground, and whether the upper (dorsal) surface of the tail membrane was furred (as in *Lasiurus*) or thinly haired and mostly naked skin (as in *Myotis* or *Eptesicus*). The bat or its skull should be identified by a mammalian taxonomist prior to destroying the skull, and the correct identity of the bat should be added to the report. Bodies of most bats can be identified even after the skull is removed. The bats preserved as mentioned above may be mailed from the State Hygiene Laboratories, to this author or to the

Bird and Mammal Laboratories, U. S. National Museum, Washington, D. C. Identifications by me or other taxonomists at Madison or Milwaukee should be recorded to determine which bats are dangerous to man. All this is additional but essential work.

Bats should be removed (with tongs or gloves) from man's habitations, and by the use of tin and nails prevented from returning. Bats should be handled with extreme caution, and children warned about picking them up. Dogs should be vaccinated to protect them from rabies from bats (possibly) and skunks (definitely). If a bat attacks and bites a dog, cat or human, see a physician or veterinarian at once. Do not destroy the bat's skull; pierce the bat's heart with a nail or step upon its body. Save the bat for possible identification, and the rabies test.

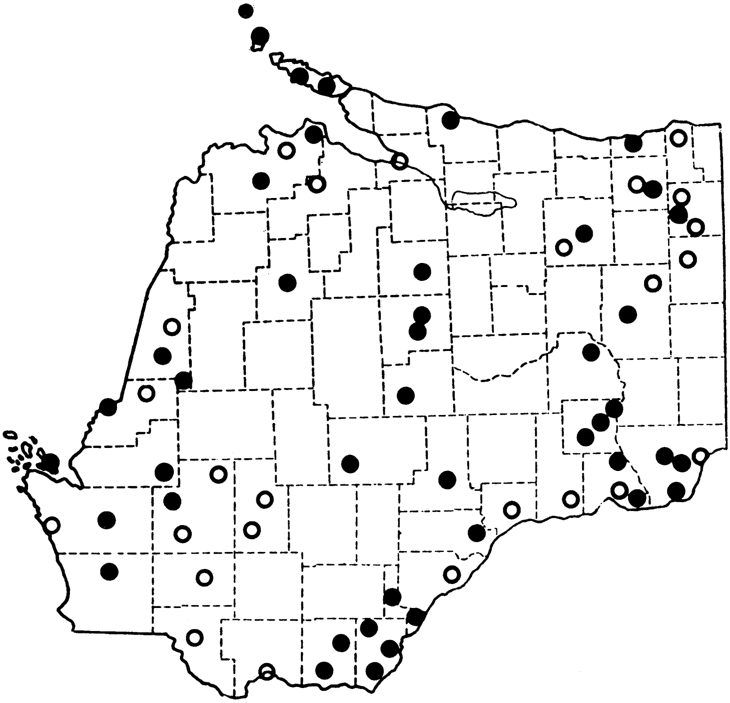
If people are taught to carefully avoid sick bats and limit contact between bats and people (also pets), then bats may be considered valued members of the Wisconsin fauna, more economically valuable to man than his dogs and cats and perhaps less dangerous too. Rare bats should be protected, and some of their remarkable cave habitats likewise preserved. Because of their gathering in caves for hibernation from miles around, the cave bats are particularly vulnerable to extermination. One mean or misguided person could probably in the course of a few days destroy most of the beautiful and harmless pipistrelles of Wisconsin during this critical season.

ACCOUNTS OF SPECIES

Family Vespertilionidae

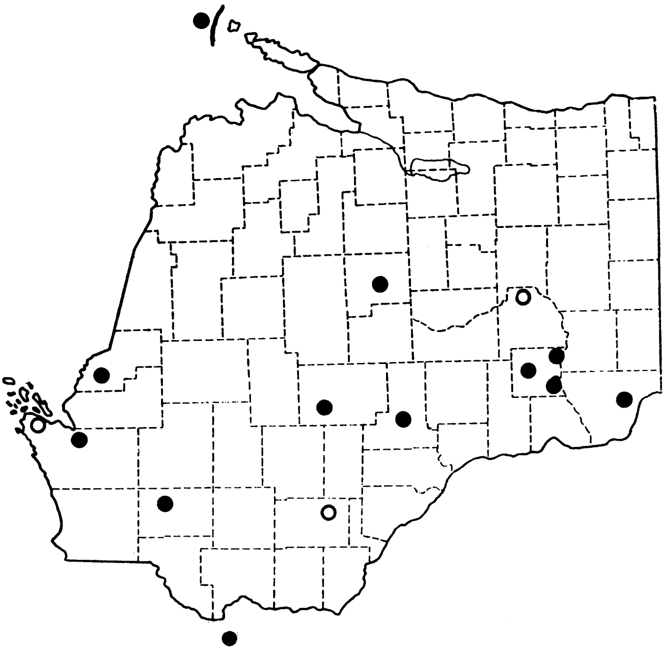
Myotis lucifugus lucifugus (Le Conte) - Little Brown Bat

The little brown bat is the most abundant bat in Wisconsin, and it occurs throughout the state (Fig. 2). Although it hibernates usually in caves it occurs in summer more often in the vicinity of barns and houses. Hibernating *lucifugus* have been observed to be mostly males. In a cave 15 miles north of Sturgeon Bay the ratio was four males to one female (20 December). In Pop's Cave, near Richland Center, the ratio in late September and November (1967) was 10:2. In the Beetown Cave, Atkinson's Diggings, in Grant County, the ratio of specimens was 6:4 (late September and December). Hibernating *lucifugus* near Black River Falls were 3:4 (February 1969). Mohr (1945) reports that male *lucifugus* comprise 56 to 71% of the hibernating populations. There is some evidence that females may aggregate together in some cases, prior to hibernation. On 17



LITTLE BROWN BAT

FIGURE 2. *Myotis lucifugus lucifugus* (Little Brown)



KEEN'S MYOTIS

FIGURE 3. *Myotis keenii septentrionalis* (Keen's Myotis)

September 1967, nine females with no males were collected from a cabin in Bayfield County.

Nursery colonies are, of course, comprised of offspring and mothers. An abandoned house near Polonia had numerous adults and young, in the lathwork of the ceiling and six adult females were preserved (19-23 July). A male was taken flying less than a mile from the nursery colony (24 July). In an unused theater in Waupaca (1 August) eight females were taken with one male. Usually there is a single fetus born in late May or June (Jackson, 1961). One female (UWSP 3782) taken June 2, 1975, at Clam Lake contained one fetus measuring 12 mm in crown-rump length. The dates of observation of the Polonia colony, subsequently destroyed, indicate that parturition occurs in late June, perhaps early July. The little brown bat was extremely abundant (thousands) during the winters of 1947 and 1948, in an abandoned iron mine in Iron County, Wisconsin (Greeley and Beer, 1949). Barbour and Davis (1969) mention that copulation between active bats may occur in winter but most mating is in the fall.

Two specimens in the Stevens Point collection have missing pairs of upper premolars, resembling *Pipistrellus*. However, little brown bats have larger, longer, more flattened skulls than do *Pipistrellus*, and lack the tri-colored hairs in the dorsal pelage. One exceptionally pale specimen (UWSP-1802) is referred to *Myotis lucifugus*, although its pale color and a slightly keeled calcar (on one side only) was puzzling. Apparently the pelage is bleached in this female taken in a late nursery colony (Heig's Farm, Portage County). Walley (1974) reported an albino from Bruce, Rusk County.

Specimens examined: Total, 185. *Ashland Co.:* Clam Lake, 1. *Bayfield Co.:* Madeline Island, 6 UWZS; Drummond, 9. *Buffalo Co.:* Alma, 1 UWZS. *Clark Co.:* Worden Twsp., 3 UWZ. *Crawford Co.:* Crystal Cave (near Wisconsin River and Wauzeka), 2 UWZ; Limery Coulee Cave, Sec. 18, R6W, T7N, 1. *Dane Co.:* Madison, 12 UWZ, 6 UWZS, 1 lacking ears labelled *keenii* UWZ. *Dodge Co.:* Beaver Dam, 15 UWZ. *Door Co.:* 5 mi. N Sturgeon Bay, 1; 15 mi. N Sturgeon Bay, 4. Lehman's Place, Washington Island, 3; Rock Island 1. *Douglas Co.:* Lake Nebagamon, 1. *Grant Co.:* Beetown Cave, Atkinson's Diggings, 11, 3 UWZ; T4N, R5W, 1 UWZ; Cassville, 1 UWZ. *Iron Co.:* Hurley, 5 UWZ; Owl Lake, 1 UWZ. *Jackson Co.:* 3 mi. E Black River Falls, 4. *Juneau Co.:* Necedah Nat. Wildlife Refuge, 1. *Langlade Co.:* Perch Lake, T34N, R11E. 9. *Manitowoc Co.:* Manitowoc, 4. *Marinette Co.:* S5-R23E-T29N, 1 UWZ. *Milwaukee Co.:* Milwaukee 9 MPM, 2 UWZ. *Pepin Co.:* 1 mi.

NE Elmwood, 1 RF. *Pierce Co.:* 1 mi. E Maiden Rock, 1 RF; Spring Valley (Crystal Cave), 1 RF; 2 mi. N Prescott, 1 RF. *Portage Co.:* Stevens Point, 2; Heig's Farm, near Polonia (Pallen Lake) 10. *Richland Co.:* Pop's Cave (Boswell Cave), 12: Gotham, 5; Bogus Cave, 1. *Sauk Co.:* Devils Lake, Baraboo, 2; *St. Croix Co.:* 2 mi. NW River Falls, 1 RF; Somerset, 1 RF. *Sawyer Co.:* Teal Lake. 1 UWZ. *Trempealeau Co.:* Galesville, 1 UWZS. *Vilas Co.:* Lac du Flambeau, 1; Trout Lake, 1 UWZ, no locality, 1 UWZ. *Walworth Co.:* 8 mi. NE Elkhorn, 1 UWZ. *Waukesha Co.:* Hartland, 1 UWZ; Delafield 1 UWZ. *Waupaca Co.:* Waupaca, 9. *Wood Co.:* Arpin 1.

Myotis keenii septentrionalis (Trouessart) — Keens's Myotis

This large-eared *Myotis* is found more often in caves in winter at least. It is found throughout the state, but seems never abundant (Fig. 3). Probably in summer it prefers loose bark and hollows of trees instead of houses. The females seem active, flying about, prior to late April (April 27, 19 May). In an Iron Mine near Hurley more than 100 were banded by Beer and Greeley (Jackson, 1961) in late August and September, but were outnumbered by *M. lucifugus* 3:1. The species *keenii* seems vulnerable because it is sparse in its distribution though widespread, and it is especially vulnerable in its hibernacula.

M. keenii was found with *M. lucifugus* at the cave near Black River Falls, both species in low numbers. This species has been found in the attic of a house (Schmidt, 1931). Schmidt found fleas and tapeworms parasitizing this bat.

Specimens examined: Total, 28. *Bayfield Co.:* White River Conservation Camp, 1. *Grant Co.:* Beetown Cave, Atkinson's Diggings, 1 UWZ; no locality, 1 UWZ. *Clark Co.:* Worden Twsp., 1 UWZ. *Iron Co.:* Hurley, 8 UWZ, 2 UWZS. *Jackson Co.:* cave 3 mi. E Black River Falls, 7. *Portage Co.:* Stevens Point, 2. *Richland Co.:* Bogus Bluff Cave, 1 UWZ. John Gray Cave, 2 UWZ; Pop's Cave, 1. *Washburn Co.:* Springbrook, 1 RF.

Myotis sodalis Miller and G. M. Allen — Indiana Myotis

This bat occurs mainly southward of Wisconsin and has been placed on the federal rare and endangered species list because it is seldom abundant and is especially vulnerable during hibernation, usually hanging near cave entrances (Anon., 1973). It is known by only a single specimen from Wisconsin (Davis and Lidicker, 1955) and is now possibly absent from the state. Its occurrence was at the Beetown Cave in extreme southwestern Wisconsin, and no other specimens have been taken there in recent years. Not mapped.

Eptesicus fuscus fuscus (Beauvois) — Big Brown Bat

This species is abundant and doubtless becoming more so as man's activities open up the northern forests (Fig. 4). *Eptesicus* is often found in habitations of man, and hibernates often in caves with both *Pipistrellus* and *Myotis lucifugus* (Pop's Cave, Richland Co., Crystal Cave, Beetown Cave) usually in lower numbers than either of them. Although not considered colonial, a colony of hibernating *Eptesicus* has been observed for nine years, nearly annually, at the Twin Bluffs cave. The bats leave the cave in spring, and nursery colonies are unknown in Wisconsin. No other species of bats has been found in this large cave. Specimens from there in February 1968, showed a ratio in favor of males, 10:5. In a rather exposed quarry tunnel north of Sturgeon Bay a few big brown bats usually are found in winter usually with no other species of bats present. In Indiana bats of *Eptesicus fuscus* often harbored rabies (24 of 264 bats, Whitaker, 1969). Beer (1953) mentioned predation in a nearby Minnesota cave by a screech owl in hibernating big brown bats, and hibernation was discussed by Beer and Richards (1956) for these Minnesota bats. Beer found (1955) that although males outnumber females in Wisconsin and Minnesota caves (68% males 1940-1954) that there was no apparent difference in survival rates of the two sexes. This surprising finding indicates that the females may hibernate outside caves. He found that recaptured banded bats average only 7.4 miles distance from the banding sites (maximum, 61 miles) showing that the winter range is about the same as the summer range. Big brown bats actively seek temperatures above freezing, even moving to other caves, and will not reenter dormancy until subfreezing temperatures rise (Davis, 1970). They evidently breed in late summer and occasionally copulate in the winter. Five males from Madison had large testes (7-14mm) in August. Females usually have two young in summer as late as July (Barbour and Davis, 1969). Long and Severson (1969) discussed some extraordinarily pale specimens from Richland County, but referred all the big brown bats in Wisconsin to *Eptesicus fuscus fuscus*. Paul Young photographed big brown bats hibernating in April in Limery Coulee Cave, in Crawford County but he obtained no specimens.

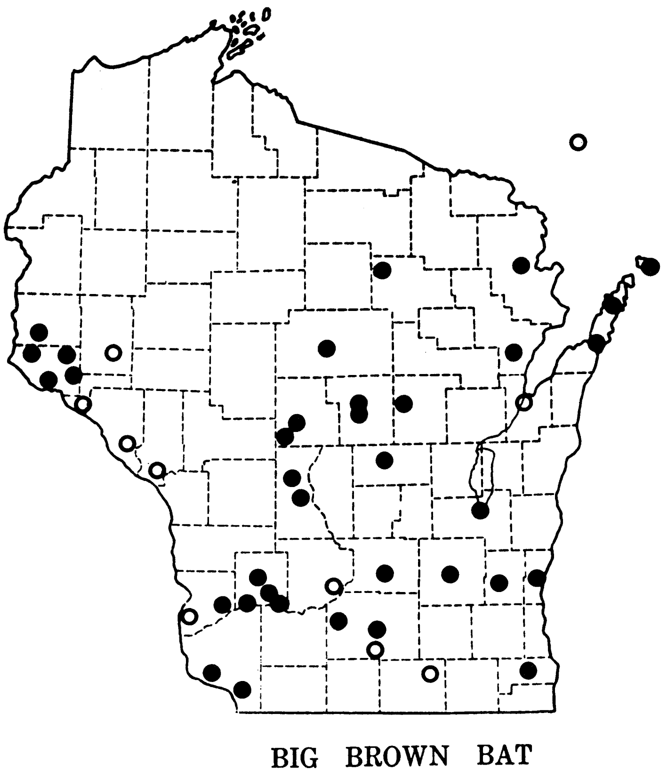


FIGURE 4. *Eptesicus fuscus fuscus* (Big Brown)

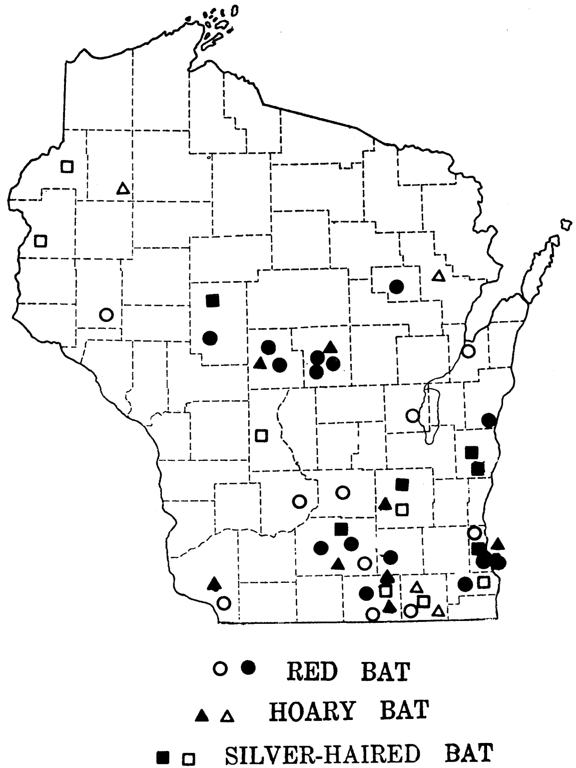


FIGURE 5. *Lasiurus borealis borealis* (Red)
Lasiurus cinereus cinereus (Hoary)
Lasionmycteris noctivagans (Silver Haired)

Specimens examined: Total, 115. *Crawford Co.:* Crystal Cave (near Wisconsin River and Wauzeka), 1 UWZ. *Dane Co.:* Madison, 24 UWZ; 10 UWZS; Black Earth, 1. *Dodge Co.:* Beaver Dam, 1 UWZ. *Door Co.:* 5 mi. S Egg Harbor (15 mi. N Sturgeon Bay), 2; 5 mi. N Sturgeon Bay, 4; Washington Island, 1. *Fond du Lac Co.:* Eden, 2 UWZ. *Grant Co.:* Beetown Cave, Atkinson's Diggings, 3; Snake Cave, Potosi, 1 UWZ. *Juneau Co.:* Twin Bluffs Cave, 15. *Langlade Co.:* Parish Town Dump, 1. *Marathon Co.:* Rib Mtn., 1. *Marinette Co.:* 8 mi. N Crivitz, on Hwy A, 2. *Milwaukee Co.:* Milwaukee, 1 MPM. *Oconto Co.:* T28N, R19E, 1. *Pierce Co.:* River Falls, 2 RF; 1 mi. E River Falls, 1 RF; Maiden Rock sand caves, 1 RF; 8 mi. N Plum City, 2 RF; Crystal Cave, at Spring Valley, 1 UWZ. *Portage Co.:* Hay Meadow Creek, 5 mi. N Stevens Point, 1; Within one mi. Stevens Point, 13. *Racine Co.:* Hwy 38 Nygaard Home, 1. *Richland Co.:* Pop's Cave. 15 mi. W Richland Center, 6; Gotham, 1; Eagle Cave, 2 UWZ; Bogus Bluff, 1 UWZ. *Rusk Co.:* Hawkins, 1. *St. Croix Co.:* 2 mi. NW River Falls, 4 RF. *Waukesha Co.:* Waukesha 1 MPM. *Waupaca Co.:* 2 mi. W Iola, 1. *Waushara Co.:* No locality 3. *Wood Co.:* 3 mi. E Arpin, 1; Sandhills Wildlife Area, near Babcock, 1.

Lasiurus borealis borealis (Muller) — Red Bat

Jackson (1961) considered the red bat to be the most abundant bat in the southern most counties of Wisconsin. This tree bat hangs up on branches of deciduous trees by day, often in elm, ash, and red oak trees, and is often observed in man's settlements of southeastern Wisconsin. Uncommon in central and northern Wisconsin, this bat nevertheless is probably maintaining if not increasing its numbers (Fig. 5). After copulation perhaps as early as August (Jackson, 1961) sperm is evidently stored until the following spring, and birth of usually 3 (2-4) young occurs in late May or June. A juvenile (UWMZ 12,206) was taken June 30, and Packard (1956) found young June 26. A juvenile in the Whitewater Collection was taken July 21. Three young were taken on 4 July 1951 (UWZ 14123) from a nursing female at Fort Atkinson. The mother carries them perhaps less frequently as they grow until their weight exceeds hers. Then she leaves them hanging in branches. Packard found a female with quadruplets at Portage, Wisconsin. The young were each "1 1/8 inches long." Long (1964) reviewed the numerous impalements of *Lasiurus* bats on barbed wire (see also Barbour and Davis, 1969). One was killed at Madison by flying against a TV tower, and George

Seeburger told me that a red bat struck the grill of his car on a rainy evening, near Milwaukee. Most if not all red bats leave Wisconsin for the winter, departing by late October and hibernating outside caves (Davis, 1970). A specimen from as late as October 21 is reported from Pine Bluff, Dane County. Three red bats from central Wisconsin were taken in October. They return in April and May. In Indiana bats of this species often harbored rabies (11 of 152 bats, Whitaker, 1969).

Specimens examined: Total, 31. *Clark Co.:* Foster Township, NW Tioga, 1 UWZ. *Dane Co.:* Madison, 1 UWZS: Vermont (=Verona?), 4 UWZ; Pine Bluff, 1 UWZ; no locality, 1 UWZ. *Dodge Co.:* Beaver Dam, 3 UWZ. *Jefferson Co.:* Fort Atkinson, 3 UWZS, *Manitowoc Co.:* T17N, R23E, Sec. 2, 1 UWZS. *Menominee Co.:* Keshena, 1. *Milwaukee Co.:* Milwaukee, 2 MPM, 1 UWZ; Wauwatosa, 1 MPM; No locality, 1 UWZ. *Portage Co.:* Stevens Point, 2 Whiting, 1; Junction City, 1. *Racine Co.:* J. I. Case Company, Racine, 1 UWZS. *Rock Co.:* Milton, 3 UWZ. *Wood Co.:* Arpin, 1; Wisconsin Rapids, 1.

Lasiurus cinereus cinereus (Beauvois) — Hoary Bat

This hoary, furry-tailed bat, strikingly beautiful and the largest in the state, prefers coniferous forests. It is nowhere common, said probably to be more abundant in the northern counties. However, there is no evidence for such a statement except that more coniferous forests are found there (Fig. 5). Hardly anything is known about this bat in Wisconsin. Jackson (1961) reports a female with two young clinging to her body taken 27 July 1903. This specimen (UWMZ 3324) is from Beaver Dam, Dodge County. A juvenile (UWMZ 13013) was taken July 25, 1947, in Madison. As mentioned earlier in this paper I observed a hoary bat in Stevens Point apparently sick and probably rabid. Jones and Genoways (1967) mentioned a hoary bat biting a woman in South Dakota. The hoary bat, although probably occurring throughout Wisconsin, seldom comes into contact with people.

Specimens examined: Total, 18. *Dane Co.:* Madison, 3 UWZ, 1 UWZS; No locality, 1 UWZ. *Dodge Co.:* Beaver Dam, 1 UWZ. *Grant Co.:* 5 mi. SW Lancaster, 1 UWZ. *Milwaukee Co.:* Milwaukee, 6 MPM. *Portage Co.:* Stevens Point, 1, ? Stevens Point, 1. *Rock Co.:* Milton, 1 UWZ; Janesville, 1 UWZ. *Wood Co.:* Arpin, 1.

Lasionycteris noctivagans (Le Conte) — Silver-haired Bat

This, the darkest brown or blackish of all the Wisconsin species, with the possible exception of some dark brown individuals of

Myotis lucifugus, is handsomely washed with silver or whitish. Preferring trees near open water the species is widely distributed (Fig. 5), never abundant, and most of these bats probably leave the state for winter sometime in September or early October (Jackson, 1961). Schmidt (1931: 105) found one with a thick layer of subcutaneous fat on "September 6 under the grate of the furnace in the cellar." Most of the records are from August and September. In early summer one or usually two young are born, but hardly anything is known of this bat's natural history in Wisconsin.

Specimens examined: Total, 14. *Clark Co.:* Worden Twsp, 1 UWZ. *Dane Co.:* Madison, 1 UW. *Dodge Co.:* Fox Lake, 1 UWZ. *Milwaukee Co.:* Milwaukee, 7 MPM. *Sheboygan Co.:* Cedar Grove, 1; T13N, R23E, Sec. 30, 3 UWZ.

Pipistrellus subflavus subflavus (F. Cuvier) — Eastern Pipistrelle

This beautiful small, yellowish bat with black wings is generally confined to the cave region of the "unglaciated" part of Wisconsin (Fig. 6). It is known by a single specimen from an Iron mine in Hurley, possibly a "straggler", and is at the least very rare since none was seen in the following year, when 1400 bats were examined (Greeley and Beer, 1949). Numerous caves in northern, central, and eastern Wisconsin have yielded no pipistrelles. This bat during hibernation often shows countless small droplets of condensation water gathered over its pelage, an interesting and beautiful thing to see, although not unique to pipistrelles. This species is a beneficially insectivorous and harmless bat feeding usually on leafhoppers and other small insects (Whitaker, 1972). The species is vulnerable in Wisconsin because it is seldom abundant and gathers together helpless in relatively few hibernacula. This species hibernates with *Eptesicus* and *Myotis,* usually in lesser numbers than the *Myotis,* with both sexes present. According to Jackson (1961) the bats begin hibernation in October, arouse and leave the deep caverns in late April or early May, and sleep in shallow caves and rocky niches in summer. Barbour and Davis (1969) stated that they sleep in branches in summer. The tiny female bears usually two offspring (1-3). Davis (1970) mentions that this species chooses and requires a stable environment for hibernation. Therefore, not all caves are suitable for pipistrelles. This bat enters caves later than *Myotis,* seldom moves to other caves, and some bats (all males) remain in torpor until late May and early June (Davis, 1959). Winter climate is a factor controlling the sex ratios of hibernating pipistrelles.

Wisconsin records taken together (late December to April), most if not all from caves at the northern margin of known geographic range, are in ratio of 13 males to 11 females, whereas in more southern latitudes the males are as numerous as 80%.

Specimens examined: Total, 30. *Buffalo Co.:* Alma, 3 UWZ. *Crawford Co.:* Soldiers Cave, 2 UWZ; Limery Coulee Cave, 1; Crystal Cave (near Wisconsin R. and Wauzeka), 1 UWZ. *Grant Co.:* Atkinson's Mine, Beetown Cave, 2 mi. NW Beetown, 5, 2 UWZ; Snake Cave, 1 UWZS, 1 UWZ. *Iowa Co.:* Mineral Point, 1 UWZ. *Pierce Co.:* Spring Valley (Crystal Cave), 1 RF. *Richland Co.:* Bogus Cave, 3 mi. S Lone Rock, 1; Pop's Cave, Boswell Cave 15 mi. NW Richland Center, 5: Eagle Cave, 4 UWZ John Gray Cave, 2 UWZ.

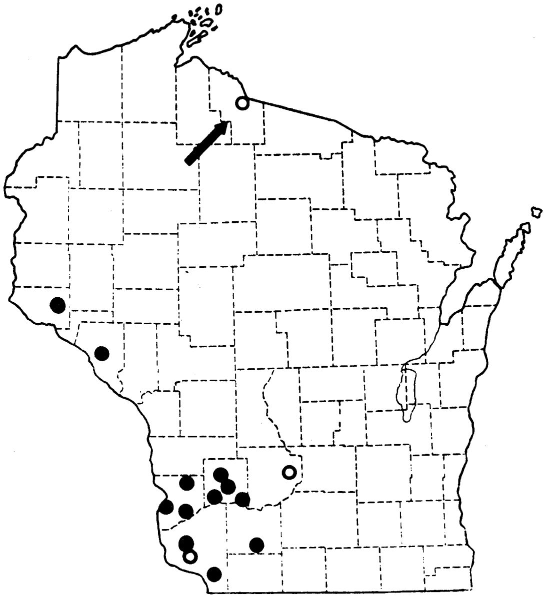
Bat Banding

No returns are recorded here. Pioneer banding was done at Eagle, John Gray, and nearby caves by John Emlen and William Elder. James Beer, Frederick Greeley and Arnold Jackson banded bats in southwest Wisconsin and Lac du Flambeau and sites near Hurley. Wayne Davis also studied the bats from southwest Wisconsin.

A LIST OF IMPORTANT BAT HIBERNACULA

These hibernacula are listed not for the purpose of facilitating the collection of bats, but instead for their preservation.

Crawford Co.: Kickapoo Caverns (commercialized); Bear Cave; Crystal Cave near Wisconsin R. and Wauzeka; Soldiers Cave; Limery Coulee Cave, Sec. 18, R6W, T7N, three species hibernate here. *Dane Co.:* Blue Mounds and lost River Caves, commercial. *Door Co.:* 15 mi. N Sturgeon Bay, cave on a hill above public beach. *Grant Co.:* Beetown Cave, Atkinson's Diggings, only site of the rare *Myotis sodalis*, many other bats present; Potosi, Snake Cave (now commercialized as St. John's Mine). *Iron Co.:* Hurley, iron mine, thousands of *Myotis*. *Jackson Co.:* cave 3 mi. E Black River Falls. *Juneau Co.:* Twin Bluffs Cave, historic Indian petroglyphs are found on this spectacular landmark. *Pierce Co.:* Crystal Cave at Spring Valley, listed on road maps. *Richland Co.:* Pop's Cave, numerous species present, presently protected somewhat; Eagle Cave, listed on road maps as an attraction; Bogus Cave, John Gray Cave.



EASTERN PIPISTRELLE

FIGURE 6. *Pipistrellus subflavus subflavus* (Eastern Pipistrelle)

FIGURE 7. Big Brown bat showing tail vertebrae confined to uropatagium

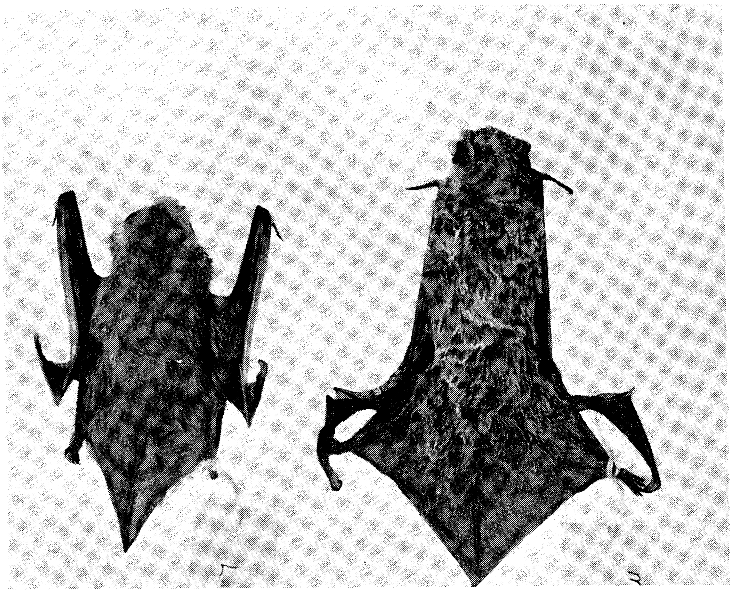


FIGURE 8. Red bat (left) and Hoary bat (right) showing furry uropatagium

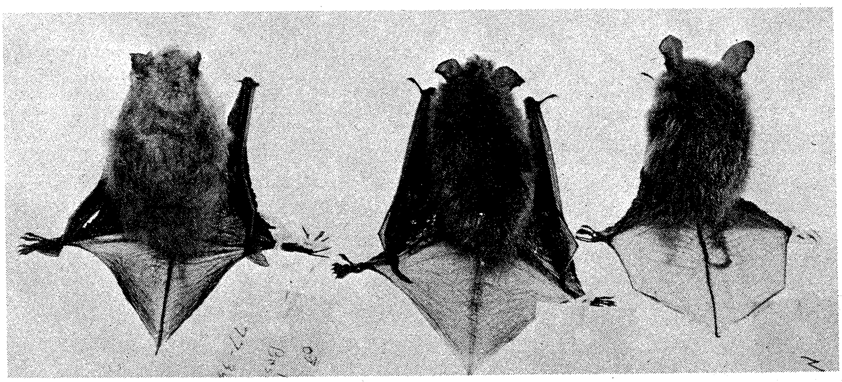


FIGURE 9. *Pipistrellus* (left); *Myotis lucifugus* (center); and *Myotis keenii* *(right)*

KEY TO THE BATS THAT OCCUR OR POSSIBLY OCCUR IN WISCONSIN

1. Tail not extending beyond tail membrane (uropatigium) or extending less than 4 mm. beyond. (See Fig. 7) 2

2. Single pair of upper incisors 3

3. Upper surface of uropatigium densely furred (Fig. 8), its skin not visible, two pairs of upper premolars, one of which a minute peg, usually a whitish spot visible on shoulder, pelage more or less hoary 4

4. Dorsal pelage maroon brown, washed with hoary whitish or buff, greatest length of skull exceeds 16 mm, forearm more than 45 mm .... Hoary Bat *Lasiurus cinereus*

4′ Dorsal pelage brick red orange or yellowish orange, thinly washed with hoary buff, greatest length of skull less than 16mm, forearm less than 45 mm .... Red Bat *Lasiurus borealis*

3′ Upper surface of uropatigium nearly naked, visible, scantily haired proximally, one pair of upper premolars, shoulder spot lacking, dorsal pelage brown ....Unverified, Evening Bat *Nycticeius humeralis*

2′ Two pairs of upper incisors 5

5. Dorsal pelage dark brownish or blackish washed with buffy or silvery white .... Silver-haired Bat, *Lasionycteris noctivagans*

5′ Dorsal pelage brownish, reddish or yellowish buff, never washed with whitish 6

6. Dorsal pelage yellowish, tan or pale reddish brown (Fig. 9); one large and one minute pair of upper premolars (total of 34

teeth); hairs conspicuously tricolored (gray-cream-brown); forearm usually less than 36 mm .... Eastern Pipistrelle *Pipistrellus subflavus*

6′ Dorsal pelage brown, or if yellowish, pale, or reddish brown, of faded, worn pelage; normally one large and two minute pairs of upper premolars (total of 38 teeth) or only one large pair (total of 32 teeth); hairs never tricolored; forearm more than 36 mm 7

7. Skull more than 18 mm in greatest length, forearm more than 44 mm, premolars 1/2 (total of 32 teeth) .... Big Brown Bat *Eptesicus fuscus*

7′. Skull less than 18 mm in greatest length, forearm less than 40 mm, premolars normally 3/3 (total of 38 teeth) 8

8. Ear pinna broad and long (16 mm. or more from notch),maxillary tooth-row more than 5.5 mm, elastic fibers of uropatagium forming a pattern of wide, prominent chevrons (Fig. 9) numbering approximately 7 (6-11) ....Keen's Myotis *Myotis keenii*

8′ Ear pinna narrower, more recurved, and shorter (usually less than 15 mm), maxillary tooth-row less than 5.5, elastic fibers of uropatigium forming narrow, indistinct chevrons numbering approximately 12 or more (Fig. 9)............. 9

9. Dorsal pelage with metallic, brassy or coppery brown glint, never pinkish or purplish, calcar not keeled or but slightly keeled, sparse hairs extend beyond toes .... Little Brown Bat *Myotis lucifugus*

9′ Dorsal pelage dull brown, dorsal and ventral pelage tinged pinkish or purplish gray over brown, calcar distinctly keeled, sparse hairs do not extend beyond toes .... Indiana Myotis *Myotis sodalis*

1′ Tail extends distinctly beyond the uropatigium .... Unverified, Mexican Free-tailed Bat, *Tadarida brasiliensis*

Tadarida brasiliensis has been taken at DeKalb, Illinois (Walley, 1970) but doubtless this bat was far from its usual geographic range. *Nycticeius humeralis* has been taken in Chicago (Necker and Hatfield, 1941).

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AMERICAN ENGINEERING AND BRITISH TECHNICAL OBSERVERS: THE FIRST TWO HUNDRED YEARS*

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As late as 1833 there was considerable ignorance of America abroad. For example, a British writer declared that in America there was almost nothing to steal but grass and water. If a man wanted to steal a pair of breeches, he had first to slay and strip the wearer, since no man from the president down had a second pair. In the United States, he added, the arts of life consisted of planting maize and potatoes, the luxuries of life in boiling these into puddings. A looking glass was a show that congregated the population of a province.[1]

This view of conditions in America was slowly altered. Much of the credit for this belongs to the small, but steady, stream of visitors whose published diaries, recollections, and reports painted quite a different picture of American life.

If Europeans were often ignorant of living conditions in America, this was even more the case with American technology. A New England engineer, Zachariah Allen, visited Belgium in the 1820s. He met a native who boasted that steamboats had recently been introduced in his country and who was startled to hear that they had been in successful operation in America for almost two decades. When Allen described a number of other American inventions—a machine for automatically cutting and heading nails, Blanchard's lathe for reproducing unsymmetrical shapes in wood, and Whittemore's machine for manufacturing cards — the Fleming's response turned from admiration to scepticism and then to disbelief. The two parted company with the Fleming doubting Allen's honesty.[2]

But just as Europe's ignorance of American politics, customs, and living conditions was remedied by non-technical visitors, Europe's ignorance of American technological accomplishments was relieved significantly by visiting engineers and industrialists. And because these men were intimately associated with contemporary European engineering practices, their observations on American technology are important from another point of view. They provide

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information nowhere else available on the differences between American and European (particularly British) engineering traditions.

It is impossible, short of a monographic study, to consider the entire spectrum of British reactions to American engineering over the past two hundred years. I will therefore concentrate on four major areas:

Transportation Systems: steamboats, railroads, roads, etc.
Structures: particularly buildings and bridges
Machinery: particularly locomotives and machine tools
Methods of Production.

In the first three areas British engineers and industrialists were frequently critical. Only in the fourth area was there reasonably unqualified praise.

I. TRANSPORTATION SYSTEMS IN AMERICA: SAFETY SACRIFICED TO CHEAP CONSTRUCTION.

An area of American engineering that attracted most attention from visitors was the American transportation system. All travelers were bound to have direct and intimate experiences with American railroads, steamboats, roads, or, in more recent times, automobilies. Many of their experiences were unpleasant. The general verdict was that American transportation systems tended to sacrifice safety to cheap construction.[3]

Before the coming of the railroad, steamboats were a popular mode of travel. America pioneered in the development of steam-powered craft, and this was duly noted by many European visitors. They were often impressed with the speed and design of the steamboats on the eastern seaboard.[4] But the more typically American boats were the western steamboats, which differed radically from their European counterparts. These utilized high rather than low pressure engines, had a shallower draft, and all equipment placed above deck.

The European engineer's reaction to the western steamboat was sometimes one of near panic. David Stevenson, a prominent British civil engineer, declared in 1838:

> . . . no one who is at all acquainted with the steam-engine, can examine the machinery of one of those vessels, and the manner in which it is managed, without shuddering at the idea of the great risk to which all on board are at every moment exposed.[5]

Economy, he concluded, was apparently the "only object" of the constructors of such vessels.[6] Stevenson accidentally boarded one of these vessels on the Ohio River. On discovering that the engine's pressure was occasionally raised as high as 150 psi, he kept his life jacket handy and abandoned the boat at the first opportunity.[7] Some non-British engineers, Klinkowström of Sweden for instance, reacted similarly, declaring: "We ought not to accept these machines (in Sweden)."[8]

The coming of the railroad did not relieve the anxiety of many British technicians traveling in America. In Britain, partially due to Parliamentary restrictions, partially due to general engineering policy, every precaution was taken to ensure safety on the rails. Curves of less than 1000 feet radius were avoided; gradiants on the line were minimal. In passing through towns or cities the rail lines were fenced in; there were no grade-level crossings. In addition, most tracks were double to avoid head-on collisions.

The contrast with the American system was stark. Several British industrialists and engineers noticed immediately that American engineering practice accepted much sharper curves and steeper gradients.[9] Most American rail lines were single track.[10] Moreover, American railroads ran with impunity down the middle of busy streets and through urban areas. They were seldom fenced and were commonly crossed by intersecting roads at rail level.[11] To make things even worse, in the eyes of British observers, the crossings had no gates, merely signs telling the unwary pedestrian to beware of oncoming trains.[12]

For obstructions that might arise from such a situation American engineers had come up with their own unique solution — the cowcatcher. This little device often attracted comment from British technicians, for it seemed a typically American innovation. One British industrialist noted that this neat implement was designed "to throw aside any stout old gentleman or other impediment" without derailing the train. Since he had just noted that children often played near or on the rails, they may have been the other impediments he had in mind. The basic principle in America, he concluded, was "look out and take care of yourself."[13]

Edward Watkin, a prominent British and Canadian railroad contractor, observed other basic differences in construction. The British engineering tradition, he said, was to design the railroad's supplementary works in brick and mortar, to last forever, to hold up any possible weight of locomotive. Drainage works were made large enough to handle any conceivable flood. Cuttings and embankments were given slopes which defied all chance of slips. The Americans, on the other hand, were interested only in a railway that worked. Their guiding principle was: "good enough is sufficient."[14] Other engineers and industrialists also noted the American preference for minimum initial construction costs.[15] Watkin concluded that in order to get railroads Americans were willing to permit their "comfort and even safety" to be violated.[16]

The alternative to steamboat and railroad was the common road. But American engineering in this area was no more reassuring. David Stevenson noted in the late 1830s that road making was a branch of engineering little cultivated in the United States, that roads were often so wretched and neglected as to hardly deserve the name of highways. They were quite unfit, he added, "for any vehicle but an American stage, and any pilot but an American driver."[17] Forty years later another British civil engineer commented that New York streets would drive road surveyors back home "delirious."[18] Another Britisher suggested that New York's city engineer should take lessons in street paving from his London counterpart.[19] The atrocious condition of American highways could of course be a serious safety hazard. Vivian, an industrialist, remarked that one did not dare allow his tongue to protrude, while traveling on most American roads, for fear of severe lacerations.[20]

The coming of the automobile, while it brought major improvements in American highway engineering, offered no respite to the safety-conscious British. Hector MacQuarrie, a mechanical engineer, called the Model-T Ford a "metal arm breaker" in 1918.[21] And another engineer in the early 1920s complained that the American automobile was "as dangerous as the railway has always been in that country. . . ."[22]

II. AMERICAN STRUCTURES: AESTHETIC APPEAL AND STRENGTH SACRIFICED TO CHEAP CONSTRUCTION

The British reaction to the American structural engineering tradition was frequently similar to his reaction to American transportation systems. The prevalent feeling was that American designs and practices tolerated flimsiness and ugliness for sake of economy.

One of the uniquely American structural innovations of the nineteenth century was the balloon-frame house. It employed much lighter framing than traditional styles; it eliminated the larger beams and heavier members of English houses. This reduced the number of workers required on a housing site, as well as the labor consuming mortising and tenoning work.[23] But professional architects who came to America trained in Continental traditions were horrified at the results. Calvert Vaux and Gervase Wheeler, for example, felt that American houses with balloon-framing had no sense of proportion, and that no attempt had been made to blend them in with the landscape. They were "bare, bald white cubes."[24]

The British engineer's initial reaction to other types of American structures was similar. Stevenson said that it was vain to seek in American constructions the finish that characterized those of France or the stability for which his own countrymen were famed. American works looked "rude and temporary." Everywhere there were things which would offend the eye accustomed to European workmanship, all tolerated in order to keep construction costs down.[25]

Deserved or undeserved, the predominant foreign conception of nineteenth and early twentieth century American structures was that of roughness and frailty, even though America pioneered the steel-frame skyscraper. When MacQuarrie posted to America as an inspector of gun and carriage production during World War I, first viewed the New York skyline, he responded:

> I felt that anything merely 'American' ought not to be so beautiful. It ought to have been flimsy and cheap looking.[26]

And although the skyscrapers of New York convinced him that American buildings had moved far beyond this stage, he still noted, later, that Americans tolerated flimsiness in their bridges.[27]

The typical American bridge was for many years very different from the typical European bridge (see Figs. 1 and 2). European bridges were often monumental works of art, constructed out of finely dressed stone. They were solid, rigid structures, strong enough to support many times the weight applied to them. The typical American bridge, on the other hand, was often a rather ugly and flimsy affair made out of wood pilings. The American preference for cheap, wood truss structures was noted by a number of visitors.[28] Their initial reaction, although most did not confess it, was probably similar to that of a San Francisco newsman:

> It will shake the . . . stoutest hearts when they see that a few feet of round timbers and seven-inch spikes are expected to uphold a train in motion.[29]

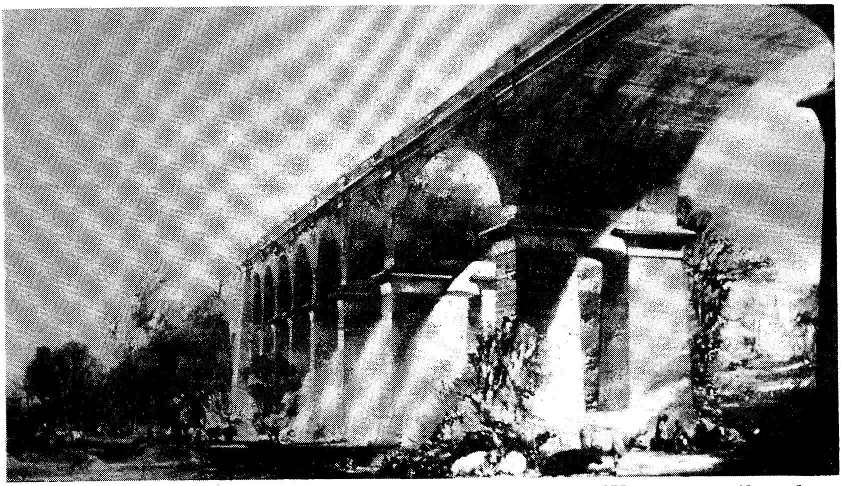

FIGURE 1: The Wharncliffe Viaduct on the Great Western Railroad at Hanwell: typical of the monumental masonry bridge structures used along British railway lines in the nineteenth and the twentieth century.

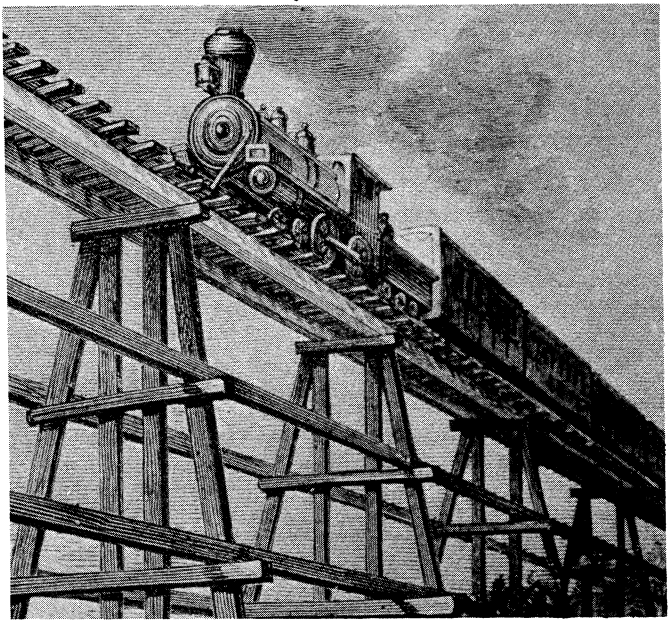

FIGURE 2: An American wood trestle bridge, late nineteenth century. The wood trestle construction was quite common on American rail lines west of the Appalachians and frequently caused some anxiety among British travellers accustomed to more rigid structures.

The development of lighter and more economical forms than the traditional European stone arch bridge was one of the major themes in American engineering in the nineteenth century. The suspension bridge, for example, was largely an American development, and hence American suspension bridges attracted comment. Watkin, traveling across the suspension bridge constructed by Roebling at Niagara, noted that he felt as if he were moving upon "a cobweb in the air, so light and fragile in appearance" was that structure.[32] Archibald Sutter, another British civil engineer, assured his readers that this bridge was, despite outward appearance, "to all intents and purposes . . . a safe and rigid structure."[33] And he considered the Brooklyn Bridge to be the "finest piece of bridge engineering" he had ever seen.[34] Other late nineteenth century American bridge experiments, like Eads' steel arch bridge at St. Louis, also received praise.[35] Clearly, as the twentieth century approached, British engineers had begun to appreciate the American approach to bridge engineering.

III. AMERICAN MACHINERY: DURABILITY, AESTHETIC APPEAL, AND ACCURACY SACRIFIVED TO CHEAP CONSTRUCTION AND TO SPEED

American machinery, like American structures, long had a reputation for being cheap, flimsy, and ugly. And the products which these machines produced were often viewed in the same light.

Locomotives are an excellent example of the contrast between American and British engineering styles (see Figs. 3 and 4). The British locomotive had a durable and heavy design; it was built with such solidity that it often became obsolete long before it wore out. It was also a beautiful piece of machinery, its lines nicely curved and blended; its uglier parts hidden. The American approach to locomotive design was distinctly different. The American locomotive was built cheaply. Lightness and speed, not durability were aimed for. Even a usually sympathetic observer of American engineering, like Watkin, considered the American locomotive to be an "ugly machine."[36] Stevenson noted that Americans made no attempt to embellish their engines. The external parts — the connecting rods, cranks, framing, and wheels — were left in a much coarser state than in engines of British manufacture.[37] And, according to one twentieth century observer, American locomotives had a reputation for breaking down after only very short service.[38]

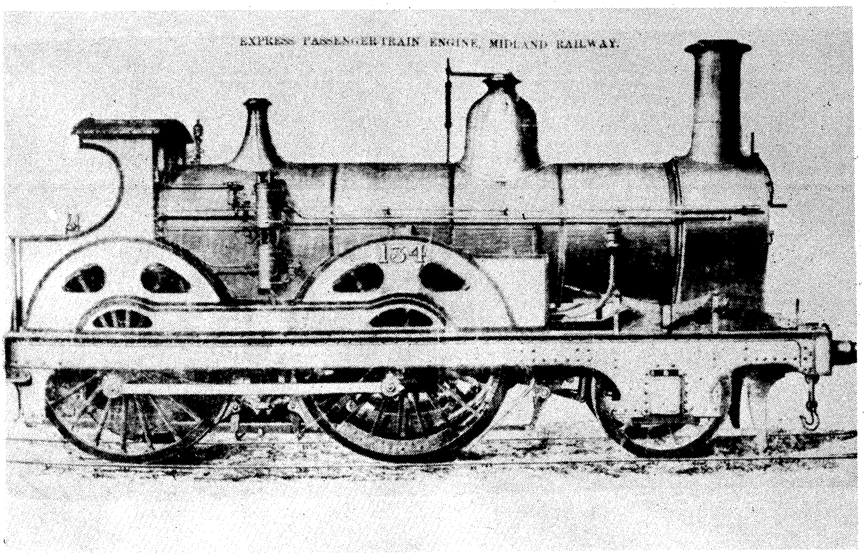

FIGURE 3: British express passenger locomotive, c. 1875. Note the rigid, massive construction, typical of British locomotive design. The wheels on the British engine are covered and the lines of the cabin were somewhat streamlined in an attempt to give the engine some aesthetic appeal. British locomotives were also often painted in bright colors.

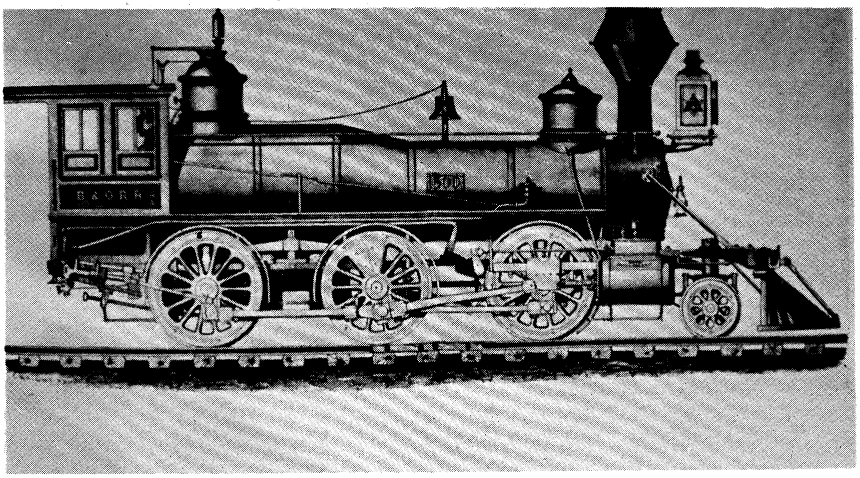

FIGURE 4: American express locomotive, c. 1875. The American construction was much lighter and more flexible than the British. But no attempt was made to embellish the appearance of the engine or to soften its harsh line, nor was the American locomotive usually painted.

The British tradition in the design of production machinery was similar to their approach to locomotive design. They built solidly. British machinery was strong, durable, and accurate. And, like British locomotives, often became obsolete before they were worn out.[39] Here again the American engineering policy offered sharp contrasts to British visitors.

One of the most crucial areas of nineteenth century technology was machine tools, central to the process of conversion from a wood to a metal dominated technology. In the 1850s Joseph Whitworth, the world's leading tool manufacturer, commented that American machine tools were similar to those used in England, but were lighter, flimsier, more inaccurate, and turned out less work than comparable English machines.[40] William Booth, a British mechanical engineer, repeated much the same charges in 1902. He believed American general purpose machine tools were "better designed than made". They were designed for handiness, but achieved this at the cost of accuracy and durability.[41] Frank Foster, who spent most of 1905 touring American engineering works, agreed with Booth's analysis, noting that American engineering policy called for the use of soft iron in order to cut production costs. The result was a flimsy and short-lived machine.[42]

It was not only general purpose machine tools that foreign engineers criticized. Flimsiness and ugliness were characteristics which they felt pervaded all, or almost all, American machinery. Foster complained that the American rule was "good enough is best."[43] In designing machinery, he concluded, American engineers paid little attention to strength and durability, substituted cheap materials for expensive ones, and took more chances with their designs.[44]

British machinery had a reputation not only for durability, but also for personal attractiveness. Sharp edges were rounded off, exposed surfaces were turned to smoothness, and buffed. Ornamentation was frequently added. Americans produced ugly machinery, merely rough-turning or hand-painting exposed surfaces. Ornamentation was avoided. This naturally attracted criticism. Foster, for example, complained that the workmen who attended machines were human and would give more care and attention to a good looking machine than to a shoddy one.[45]

Not only American machinery, but American consumer products fell under the same sharp criticism. In comparing American goods with those of Britain and Germany, Arthur Shadwell in 1906 accused Americans of sacrificing "quality to quantity" and of

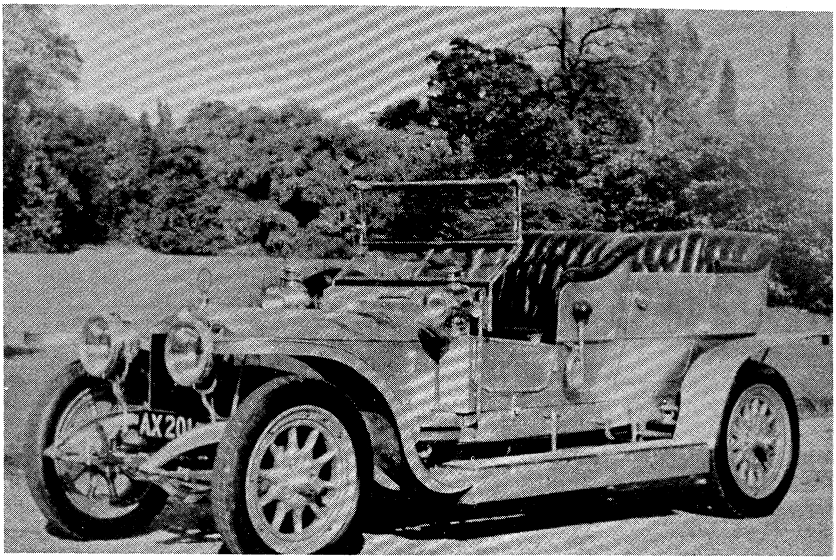

FIGURE 5: 1907 Rolls-Royce 'Silver Ghost'. Typical expression of the British engineering tradition — a precision built machine, designed to last a life time; often custom designed; aesthetically appealing; but also expensive.

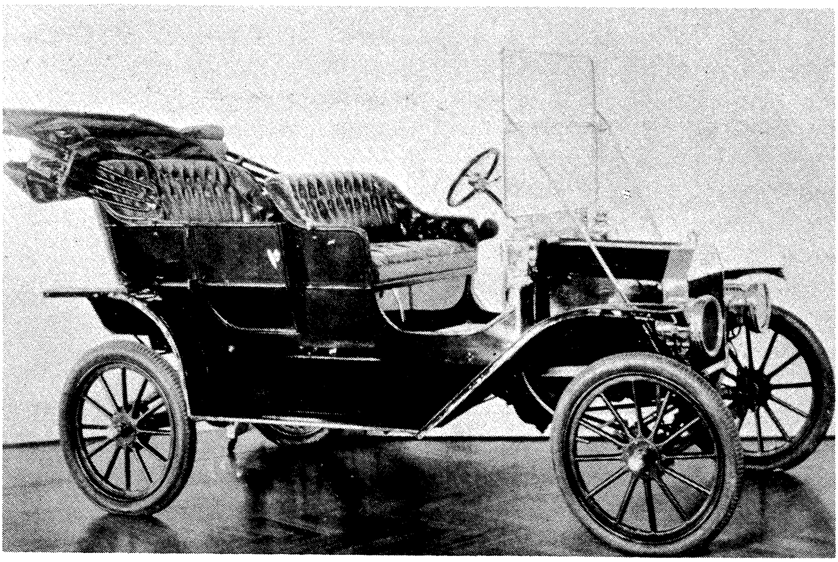

FIGURE 6: 1907 Model T Ford. Typical expression of the American engineering tradition — strictly utilitarian, cheap, ugly (at least by British standards), flimsy, mass-produced.

turning out "hurried and badly-finished work". The chief characteristic he saw in American manufactures was "the prevalence of rough, badly finished or flimsy work."[46] A visiting English civil engineer in the 1920s observed that "Yankee goods" had not entirely lost this reputation.[47] It would appear, therefore, that between 1776 and, say, 1930 "Made in U.S.A." had much the some connotation that "Made in Japan" had in the 1950s and early 1960s — cheap, flimsy, ugly.

Perhaps the best way to comprehend the different traditions in product design followed by British and American engineering is to compare the classic automobiles of each country. Britain's classic automobile was the Rolls Royce. An expensive piece of machinery, the Rolls Royce was a precision-built car, designed to last a life time, to carry its owner in luxury, and to be aesthetically appealing. The Rolls was produced in relatively small numbers and often custom built. The automobile most closely associated with the rise of the automotive industry in America was the Model-T Ford. The contrast with the British product was stark. The Model-T Ford was rigidly utilitarian. Almost ugly with its spidery lines, it was much lighter and less durable than the Rolls Royce. One expected to have to repair it frequently and it was, therefore, made so that it could be repaired easily. It was cheap and mass-produced, available in only one color (black) with few frills or luxuries. The Rolls Royce was a typical product of the British approach to engineering; the Model-T the logical outcome of America's engineering tradition (see Figs. 5 and 6).

IV. METHODS OF PRODUCTION: AMERICA'S SPECIAL PROVINCE

While European technical visitors often went away unimpressed by American transportation systems, structures, and products, there was one area where they usually were impressed — manufacturing methods. It was in this area, they believed, that American engineering had made its most important contributions to world technology. So unique and so original did the American approach appear that by the 1850s Europeans referred to it as the "American System of Manufacturing".

The American System did not come to the attention of the rest of the world until the Crystal Palace Exposition in London in 1851. The American exhibits there at first attracted little attention. The products seemed typically American — aesthetically unappealing, cheap looking. McCormick's reaper, for example, was described by the *Times* as a "cross between a flying machine, a wheelbarrow and an Astley chariot."[48] Only gradually did the exhibit begin to attract notice. First the superior performance of American yachts, American reapers, and American locks brought it into the public eye. Then it was recognized that the uniqueness of the American exhibit lay not so much in the products, but in the way they were manufactured — standardized, constructed out of interchangeable parts, made with special purpose machinery. The specialized machinery was as important as the interchangeable parts, the characteristic usually associated with the "American System of Manufacturing". Only with special purpose machines and machine tools could one achieve the uniformity and close tolerance that made interchangeability possible. Interchangeable parts and special purpose machines are so common today that it is a little hard to realize how unique the system seemed to foreigners in the mid-nineteenth century. But it was. By the end of the Crystal Palace Exposition America's exhibit had become a major attraction.[49]

The British were startled by the achievements of "the colonials". Worried about the possibility of an American challenge to British industrial superiority, they sent several observers to America in the years immediately following the Crystal Palace. George Wallis, head of the Birmingham School of Art and Design, was one. Joseph Whitworth, Britain's leading machine tool manufacturer, was another. The British Ordnance Department also sent a team to specifically study the feasibility of equipping the proposed new arsenal at Enfield with American tools, since the required special purpose machinery was not to be had in England. John Anderson, inspector of machinery for the British Ordnance Board, headed this team.[50]

The reports submitted to Parliament by Anderson's committee, by Wallis, and by Whitworth are an invaluable source of information for Anglo-American technological differences at mid-century. These men usually shared the negative opinions of other British engineers and industrialists with respect to general-purpose American machinery and American products.[51] But they had nothing but praise for American ingenuity in the area of special purpose design.

Anderson's committee was probably the most impressed, for they closely studied machinery in the area where the greatest advances had been made — gun stocking lathes. British technicians had expressed scepticism over the possibility of mechanically forming irregular shapes in wood.[52] But the Blanchard gunstocking lathe, originally invented in 1818, made it possible to produce identical gun stocks in large quantities. When the Committee on Machinery inspected U.S. arsenals in the mid-1850s, American engineers had already specialized the original Blanchard machine into sixteen different machines, each one of which carried out one small operation or sequence of operations on a gun stock. The committee described these machines at some length in their report and were enthusiastic, without reservation, at performance:

> It is most remarkable that this valuable labour-saving machine should have been so much neglected in England . . . ; its introduction into the armory will prove a national benefit.[53]

The great advantage of interchangeable parts, besides ease of repair, is ease of assembly. This also attracted the committee's attention. In the British gun trade assembling a musket from its fifty-seven different parts was a job for highly skilled craftsmen, who, with files, jigs, and chisels, painstakingly fitted the different parts together. The parts for the next musket, all hand forged, would require similar efforts, and the parts from any two muskets would be non-interchangeable without extensive hand fitting operations. At the arsenal in Springfield, Massachusetts, the committee withdrew ten muskets from the armory, each made in a different year between 1844 and 1853. They took them apart and mixed the different parts thoroughly. They then asked a workman to re-assemble the ten muskets with only a screwdriver, handing him the parts at random. The extreme ease with which the muskets were reconstructed was considered remarkable. The committee, in using the term "assemble" to describe the process, always enclosed it in quotation marks.[54] It highlighted the principal difference between the European and American systems of production. The Europeans "fitted"; the Americans "assembled". To the writers of the report "assembling" a firearm was a technological innovation of major proportions. Anderson's committee concluded its report by warning that in the adaptation of special apparatus to a single operation "in almost all branches of industry", Americans displayed "an amount of ingenuity" which Britain had better imitate if they meant to hold their position in the world market.[55]

The impact that the "American System of Manufacturing" had on British engineers can also be appreciated through the reaction of James Nasmyth, inventor of the steam hammer. In questioning before a Parliamentary committee on machinery in the mid-1850s he was asked if he had visited Samuel Colt's new firearms factory near London and his impression of it. He replied:

> It produced a very impressive effect, such as I shall never forget. The first impression was to humble me very considerably. I was in a manner introduced to such a masterly extension of what I knew to be correct principles, but extended in so masterly and wholesale a manner, as made me feel that we were very far behind in carrying out what we know to be good principles.[56]

In answer to another question about American special purpose machinery he responded: "In those American tools there is a common-sense way of going to the point at once, that I was quite struck with."[57]

Anderson, after returning with his committee from America, remained a permanent convert to American methods. American machinery, he declared later, was "so different" and "so rich in suggestions" that when Enfield was equipped, it should be thrown open to British manufacturing interests for study.[58] He tried vainly to warn Britain of the coming Challenge to British industrial leadership:

> A few hours at Enfield will show that we shall soon have to contend with no mean competitors in the Americans, who display an orginality and common sense in most of their arrangements which are not to be despised, but on the contrary are either to be copied or improved upon.[59]

Wallis and Whitworth also responded positively to what they saw of American special purpose designs. For instance, Whitworth was deeply impressed with American special purpose woodworking machinery, believing that this was the area where the application of labor-savings devices had gone the farthest.[60] He observed manufacturing facilities in various American towns occupied exclusively in making doors, window frames, or staircases, entirely by self-acting machinery.[61] He also observed the extensive use of special purpose and labor-saving machinery in the production of clocks, firearms, agricultural implements and other things.[62] Wallis was more interested in the aesthetic elements of American manufacturing, but he too remarked on the extensive substitution of mechanical power for skilled labor in America and affirmed that

Americans deserved their reputation in the design of special purpose machinery.[63]

Foreign admiration of American ingenuity in the invention and application of labor-saving devices continued through the remainder of the nineteenth century and on into the twentieth. In 1885, for example, a visiting engineer David Pidgeon, declared that it seemed the "special province" of Americans to devise automatic machinery.[64] And, he added, tools and processes which his own countrymen were inclined to consider exceptionally clever were commonplace in American shops.[65] The Mosely Commission of Trade Unionists, visiting American plants around 1902, were struck by the greater variety of special tools for special work and repetitive work.[66] American milling machines and turret lathes sometimes got special attention.[67]

While American methods of assembly via interchangeable parts and special purpose devices were attracting attention, so were American methods of disassembly. There were a handful of foreign technicians with stout stomachs who toured the vast slaughterhouses of Cincinnati, and later Chicago. The overhead railway (forerunner of the modern assembly line) which transported the animals inside the houses, the rigid specialization of the disassembly, and the ingenious machinery invented to aid the process, plus the enormous quantities of raw meat handled were all considered unique.[68]

The union of interchangeable parts and special purpose machinery with the moving assembly line and worker specialization was finally made by Henry Ford in the 1910s. He combined these elements of American manufacturing technology with an automobile designed along the lines of traditional American engineering policy — ugly, flimsy looking, unornamented, cheap, and dangerous — and created the modern mass production system. The effectiveness of the combination was immediately clear. Ford was able to reduce chassis assembly time from fourteen hours to about an hour and a half. A British engineer visiting American factories in Detroit in 1918 remarked simply: "I have seen nothing in this country (Britain) to compare with them."[69] And throughout the period between the two world wars this new American approach to manufacturing, first exhibited in the automobile industry, attracted close attention from visiting foreign engineers anxious to discover the secret of American productivity and America's rapid rise to world industrial prominence.[70]

V. WHY DID AMERICA DEVELOP A DISTINCTIVE ENGINEERING TRADITION?

Many of those who observed unique elements in American engineering turned quite naturally to attempts to explain their origin. The usual explanation for the cheap and often dangerous construction of American transportation systems, for example, was the shortage of capital in the States. One very sympathetic British engineer noted that in many cases America had to construct things cheaply or not at all. And he had little but admiration for the economy with which American engineers managed to complete their lines.[71] Many agreed that the unfinished and cheap appearance of American products was due to this factor and not to lack of engineering know-how.[72]

There were some, however, who felt that the dangers of the American transportation systems and the flimsiness of American bridges were but a reflection of broader values in American society, that the engineering decisions merely reflected the low value placed on human life generally. T. C. Grattan, British Council in America for many years, related an incident of this general American unconcern about human life. According to Grattan, he was riding a train one day, when he felt a violent jolt and heard a loud crash. But the train continued with undiminished speed. At the next stop he asked the conductor and engineer about the incident. "Oh", the engineer explained, "that was probably when we went over that horse and buggy". "Was anyone in it?", Grattan asked. "Yes, two ladies". "Were they thrown out?" "Yeah, I guess they were, and pretty well smashed too". "Good God, then why didn't you stop to see what state they're in". "Well, mister", the engineer replied, "I reckon they're in the state of Delaware, and you'd better climb back on board or we'll leave you."[73] Another man reported that competition between river boats was so sharp, that if one grounded, the others would steam past without stopping, while passengers and crews cheered.[74] A number of engineers suspected that a general lack of concern with human life was at least partially behind the absence of safe construction in American transport systems and structures.[75]

The unfinished, flimsy appearance of many American structures was usually explained in much the same way. In a nation and region where labor as well as money was in short supply, the elaborate ornamentation, the over-built, totally stable British-type construction could not be expected. America had an incentive to develop lighter, more economical structures.[76]

The area which attracted the most attention was, of course, the American system of manufacturing. Here there is an amazing similarity between some of the explanations offered by British engineers who toured America in the 1850s and British productivity teams which studied American methods under the Marshall Aid Plan shortly after World War II. A few samples from these two eras should suffice to illustrate this point.

A. *The high price of labor.* Foreign engineers and industrialists cited the shortage and high price of American labor and believed that this stimulated American ingenuity and accounted for the eagerness with which American industries took up automatic and labor-saving machinery.

> Committee on Machinery, 1855: "In consequence of the scarcity and high price of labour in the United States . . . a considerable number of different trades are carried on . . . with machinery applied to almost every process . . . ."[77]

> Wallis, 1854: ". . . to this very want of human skill, and the absolute necessity of supplying it, may be attributed the extraordinary ingenuity displayed in many of those labour-saving machines, whose automatic action so completely supplies the place of the more abundant hand labour of older manufacturing countries."[78]

> Hutton, 1953: "[The United States is] a country where human skill has always been costly relative to other ingredients of production, and where machinery is therefore more plentiful and important."[79]

B. *A favorable attitude in workers and society generally towards machinery.* Related, of course, to the previous factor, but somewhat independent of it, was the generally favorable attitude of both employers and employees in America toward the adoption of machinery.

> Whitworth, 1854: "The workmen hail with satisfaction all mechanical improvements, the importance and value of which, as releasing them from the drudgery of unskilled labour, they . . . understand and appreciate."[80]

> Materials Handling Productivity Team, c. 1950: ". . . in not a single case did we find serious opposition to the introduction of new methods of materials handling or mechanical aids."[81]

> Hutton, 1953: "The first Teams that visited America were struck by . . . the generally favourable attitude of American trade unions to improved techniques of production, the introduction of new methods and new machines . . . ."[82]

C. *A general outlook in American society favorable toward change.* This was another social factor which visiting British engineers noted as generating a progressive mechanical climate in America.

> Wallis, 1854: ". . . traditional methods have little hold upon the American, as compared with the English artisan . . . ."[83]

> Field, 1868: ". . . the Englishman . . . is unwilling to change the methods which he has been used to . . . ."[84]

> Watkin, 1852: "They (the Americans) say . . . that our desire for 'permanence' is a bar to future improvement . . . ."[85]

> Furniture Productivity Team, c. 1950: "It is characteristic of Americans that they seldom hesitate to make changes . . . ."[86]

> Hutton, 1953: "The British are a traditional, tradition-ridden, conservative people. They dislike change."[87]

D. *The American educational system.* America, even before 1850, probably had a larger proportion of its population in school than any country in the world. The importance of this social factor to American technology was observed early, and the generally more intelligent actions and appearance of American workers was often a source of amazement to British engineers and industrialists.

> Wallis, 1854: "This [wide-spread education] lays the foundation for that wide-spread intelligence which prevails among the factory operative of the United States, and . . . the system reacts to the permanent advantage of both employer and employed . . . (W)ith minds . . . prepared by sound practical education, the Americans have laid the foundation of a wide-spread system of manufacturing operations . . . ."[88]

> Whitworth, 1854: "The benefits which . . . result from a liberal system of education and a cheap press to the working classes of the United States can hardly be over-estimated in a national point of view . . . ."[89]

> Hutton, 1953: ". . . Americans . . . believe that men (and, be it noted, women) deserve to be educated as though their innate ability and capacity *were* equal . . . ."[90]

> Hutton, 1953: ". . . the American worker is certainly not 'better educated' in the sense of primary education. He is better trained, after (public) schooling ceases."[91]

It is fairly clear that British technical observers in the mid-nineteenth and mid-twentieth centuries often had strikingly similar explanations for America's superior mechanical ingenuity and greater dependence on machine production. It would also appear that America's general social and economic climate, aside from the more narrowly technical sphere, played a major role in giving American technology certain of its unique and persisting features.

However, in the twentieth century, particularly since the Second World War, the distinct and unique style which foreign observers once saw in American engineering began to disappear. With vastly improved means of international transportation and communications, with the large number of technical publications, the frequency of international congresses, the magnitude of international trade, and the associated export of technological equipment and know-how, the distinct engineering styles that could once be identified in traveling from country to country have become blurred. Technology has become increasingly international.

But the funny thing about history is the way it sometimes strings out into the present. An observer, familiar with previous critiques of American technology, may spot a few instances of this, for instance in America's transportation systems. The traditional foreign evaluation was "safety sacrificed to cheap construction." This tradition lives on in the American rail network. American railroads have a notorious, worldwide reputation and must be considered a national humiliation. The inferior state of American tracks has already caused the "American Freedom Train" to derail several times in its short lifetime, and one of the major American networks recently televised a special report on the dangers of shipping toxic chemicals on American rail lines. Similarly, the American automobile may be seen as a continuation of the same tradition. Ever since Ralph Nader's *Unsafe at Any Speed* there has been a continuous stream of criticism directed at safety standards in the American automobile. It would seem, then, that the traditional American approach to the construction of the basic means of transportation still lives on, long after the conditions which initially dictated the sacrifice of safety to economy have disappeared.

On a more positive note, it is also clear that certain elements which led to American greatness in the development and application of special purpose and labor-saving machinery continue to operate. One notable example should suffice — the high cost of labor. In the nineteenth century this factor was believed by visiting engineers to be one of the primary reasons why Americans were so ingenious in devising labor-saving and automatic machinery and why American industrialists so eagerly encouraged and adopted them. That labor still commands a high price in America is not open to question. And this has been one of the major factors behind America's continuing lead in the development and adoption of computer technology.

NOTATIONS

1. A Citizen of the World, *America and the Americans*, London, 1833, p. vii. Americans, of course, were often equally ignorant of Britain. William Brown, a Clothier from Leeds, complained in 1849 that most Americans believed that the Queen lived in the Tower of London; that William Shakespeare was born at Hartford, in Connecticut; and that Robert Fulton invented the first steam engine. William Brown, *America: A Four Years' Residence in the United States and Canada*, Leeds, 1849, pp. 62-63.

2. Zachariah Allen, *The Science of Mechanics* . . ., Providence, Rhode Island, 1829, pp. 348-349n.

3. This was also the feeling of a number of non-technical visitors. See, for example, Max Berger, *The British Traveller in America, 1836-1860*, New York, 1943, pp. 41-48.

4. David Stevenson *Sketch of the Civil Engineering of North America* . . ., London, 1838, pp. 116ff. The Swedish engineer, Baron Klinkowström, was also impressed. Axel Klinkowström, *Baron Klinkowström's America, 1818-1820*, transl. by F. D. Scott, Evanston, Ill., 1952, pp. 93n, 115.

5. Stevenson, *Sketch*, p. 153; cf. Michael Chevalier, *Society, Manners, and Politics in the United States (1833-1835)*, ed. by John Ward, Garden City, New York, 1961, pp. 210-214.

6. Stevenson, *Sketch*, p. 150.

7. *Ibid.*, p. 154.

8. Klinkowström, *Klinkowström's America*, pp. 55, 93n, 125; cf. Francis Anthony Chevalier de Gerstner, "Letters from the United States of North America on Internal Improvements . . .," Franklin Institute Jour., 31 (1841), pp. 170-173. Gerstner was a German engineer.

9. Joseph Whitworth, *Special Report of Mr. Joseph Whitworth, presented to the House of Commons . . . on February 6, 1854*, in Nathan Rosenberg, ed., *The American System of Manufactures*, Edinburgh, 1969, p. 360. All references to Whitworth's report in the notes which follow are to

the Rosenberg edition. See also: William Ferguson, *America by River and Rail . . .*, London, 1856, p. 233; Gerstner, "Letters," Franklin Institute, Jour., 30 (1840), p. 296; and Chevalier, *Society, Manners, and Politics*, pp. 229, 256.

10. S(amuel) M. Peto, *Resources and Prospects of America*, New York, 1866, p. 257; Edward W. Watkin, *A Trip to the United States and Canada . . .*, London, 1852, p. 121.

11. Archibald Finlayson, *A Trip to America: A Lecture . . . in the Public Hall of the Johnstone Working Men's Institute*, Glasgow, 1879, pp. 32-33; Hugh Tremenheere, *Notes on Public Subjects, made during a Tour in the United States and Canada . . .*, London, 1852, p. 153; *From the Clyde to California*, Greenock, 1882, p. 108; and Watkin, *Trip*, pp. 122-123. Ferguson, *America*, p. 321, commented that the destruction of cattle in the United States due to unfenced rail lines was enormous, 1600 head in four years on the Little Miami Railroad alone.

12. Thomas Greenwood, *A Tour in the States and Canada: Out and Home in Six Weeks*, London, 1883, p. 25; Ferguson, *America*, p. 10; Watkin, *Trip*, pp. 122-123; and Finlayson, *Trip*, p. 33. On the primitive state of American signalling apparatus on some lines see C. O. Burge, *The Adventures of a Civil Engineer: Fifty Years on Five Continents*, London, 1909, p. 240.

13. Finlayson, *Trip*, p. 33. The cowcatcher was also noted by H(enry) H. Vivian, *Notes of a Tour in America from August 7th to November 17th, 1877*, London, 1878, p. 77; Stevenson, *Sketch*, p. 260; and Ferguson, *America*, p. 107, among others.

14. Watkin, *Trip*, p. 124. Cf. C(harles) R. Enock, *Farthest West: Life and Travel in the United States*, New York, 1910, pp. 71, 85-86.

15. Peto, *Resources*, pp. 253-261; Watkin, *Trip*, pp. 123-124; Whitworth, *Special Report*, p. 360; Ferguson, *America*, p. 160; Chevalier, *Society, Manners, and Politics*, p. 256; and Enock, *Farthest West*, p. 97.

16. Watkin, *Trip*, pp. 123-124. Cf. Ferguson, *America*, p. 234, and Peto, *Resources*, pp. 254, 260-261. Peto noted the absence of 'fish joining' on American lines, calling it the worst possible economy. American writers often agreed with the observations of their British counterparts. For example, George A. Rankin, *An American Transportation System*, New York and London, 1906, pp. 11-13, considered European lines 90% safe, American 10%.

17. Stevenson, *Sketch*, pp. 215, 216.

18. Archibald Sutter, *American Notes, 1881*, Edinburgh and London, 1882, pp. 3-4.

19. Robert P. Spice, *The Wanderings of the Hermit of Westminster between New York and San Francisco in the Autumn of 1881*, London, n.d., p. 9.

20. Vivian, *Notes*, p. 201. Klinkowström, *Klindowström's America*, pp. 20, 232, also complained about American roads, and Enock, *Farthest West*, p. 133, declared that American roads were "a disgrace to a civilized nation".

21. Hector MacQuarrie, *Over Here*, Philadelphia and London, 1918, p. 56.

22. Enock, *America and England*, London, 1921, p. 194.

23. Carl Condit, *American Building*, Chicago, 1968, pp. 43-45.

24. John Kouwenhoven, *Made in America*, Garden City, New York, 1948, p. 65.

25. Stevenson, *Sketch*, pp. 20, 192.

26. MacQuarrie, *Over Here*, p. 17; cf. Enock, *Farthest West*, pp. 107, 112-113.

27. MacQuarrie, *Over Here*, pp. 143-144.

28. Watkin, *Trip*, p. 124; Peto, *Resources*, p. 259; Chevalier, *Society, Manners, and Politics*, p. 256; and Guillaume Tell Poussin, *The United States; Its Power and Progress*, transl. by Edmund DuBarry, Philadelphia, 1851, pp. 273-274. Pussin and Chevalier were French engineers, but their observations on American engineering often paralleled that of their British counterparts. Ferguson, *America*, pp. 42-43, considered American covered bridges an "ugly feature in the landscape".

29. David Jacobs and Anthony E. Neville, *Bridges, Canals & Tunnels*, New York, 1968, p. 55.

30. Sutter, *American Notes*, pp. 82-83.

31. Greenwood, *Tour*, pp. 28, 123; Ferguson, *America*, p. 342.

32. Watkin, *Trip*, p. 46.

33. Sutter, *American Notes*, pp. 21-22. Ferguson was somewhat impressed by the Niagara suspension bridge, but said that he preferred the permanence and capacity of British structures. Ferguson, *America*, p. 457.

34. Sutter, *American Notes*, p. 91. Cf. Spice, *Wanderings*, pp. 77-78.

35. Vivian, *Notes*, pp. 186-187. Cf. Greenwood, *Tour*, pp. 89-90.

36. Watkin, *Trip*, p. 131. Cf. Enock, *Farthest West*, p. 73.

37. Stevenson, *Sketch*, pp. 258-259.

38. Arthur Shadwell, *Industrial Efficiency: A Comparative Study of Industrial Life in England, Germany and America*, v. 2, London, 1906, p. 78.

39. William Booth, "An English View of American Tools," *American Machinist*, v. 25 (1902), p. 1578. Cf. Shadwell, *Industrial Efficiency*, p. 64 and Frank Foster, *Engineering in the United States*, Manchester, 1906, p. 9.

40. Whitworth, *Special Report*, p. 336.

41. Booth, "English View," pp. 1578, 1579.

42. Foster, *Engineering*, pp. 9-10, 78.

43. *Ibid.*, p. 8.

44. *Ibid.*, pp. 10-11. James Robertson, *A Few Months in America*, London, (c. 1855), p. 217, also referred to the "general inferiority" of American machinery. See also *Report of the Committee on the Machinery of the United States of America, presented to the House of Commons, in Pursuance of their Address of the 10th July, 1855*, reprinted in Rosenberg, *American System*, pp. 128-167. All subsequent citations of this report are to the Rosenberg edition.

45. Foster, *Engineering*, p. 11. Cf. George Wallis, *Special Report of Mr. George Wallis, presented to the House of Commons . . . in pursuance of their Address of February 6, 1854*, in Rosenberg, *American System*, p. 281, and *Report of the Committee on Machinery*, pp. 136, 167. All subsequent references to Wallis' report refer to the Rosenberg edition.

46. Shadwell, *Industrial Efficiency*, pp. 63, 76-77. Cf. Enock, *Farthest West*, pp. 214, 307. Greenwood, *Tour*, pp. 129-130, complained specifically about American pottery products. He also noted (p. 150) the American tendency to sacrifice quality to quantity in production generally. William Brown, *America*, p. 8, referring specifically to American woolen manufacturing, said much the same thing.

47. Enock, *America and England*, p. 195. Wallis, *Special Report*, p. 304, noted that American textiles were expected to last for only a short time and tended to be at the low quality end of the spectrum.

48. Rosenberg, *American System*, p. 7.

49. For an account of the American showing at the Crystal Palace see Rosenberg's "Introduction" in Rosenberg, *American System*.

50. John Anderson, *Statement of Services Performed by John Anderson, Superintendent of Machinery to the War Department, from the Year 1842 up to the Present Time*, London, 1873, pp. 28-29

51. *Report of the Committee on Machinery*, p. 167; Wallis, *Special Report*, p. 304; Whitworth, *Special Report*, p. 336.

52. *Ibid.*, p. 137; "Report of the Select Committee on Small Arms," *Parliamentary Papers*, v. 18 (1854), Q. 2655-2657.

53. *Ibid.*, p. 138. The operation of the Blanchard machines was described in some detail on pp. 137ff.

54. *Ibid.*, pp. 121-122, 142.

55. *Ibid.*, pp. 128-129; cf. p. 193.

56. *Ibid.*, "Report of the Select Committee on Small Arms," Q. 1366-1367.

57. *Ibid.*, Q. 441.

58. Anderson, *General Statement of the Past and Present Condition of the Several Manufacturing Branches of the War Department*, London, 1857, p. 31.

59. *Ibid.*

60. Whitworth, *Special Report*, p. 343.

61. *Ibid.*, p. 344.

62. *Ibid.*, pp. 342, 346.

63. Wallis, *Special Report*, p. 203.

64. Daniel Pidgeon, *Old-World Questions and New-World Answers*, New York, 1885, p. 10. Cf. Peto, *Resources*, p. 142.

65. Pidgeon, *Old-World Questions*, p. 11. Cf. Greenwood, *Tour*, p. 142.

66. *Mosely Industrial Commission to the United States of America, October-December 1902*, Manchester, 1903, preface to Mr. W. C. Steadman's report by Mr. A. Mosely. Even the most unfriendly British technical observers were willing to concede that the inventive talents of the Americans in the labor savings field were of the first order, e.g., Brown, *America*, pp. 10, 68-69.

67. For example, H.F.L. Orcutt, "Modern Machine Methods," Institution of Mechanical Engineers, *Proceedings*, 1902, pp. 9-112.

68. Vivian, *Notes*, pp. 90-91; Spice, *Wanderings*, p. 19; Tremenheere, *Notes*, p. 92; *Clyde to California*, p. 119; Greenwood, *Tour*, p. 81; Ferguson, *America*, p. 320.

69. MacQuarrie, *Over Here*, p. 55.

70. For example, Bertram Austin and W. Francis Lloyd, *The Secret of High Wages*, London, 1926, and *The Daily Mail, Trade Union Mission to the United States . . .*, London, 1926. Cf. Enock, *America and England*, p. 196.

71. Watkin, *Trip*, p. 121. Watkin noted that American railroads cost 6.5 times less per mile than British roads (p. 124). Cf. Gerstner, "Letters," Franklin Institute, Journal, 30 (1840), pp. 296-297. Foster, *Engineering*, p. 1, observed that cheap construction had become to a certain extent a settled feature of American engineering (written in 1906).

72. For example, Stevenson, *Sketch*, pp. 192-193.

73. T. C. Grattan, *Civilized America*, v. 1, London, 1859, pp.161-162.

74. Berger, *British Traveller*, p. 42.

75. Dionysius Lardner, *Railroad Economy*, London, 1851, pp. 382-383; Enock, *America and England*, p. 201; Greenwood, *Tour*, p. 25; and Chevalier, *Society, Manners, and Politics*, p. 215.

76. Stevenson, *Sketch*, pp. 192-193, 224. Cf. Ferguson, *America*, p. 235, and Gerstner, "Letters," Franklin Institute, Journal, v. 30 (1840), pp. 220, 224, 297.

77. *Report of the Committee on Machinery*, p. 128.

78. Wallis, *Special Report*, p. 203. Cf. Whitworth, *Special Report*, p. 387.

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83. Wallis, *Special Report*, p. 207.

84. "Report of the Select Committee on Scientific Instruction," *Parliamentary Papers*, v. 15 (1867-1868), Q. 6722.

85. Watkin, *Trip*, p. 124.

86. *Furniture*, p. 70, quoted in Sawyer, "Social Basis," p. 365.

87. Hutton, *We Too*, p. 139; cf. p. 59.

88. Wallis, *Special Report*, p. 306.

89. Whitworth, *Special Report,* p. 389.

90. Hutton, *We Too,* p. 44.

91. *Ibid.*, p. 161.

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Fig. 1: Wharncliffe Viaduct: J.P.M. Pannell, *An Illustrated History of Civil Engineering,* London: Thames and Hudson, 1964, p. 121.

Fig. 2: American Timber Trestle Bridge: Samuel Manning, *American Pictures,* London: Religious Tract Society, n.d. (c. 1875), p. 90.

Fig. 3: British Locomotive, 1875: John A. Kouwenhoven, *Made in America,* Garden City, New York: Doubleday & Company, 1948, f. p. 48. Kouwenhoven drew the illustration from *Scientific American Supplement,* no. 27, July 1, 1876.

Fig. 4: American Locomotive, 1875; John A,. Kouwenhoven, *Ibid.* f. p. 48. Kouwenhoven drew this illustration from *Railway Journal,* November 17, 1876.

Fig. 5: 1907 Rolls Royce: Gianni Marin and Andrea Mattei, *The Motor Car: An Illustrated History,* New York: London House and Maxwell, 1962, p. 59.

Fig. 6: 1907 Model T Ford: Gianni Marin and Andrea Mattei, *Ibid.*, p. 57.

REPRODUCTIVE BIOLOGY OF *PODOPHYLLUM PELTATUM* (BERBERIDACEAE): The Comparative Fertility of Inter-and Intra-populational Crosses

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Podophyllum peltatum L., the May Apple, is a common member of the Spring flora of deciduous forests of Eastern North America. The distinctive form of the plant is relatively well known even by people who have only a passing acquaintance with these forests in the Spring. Interestingly enough, little or no information is available concerning the reproductive biology of the species, even though, as has been pointed out by Meijer (1974), it has great potential economic value, particularly in the area of cancer research.

The junior author has been interested in the floral biology, cytology, and sexual reproduction of the species, and encouraged the interest of the senior author. An experimental breeding program was established in the Spring of 1973 and continued in 1974, to determine the role of sexual reproduction in the species as represented by selected populations in Southwestern Wisconsin and adjacent Minnesota. The preliminary data concerning inter- and intra-populational crosses is presented here.

MATERIALS AND METHODS

For the experimental crosses, glassine envelopes, marked with indelible ink were placed on floral buds prior to anthesis. The design for the crosses called for these plants to be divided into four experimental groups. One group consisted of individuals whose flowers were not further disturbed after bagging, and another consisted of individuals whose flowers were destaminated and rebagged. The other two groups consisted of individuals used for the intra- and inter-populational crosses. The success of the crosses was measured by the number of seeds produced.

For the cytological work, floral buds at an appropriate stage of development were placed in a modified Carnoy's solution consisting of chloroform, absolute ethanol and glacial acetic acid (4:3:1). After approximately 24 hours, the buds were placed in 70% ethanol and stored in a refrigerator until utilized. Cytological preparations were made utilizing the squash technique and 1% aceto-orcein in 45% acetic acid.

Stamens were removed from the flowers of randomly selected individuals at anthesis for the pollen sterility analyses in the populations utilized for the crossing experiments. The pollen was stained with 1% aniline blue in lacto-phenol and scored one day after preparation. Approximately 500 pollen grains were scored per slide.

Populational Structure and Locality

The locations of the populations utilized are given in Table 1. One is in Wisconsin and the other in Minnesota. There are three clearly defined populations in the Wisconsin locality and one extended population in the Minnesota locality. We believe that these populations are maintained and expand principally via asexual reproduction and are probably highly clonal. We have also found no evidence of seedlings in these populations and believe it highly unlikely that seedlings can become established within a dense, well established population.

Asexual reproduction in the May Apple is accomplished via rhizome growth. At each node 2 to 3 lateral buds develop and give rise to branch rhizomes. As the rhizomes age, the older parts die. In this area of the country, the leaves appear about 15-20 April, and flowering during the latter part of May. Exposure, elevation and slope directly affect these dates. The plants undergo chlorosis and desiccation 4-6 weeks after flowering. If a fruit has developed, it remains attached to the dry, but standing plants until about the middle of August.

The May Apple is definitely insect pollinated in this area of its range, although it is unknown at present whether there exists a specific mechanism. Several protracted periods of observation recorded visits by the common bumble bee and honey bee. Insect pollination and the tendency for protandry, indicate that the species has tended to an outcrossing breeding system. The fruits are the means of dispersal for this species. It is probable that several to many seedlings start as a clump from successfully dispersed fruit and that competition between the seedlings eventually eliminates all but one or a few. This kind of situation was observed over a 3 year period by Gleason and Cronquist (1964).

Experimental Crosses

The experimental crosses were designed to test the hypothesis that inter-populational crosses would be more fertile than intra-

TABLE I. LOCALITY OF MAY APPLE POPULATIONS UTILIZED AND RESULTS OF THE EXPERIMENTAL CROSSES AND POLLEN-STERILITY ANALYSIS.

Population	Intra-populational Crosses						Inter-populational Crosses						Pollen Sterility %			Locality
	1973			1974			1973			1974						
	S*	Avg. # Seeds	Range in Seed #	S*	Avg. # Seeds	Range in Seed #	S*	Avg. # Seeds	Range in Seed #	S*	Avg. # Seeds	Range in Seed #	N+	% Sterile	% Range	
I	7	1	0-3	20	16.3	0-59	14	32.5	14-48	30	31.9	13-64	15	2.5	0.4-4.9	N end of woods at E side of Kothe's Woods Wayside. 10 mi. SE of La Crosse, on Hwy. 14.
II	6	1.6	0-5	15	0.0	0	15	31.3	24-45	20	36.7	30-46	15	9.6	3.8-21.5	In middle of the Woods E of Kothe's Woods Wayside.
III				20	0.1	0-3	15	28.9	21-44	20	35.3	30-58	15	1.5	0.0-4.1	S end of woods east of Kothe's Woods Wayside.
IV				25	0.0	0				24	30.3	28-53	22	3.5	0.4-8.9	Woods W of Hwy. 26, 2.2. mi. S of Root River Bridge between La Crescent and Brownsville, Minn.

*S = the number of individuals utilized in the cross.

+N = # of individuals sampled; approximately 500 pollen grains scored per individual.

populational crosses, as measured by the number of seeds produced. The assumption is that many individuals in a May Apple population are genetically identical due to asexual reproduction, and that this should lead to low fertility in individuals randomly selected for intra-populational crosses, particularly if there exists an incompatibility mechanism. The results reported in Table 1, where all of the inter-populational crosses are grouped without regard to the actual pollen source, tend to support this assumption and hypothesis. The differences between intra-populational and inter-populational crosses are clearly significant. In population I, which is heterogeneous in having three broad extensions from a central area, rather than an area with a rather definite circular perimeter as in most populations, several individuals did show high seed set in 1974. However, the pollen source utilized for the crosses in 1974, came from one of the extensions of that population and was utilized in all the other parts of the population. In 1973, crosses were carried out in only one portion of the population. This population I probably represents 3 original populations that have become sympatric via rhizome growth. All seeds recovered from the crosses had full contents, although there were often differences in size.

None of the individuals whose flowers were bagged and not further molested, or destaminated and bagged, produced fruit. This demonstrated that self-pollination, if it occurred, does not lead to fruit production and that apomixis does not occur in these populations. The pollen analysis, also reported in Table 1, demonstrated that most of the populations produced a high percentage of fertile pollen. The reasons for the lower fertility of pollen produced in population II is unknown at present. All meiotic divisions observed during the cytological analysis appeared normal. The haploid number of 6 was confirmed for each population.

DISCUSSION

Podophyllum peltatum has apparently evolved a definite life strategy. As a member of the Spring flora, it utilizes the time between Spring growth initiation at these latitudes and the time when leaves are fully developed on the dominant deciduous tree species of its habitat, to complete most of its life cycle. The time in question in the area of study is not very long (from about mid-April to about the beginning of July) but during that time the plant produces enough photosynthate to permit flowering, fruiting, and the growth of new rhizomes, from which to initiate growth the following Spring. This is a great deal of activity during a relatively short period of time.

In terms of populational maintenance, the May Apple has apparently invested heavily in asexual reproduction. The populations, therefore, once established, continue to exist and grow mainly through rhizome growth. The role of sexual reproduction in this species apparently lies in permitting the recombination of genes necessary for the long-term survival of the taxon by providing enough diversity in genotypes to permit adaptation to changing environmental conditions over the long run. In the May Apple, sexual reproduction also provides for dispersal of the species, as the structure that acts as the disseminule is the fruit. This situation is very much akin to that in *Nelumbo pentapetala* (Walter) Fernald, the American lotus, (Sohmer, 1976), of a very different habitat.

The May Apple approaches anthesis at a time when there is probably competition among insects for plants, rather than vice versa (Mosquin, 1971). As the species is insect pollinated and tends to protandry, the direction for sexual reproduction appears to be to maximize outcrossing between populations. The fact that inter-populational crosses were so significantly more productive of fruit and seed than intra-populational crosses tends to indicate that sexual reproduction serves a limited but significant long-term role in *Podophyllum peltatum.*

SUMMARY

Podophyllum peltatum is a Spring-flowering herb common in the deciduous forests of Eastern North America. The populations are maintained asexually via rhizome growth; and populations appear to be highly clonal. The present study seeks to elucidate the role of sexual reproduction in this plant and this report demonstrates the low fertility of intra-populational crosses as compared to inter-populational crosses. This evidence, the tendency to protandry, and the closed environments that an established May Apple population presents to its own seedlings have led us to consider sexual reproduction in the May Apple as a means to dispersal and to long-term adaptation to changing environments, rather than as a means to the immediate reproduction of the species.

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THE BIGNON DYNASTY 1649—1788: A STUDY IN OFFICIAL PATRONAGE

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In the closing decades of the Seventeenth Century the economic situation of French scholars, scientists, and men of letters was at best a precarious one. It was virtually impossible to earn a reasonable living from one's pen, if one tried to produce works of sound scholarship and literary value. The savant who lacked inherited wealth or a profession that could bring him a comfortable income usually had to support himself by a more humdrum occupation. Fortunately, several career options were then open to the aspiring scholar. He might enter the Catholic church and seek a comfortable sinecure; he might enter the royal bureaucracy as a junior civil servant; or he could solicit a post in a library or a learned academy.

Still another source of income open to impecunious savants was the patronage of great noblemen and wealthy officials. Many magistrates considered it one of the duties of their station to have a man of learning attached to their household. They expected these captive men of letters to earn their keep, however, by extravagantly praising a patron in prose or verse. The scholars' writing and scientific investigations were usually rewarded with generous cash payments or pensions.

Typical of the aristocratic families that took pride in subsidizing the "Republic of Letters" was the Bignon family, a dynasty of academicians and magistrates who administered the royal library for a century and a half prior to 1789. The Bignons proudly traced their descent from Jérôme I, 1589-1656, the "Cato of his Day," who began his career as a tutor to Louis XIII, and rose to become Advocate General of the Parlement of Paris and Master of the King's library.[1] A meticulous scholar in his own right, with a half dozen books to his credit, Jérôme Bignon was the friend and patron of most of the leading intellectuals of his day. He was always quick to produce a thoughtful and encouraging critique of a new work, to drop a word of recommendation in the right place, or even to provide small sums of money that would enable a writer to finish his book. No one understood more clearly than he the necessity of rendering financial assistance to "talented young men without fortune."

To his contemporaries Jérôme personified the ideal of the scholar magistrate, a "virtuous" official who knows how important learning is for the proper exercise of political power. His sons, Jérôme II and Thierry, were among the first pupils enrolled at the Jansenist "Little School" at Port Royal des Champs where they acquired a genuine enthusiasm for books and learning. Both brothers figured prominently in the intellectual life of the capital, Jérôme II as Master of the Royal Library and Thierry as a wealthy and generous magistrate who served for a time as dean of the faculty at the Sorbonne. Their father spared neither advice nor his own austere example to keep his sons and other young men of their class on "the path of honor and virtue." For many years he conducted a literary and historical seminar in the library of his mansion at Paris "for brilliant young men of good family".[2]

Understandably, the fame of these modern Maecenii attracted many promising young men to their service. Typical of those savants whose careers benefited from their association with the Bignons was the orientalist Antoine Galland, a native of Picardy.[3] Galland came to Paris at an early age and eked out a meager living as a teacher and translator. He soon attracted the attention of the Bignons who assisted him in securing the post of royal antiquarian and later secretary to the French Ambassador to Constantinople. In 1694 Thierry Bignon appointed Galland curator of his rich collection of books, coins, and medals.[4] Galland was also provided with a small apartment in the family's spacious mansion on the Rue Saint Augustin where he regularly mingled with the intellectual elite of robe society who met each Thursday in the Bignons' famous salon. In the fashion of the day Galland composed and dedicated to his patron a delightful little volume, entitled *Paroles remarquables, bons mots et maximes des Orientaux* (Paris, 1694).

After Thierry's death in 1697 his nephew Jean-Paul Bignon found a place for Galland among the 36 members of the newly reorganized Academy of Inscriptions. Galland repaid this new patron by designing a medal commemorating his brother's (Jérôme III) service as Provost of the Paris Merchants, the Civil Mayor of the Capital. Profoundly grateful for their generosity, Galland remained closely tied to the Bignon family for the remainder of his life.

By the turn of the century the Bignon family patronage was largely in the hands of Abbé Jean-Paul, the third son of Jérôme II and of Suzanne Phelypeaux who was a sister of Chancellor Pontchartrain.[5] Jean Paul was an Oratorian priest and a Court Preacher to Louis XIV. Under his uncle's tutelage, the little Abbé assumed general responsibility for the direction of the official academies and later of the Royal Library. His orders were to recruit the finest minds of the day and to encourage them to undertake socially useful research. To Louis XIV and his great ministers Colbert and Pontchartrain these academies were a justifiable expenditure of public funds "because of the utility which the state can derive from them.[6] Consequently, the royal pension lists were large and fairly lucrative.

Members of the academies of Science and of Inscriptions drew annual stipends ranging from 3600 to 4000 livres, depending on their rank, seniority, and reputation.[7] Funds for instruments and experimentation were also placed at their disposal. Additional sums might be earned by working on special projects for the government such as the improvement of the engineering of the fountains at Versailles or the invention of a military weapon. "The budget for all these scientists hovered around 30,000 livres in the 1670s," and gradually rose to 50,000.[8] All of these men holding academic appointments were both personally and favorably known to Bignon and his uncle, Chancellor Pontchartrain.

This great magistrate and his nephew resolved to infuse new life into the moribund Academy of Science "so that it might enhance the intellectual prestige of the monarchy." On their advice the King agreed to send teams of scientists to study the customs, geography, botany, and minerals of several lands that were little known to European savants. Seizing this opportunity, Bignon proposed his protege Joseph Tournefort as one of the first recipients of such an award. The Abbé accompanied his friend to Versailles and had his uncle present Tournefort to Louis XIV.[9] Tournefort showed his gratitude for this patronage by naming a hitherto unidentified group of plant after Bignon, the Bignoniaceae or the trumpet creeper family.

A few years later Bignon befriended the naturalist René Réaumur and arranged for his election to the Academy of Science at the early age of 24. Réaumur soon became a dominant figure in French science and hardly a year passed that he did not announce some new discovery in meteorology, animal physiology, or entomology. After this time also Bignon asked his friend, Bernard Fontenelle, to edit the Academy's proceedings and to act as its Perpetual Secretary at a handsome salary. The Academy of Science, under Abbé Bignon's capable leadership, became the most influential scientific society in Europe.

For nearly forty years Abbé Bignon dominated the elections to the Academies of Science and of Inscriptions. Ostensibly, the academicians selected three candidates for each vacant post in their ranks and Bignon recommended his choice to the King. In fact, however, the Abbé frequently had to conciliate opposing factions of scholars in order to persuade them to elect the best qualified candidates. On more than one occasion Louis XIV complained bitterly to Bignon that the jealousies and quarrels of the academicians were disrupting the intellectual life of the nation.

Bignon also controlled the patronage positions in the King's library whose Grand Mastership was generally regarded as "the foremost position in the world of letters." In 1740 he was succeeded as royal librarian by his nephew Jérôme IV whom he had personally trained for this "true profession".[10] Unfortunately, this promising young man died just seven days before his uncle. The charge of royal librarian, the family membership in the great academies, and a place in the royal council then passed with the king's approval to another nephew, Armand Jérôme, who held these posts until 1770.

Armand Jérôme Bignon was a lawyer and administrator by profession with a decade of increasingly responsible service in the royal bureaucracy.[11] He had inherited his uncle's literary tastes and he now devoted his energies to enlarging the rich collections of the *Bibliothèque du Roy* which proudly claimed the "first rank among the scholarly libraries of Europe." Bignon carried on an extensive correspondence with scholars and officials in India and China in order to acquire important works published there. French diplomats were urged to ferret out rare tomes for their national library, and travelers were commissioned to acquire all materials of a scholarly nature. The peripatetic orientalist Abraham Anquetil-Duperron, who brought back many Indian books to France, was rewarded with an appointment as Interpreter of Oriental Languages at the Royal Library. Other travelers were rewarded with sums of money or extensive library privileges.

Nor was this all. Each year Armand Jérôme set aside a portion of the library budget to subsidize indigent scholars (talents sans fortune)who used the library for their research. Many of these savants gathered weekly in the drawing room of Bignon's spacious mansion on the Rue Vivienne where they exchanged ideas, literary opinions, and new scientific information. As a sign of his gratitude for the many favors lavished upon him by this generous family the aging tragic poet, Prosper Jolyot de Crébillon, dedicated his last play to Angélique Bignon, "the wise and enlightened" wife of his benefactor.[12]

The fifth and last generation of Bignons to subsidize the "Republic of Letters" was headed by Jérôme Frédéric, a lawyer and parlementary councillor, with a strong taste for literature, who assumed the direction of the Royal Library in 1770. At 23 years of age, Jérôme V thus found himself master of the largest library known to Europeans since the destruction of the Serapeum in ancient Alexandria.[13] His staff consisted of a distinguished corps of scholars, linguists, and academicians, "dedicated to the service of the public." This was an age of plural office holding and many of the library's top officials held an additional post in a learned academy, a chair at the College Royal, or even an appointment as a royal censor. It was also a dynastic age and there were numerous relatives on the library staff, most notably the two Barthélemys in the cabinet des médailles (Jean Jacques and his nephew André), the two Capperonniers (Jean and Jean Augustin) in the department of printed books, and their erudite cousin Francois Béjot. All of these offices were dependent upon the backing of some great magistrate (like the Bignons) who would intercede with the king or his ministers on the applicant's behalf.

In this aristocratic society family connections were all important and the Bignons used their influence effectively "to promote the progress of learning in France." They were, on the whole, thoroughly conscientious magistrates who aspired to be intellectual leaders as well as administrators. Piety and probity were mingled in their character with "an hereditary passion for learning." They consistently used their wealth and influence to advance the careers of countless young scholars and scientists who were struggling to make their way upward in this highly stratified society.

NOTATIONS

1. For information on the Bignons' ancient lineage see a "Mémoire généalogique de la famille de Bignon. Branche de Paris," in *Bibliothèque nationale*. Dossier bleu 96 fol. 3 vo. — 5 vo. An official copy of their coat of arms may be found in Manuscrits français 32,353 fol. 171-173. Both of these documents, which contained proof of noble status, were required for admission to the middle and higher robe offices.

2. Claude Le Peletier, one of the members of this elite seminar, has provided us with a most reliable source of information on Jérôme I in two "Mémoires", now in the *Bibliothèque nationale*. Manuscrits français 9549 fol. 166-181 and 203-216 vo.

3. The two best biographies of Antoine Galland are : Mohamed Abdel-Halim. *Antoine Galland, Sa vie et son oeuvre* (Paris, 1964) and Raymond Schwab *L'auteur des mille et une nuits, vie d'Antoine Galland.* (Paris, 1964)

4. Galland's relations with the Bignons are discussed at length in his "Journal Parisien (1708-1715)," which has been printed in the *Mémoires de la Société de l Histoire de Paris et de l' Ile-de-France.* XLVI (1919): 1-135. Passim.

5. Abbé Bignon's distinguished career as a patron of savants and scientists is outlined in Jack A. Clarke "Abbé Jean-Paul Bignon: Moderator of the Academies and Royal Librarian" *French Historical Studies* VIII (Fall, 1973): 213-235.

6. *Le Mercure Galant* July, 1687, p. 34

7. These pension lists, entitled "L'État des Sommes que le Roy veut et ordonne estre payées par le garde de son Trésor Royal à ceux qui composent les académies des Inscriptions et Médailles et des Sciences par gratification" may be found in *Bibliothèque nationale* 22,225-22,226. Annual lists scattered throughout these collections (fonds).

8. Roger Hahn. "Scientific Careers in XVIIIth Century France." Paper read before the Summer Meeting of the British Society for the History of Science, Leeds, July 4, 1974. p. 7.

9. Georg B. Depping, comp. *Correspondance administrative sous le règne de Louis XIV.* (4 vols., Paris, 1850-55) IV, 615-616.

10. Jean-Paul Bignon to M Herault, Oct. 13, 1735 *Bibliothèque nationale* Manuscrits français 22,236 fol. 24.

11. On the details of his career see Louis Dupuy "Éloge de M Bignon" *Histoire de l'Académie royale des Inscriptions et Belles-Lettres* (Paris, 1780) (XL: 187-197 and *Bibliothèque nationale)* Dossier bleu 96 fol. 5 vo.

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PRELIMINARY REPORT ON THE TOTAL SEASON RAGWEED POLLEN COUNT IN AN URBAN AREA

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ABSTRACT

A study of the total season ragweed pollen count was undertaken in the metropolitan area of Green Bay, Wisconsin. Samplers were arranged so as to avoid the main high but isolated pollen concentrations from urban sources, and therefore the count recorded represents in the main the urban background count during the 1972 pollen season. Marked variation in this total season count was found over the geographical distribution of the population. A preliminary survey of local ragweed growth indicates that rural oat fields dominate in the production of pollen contributing to the urban count. Improvements in community pollen monitoring are suggested, and it is proposed that the pollen count together with associated data can be used to help relieve the impact of this aeroallergin on the community.

INTRODUCTION

Ragweed pollen is now recognized as an air pollutant contributing widely to a variety of health problems (Hewson, 1967; Finkelstein, 1969). It is estimated that between two and ten percent of the population suffers from this aeroallergin where growth of ragweed is prevalent (Broder et al., 1962), and as many as forty percent of those who suffer from hayfever may eventually develop the more serious malady of asthma (Huber, 1931). Ragweed pollen is the major member of a number of air borne substances of biological origin known to cause allergic responses in sensitized individuals. Certain fungal spores, rusts, and pollens from trees and grasses among others are also aeroallergins which have a somewhat similar but generally lesser impact on the population.

In ragweed sensitive individuals, symptoms usually begin at concentrations between 10 and 100 grains per cubic yard of ambient atmospheric levels of pollen. The degree of response can also depend on the history of exposure and probably on pollen concentrations in only an approximately linear fashion (Solomon, 1967). Nevertheless, a general correlation between the daily progress of the hayfever season and symptoms does seem to exist in those susceptible (Freedman, 1967; Brown and Ipsen, 1968).

Short ragweed (*Ambrosia artemisiifolia*) is the most common of the ragweeds in Wisconsin and is distributed widely and in high concentrations throughout the state except for the majority of the northern third of its counties (Payne, 1970). It generally occurs on disturbed soils. Here it is among the first plants to prosper, but is rapidly succeeded in following seasons by others unless the soil is again disturbed. It thus is most frequently associated with agriculture where it is found in greatest abundance in cereal grain fields (Gebben et al., 1962). It can also be found in areas such as roadsides, river banks, and vacant lots. Wherever established the total potential for pollen production can vary widely from season to season depending on spring and early summer climatological conditions. Although such factors as rainfall and temperature correlate with productivity (Hewson, 1967), no dependable predictor formula of the severity of the pollenosis season has as yet been discovered.

The pollen season in Wisconsin normally extends from mid-August to mid-September, peaking about September 1. Total day-to-day concentrations can vary considerably from the general smooth trend that would occur if daily meteorological conditions were similar throughout the season. Available solar radiation, wind speed, and humidity particularly can have a major influence on the daily count (Sheldon and Hewson, 1962). Usually strong and dry southwesterly winds cause large counts, although no suitably predictive relationship, except in a rough qualitative sense, has been found between weather and the daily pollen count (Hewson, 1967).

Most of the pollen leaves the plant between sunrise and late morning. Concentrations usually reach a maximum before mid-day and are relatively low in evening hours. Though most air borne pollen returns to the ground near its source, a small percentage reaches altitude above surface obstacles. From here it may travel long distances and major sources can cause significant concentrations over large areas, especially under conditions of strong wind. On the downwind side of a source, concentrations can be several orders of magnitude larger than the background count, which can average between several grains to several hundred grains per cubic meter (Raynor and Ogden, 1965).

Community ragweed monitoring programs usually consist of a single station and although more quantitive samplers are available, the Durham sampler is still the most common instrument used (Ogden et al., 1974). Some attention is usually paid to sampler location, and most are placed centrally in the community, some distance from any known major pollen sources. Although there is some evidence (Shapiro and Rooks, 1951) of variation of total season pollen counts within an urban area, little is known about the representativeness of the central sampler's count with respect to the count over the general distribution of the population. Therefore there is no widely accepted criterion on what constitutes the "urban pollen count" in a particular community. The single sampler merely serves to indicate what the pollen count has been at one location and the general progress of the season. However, usually no general guidance is given to possible future counts by particular meteorological forecasts or to the dependence of exposure levels on other factors such as location within the urban area. Such information supplementing medical treatment for pollenosis and an effort to eradicate ragweed can reduce the impact of this aeroallergin on the community.

This paper presents a preliminary study of the total season outdoor pollen count of ragweed pollen throughout an urban area of moderate size. The results were recorded with a standardized mass sampling system located so as to record the urban background pollen levels, but to avoid high counts near local sources. The distribution of the count so obtained is related to the geographical distribution of the urban population. Considerable systematic variation of the pollen count is observed and it is found that rural sources here are largely responsible for it. On the basis of these results improvements in the procurement and use of the urban pollen count are suggested.

The study was carried out in Brown County in Northeastern Wisconsin. The county's population of approximately 150,000 is predominantly located in the moderately industrialized Green Bay metropolitan area, where it is distributed in high concentrations along the shores of Green Bay and along the Fox River entering the bay. Extensive farming is carried out in the rural area; major crops are hay, corn, and oats. Clinical data from the community indicate that pollenosis is frequently severe here during the ragweed pollen season.

METHODOLOGY

Ragweed Pollen

To obtain the geographical distribution of the community's average daily pollen concentration, a system of 25 sampling stations was located so as to form a roughly square grid pattern over the 75 square miles containing the major population. Placement of samplers was avoided near major sources of urban ragweed. This was readily accomplished except for urban outskirts adjacent to major farming acreage. The study avoided sampling near major intra-urban ragweed fields so as to obtain data representative of the bulk of the urban population. In addition, sites were chosen as far as possible from buildings and streets and other topographical features which have a major effect on the flow of air.

Because of its low cost and ease of use, the Durham sampler was chosen for monitoring most stations (Durham, 1946). To improve comparability of sampling stations, all instruments were oriented so that the horizontal slides faced the same direction and were five feet above ground level. Slides were changed in all samplers daily between August 20 and September 15 in the hours 6:00 and 10:00 P.M., a period during which the atmospheric pollen density is low. Roto-Rod samplers (Harrington et al., 1959), which are more accurate, were employed simultaneously at three of the urban stations in order to test the comparability of data from the Durham and Roto-Rod samplers.

All pollen samples were collected with standard impregnating materials (Karau, 1970). A 2.25 cm^2 area was read at a 150x magnification under a standard microscope and the counts converted to grains per cubic yard per day. The collecting slide area counted, together with the average density of pollen grains during the season, indicated a statistical counting error considerably smaller than errors introduced by the sampling method. Data on the pollen index are reported as the average number of grains of pollen per cubic yard per day of the season. All species of ragweed pollen were included in the count. Data on wind speed and direction were obtained from two meteorological stations located on opposite sides of the urban area. The stations are approximately 12 miles apart and lie on a northeast-southwest line which roughly bisects the populated area. The southwest station is a U. S. Weather Bureau facility, and the northeast station is run by the University of Wisconsin-Green Bay.

Population

To determine the spatial distribution of population in the Green Bay metropolitan area and its surroundings, a map of a region, 10 miles by 10 miles, was constructed based upon range and township divisions. The region was divided into 400 grid sections, each 0.5 by 0.5 mi. From the U. S. Bureau of the Census 1970 Block Statistics, the total population in each grid was determined, assigning population proportionally where blocks appeared in more than one grid section. Additional data on non-residence location of the population during occupational and recreational activities were obtained from local government agencies.

Ragweed Pollen Sources

Ragweed sources within the urban area were located largely with the use of plat maps. The major extent of ragweed growth, however, was determined with the aid of the Wisconsin Farm Statistics which gives farm crop acreage according to township, village, and city divisions. Data on the expected ragweed plant densities according to land use were obtained from the land use categories of Sheldon and Hewson (1962), and from direct observation in this area.

RESULTS

Population

The population distribution of the Green Bay metropolitan area shown in Fig. 1 was found to approximate roughly a relatively high density T-shaped figure, oriented in the north-northeasterly direction of the Fox River with the figure's head on the bay. This area is surrounded by an outer region of lower population density. The average population density in grid cells with non-zero population was about 1800 persons per square mile, with a maximum density of about 15,000 persons per square mile in two central city areas. Employment location data indicate that during weekdays higher population densities exist in the central T, especially along its top portion. Recreational activities tend to increase population densities in the outer region. The location of the geographical residential population center is indicated at the base of the 50 grains per cubic yard isopleth.

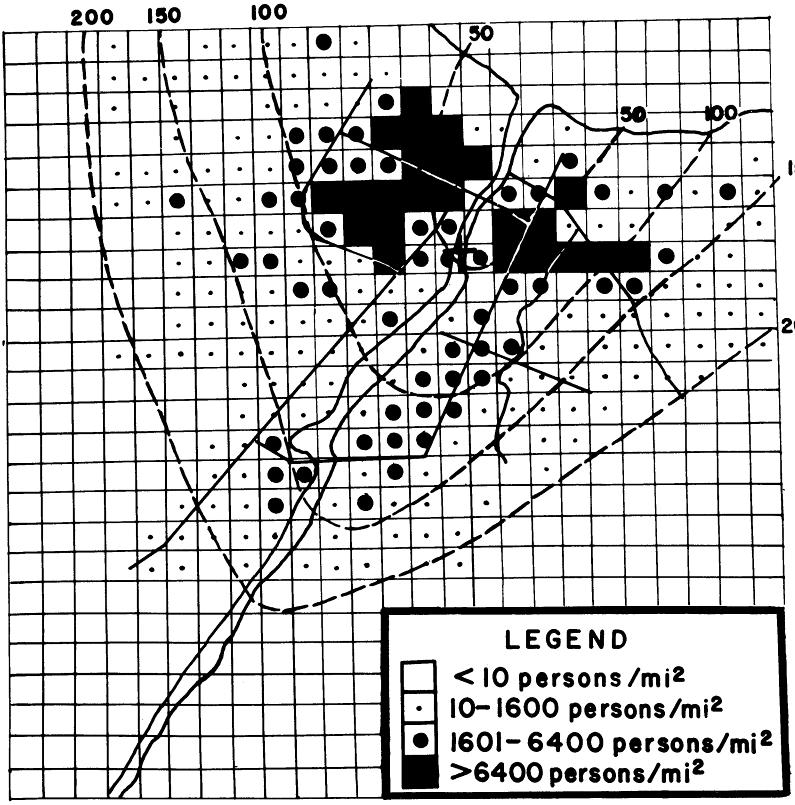

FIGURE 1. The geographical distribution of population and average pollen counts in the greater Green Bay metropolitan area, in terms of the total population within 0.5 by 0.5 mi. grid sections. The pollen count distribution is represented by lines of constant count as average daily concentrations in grains per cubic yard. The geographical population center is indicated by the + at the lower portion of the 50 grains per cubic yard isopleth.

Ragweed Pollen

Figure 1 also shows the geographical variation of the average daily pollen count (the total 1972 season count at each site divided by the number of sampling days). In order to bring out the general pattern of variation within the city, curves have been drawn representing constant, total seasonal pollen levels. These isopleths represent mean daily counts in pollen grains per cubic yard, and are independent of major influences from urban sources which contribute only slightly to the general background count. Isopleths near the fringes of the urban area are especially noncontinuous as the incidence of major sources is large here.

Data obtained from the Durham samplers were compared with those from Roto-Rod samplers at three sites. These analyses indicate that the Durham slides give only a gross measure of day-to-day variation. This supports observations by others (Ogden et al., 1974). Nevertheless, total season counts are fairly accurately recorded with the ratio between Durham and Roto-Rod total seasonal counts holding to within 5% of the average for the three comparison sites. The absolute seasonal pollen concentration scale used in Fig. 1 is derived from this proportionality.

The variation in ambient air levels of ragweed pollen over the geographical distribution of population has several features of note. In general, the pattern shows a rapid decrease in pollen concentration from rural areas toward the geographical center of population. For purposes of comparison of concentrations, a population-density-weighted seasonal pollen count average was calculated and was found to equal 105 grains per cubic yard per average day. Areas near the city population center have less than half of this weighted average, while pollen levels near the edge of the city have nearly twice this average. Few samplers were placed deep in the low population rural areas, but two placed in rural villages of less than 100 population recorded seasonal averages of more than three times the population-weighted average of the Green Bay metropolitan area. One sampler placed less than 150 feet from the northeast corner of an urban oat field recorded more than twice the seasonal background count in that area.

As observed by others (Sheldon and Hewson, 1962) in the Midwest, a major portion of the pollen arrives at the samplers from the west through southerly directions due to both higher wind frequencies and more propitious pollen release conditions, when the winds are from these directions. For the 1972 season more than 60% of the count averaged over the urban area occurred during these conditions.

Ragweed Pollen Sources

As expected, the approximately two dozen rural townships surrounding the Green Bay metropolitan area contained by far the greatest concentration of ragweed plants. Plant densities in villages and cities overall were less than 0.1 those in rural townships. In and near the higher population areas of the metropolitan area the densities were usually less than 0.03 those in rural areas. Hay and corn constituted approximately 25% each of the cropland in both the townships and other areas. However, preliminary results indicate that oat fields which account for about 15% of the cropland have a much higher density of ragweed growth and may produce as much as 80% of the ragweed crop in the area. Possible variable plant vigour, the effect of plant environment on pollen dispersion and crop cutting practices are unlikely to affect the conclusion that rural oat fields cause most of the atmospheric pollen in this urban area.

DISCUSSION

The results of the study indicate that the average daily outdoor ragweed pollen count varies markedly over the geographical distribution of population in the community studied. The pollen count distribution, which could be characterized in a simple way by isopleths, together with the population distribution data suggest improvements in both the methods of pollen count monitoring and advice to the allergy patients.

In the establishment of a ragweed pollen monitoring system for whatever purpose, the single site sampler in a community would not appear to be sufficent by itself to characterize the urban pollen count. The centrally located urban pollen samplers will probably record too low a count for much of the population, if the community population is distributed in a fashion similar to that in the present study. Here the central city sampler recorded only half the population-weighted count. This makes comparisons between urban counts as a measure of the severity of the season within that area and between different areas somewhat misleading. The size of the count depends significantly on the distance of the sampler from the dominant rural sources, particularly those in the westerly to southerly directions from which a major portion of the pollen arrives in the urban area. Additional samplers located in other representative areas would improve the accuracy of the count. If only a central urban sampler is used, some comments about likely levels in other regions of the city could be made after preliminary study of this type. Better accuracy in daily counts could also be achieved by replacing the Durham sampler with a more quantitative device such as the Roto-Rod sampler.

The additional information to be gained from these sampling improvements can be useful to the ragweed allergy patients in terms of the location of their activities in the urban area. However, care must be taken in advising patients on the basis of this discovery of marked geographical variation of the total seasonal pollen count. The count is not necessarily proportional to the influence of the aeroallergin, even assuming that the total seasonal count itself can be used as a guide to human response. Many patients spend a major portion of their day, especially during peak daily pollen concentrations, within buildings where the pollen count is lower than outdoor levels. However, the fractional reduction is less as the count increases (Benson et al., 1972). Thus it would appear that there is less importance to be attached to urban location for patients who spend a major portion of their time indoors than would be indicated by the outdoor pollen count variation in the urban area concerned. For those whose activities are out of doors the information on pollen count variations with urban location is most useful. Here good advice would be to avoid regions near the rural areas of the community and significant urban pollen sources. Sheldon et al. (1962) have shown that this is particularly advisable before noon; rural and urban pollen levels tend to equalize, particularly in late afternoon and early evening.

The possible benefit of avoiding high concentrations of pollen so as to reduce the total season exposure has some support from data in this area. Pollen counts taken over a period of twenty years here correlate qualitatively with the severity of the season's pollenosis (Kuehl, 1972). Severe pollenosis symptoms usually occur when the total season count is about twice the average, and milder symptoms when the count is half or less than the average. The total season concentration here varies by at least a factor of two over the major population of the urban area in this study. Thus the avoidance of high counts indicated by the above strategies could have a significant effect in reducing pollenosis symptoms here and in other urban areas.

In summary this study demonstrates a geographical variation in total season ragweed pollen concentrations for an urban community of moderate size. This information supplements other data on expected pollen count variations with time of day and date within the season, and variations due to meteorological conditions. All of these factors can have a major, if not always a quantitatively predictable, influence on the pollen count. Together, however, they provide a reasonable basis for guidance to the general public. It is suggested here that those engaged in single site pollen count reporting consider broadcasting such guidance along with the pollen count. Such a program of information on avoidance of high ragweed pollen counts is now being implemented in the Green Bay area.

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AGE AND GROWTH OF THE WHITE SUCKER IN LAKE WINNEBAGO

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INTRODUCTION

The white sucker, *Catostomus commersoni* (Lacepede), has never attained any value in either the sport or commercial fishery in Lake Winnebago (Fig. 1), a large, shallow, 137,708-acre lake in east

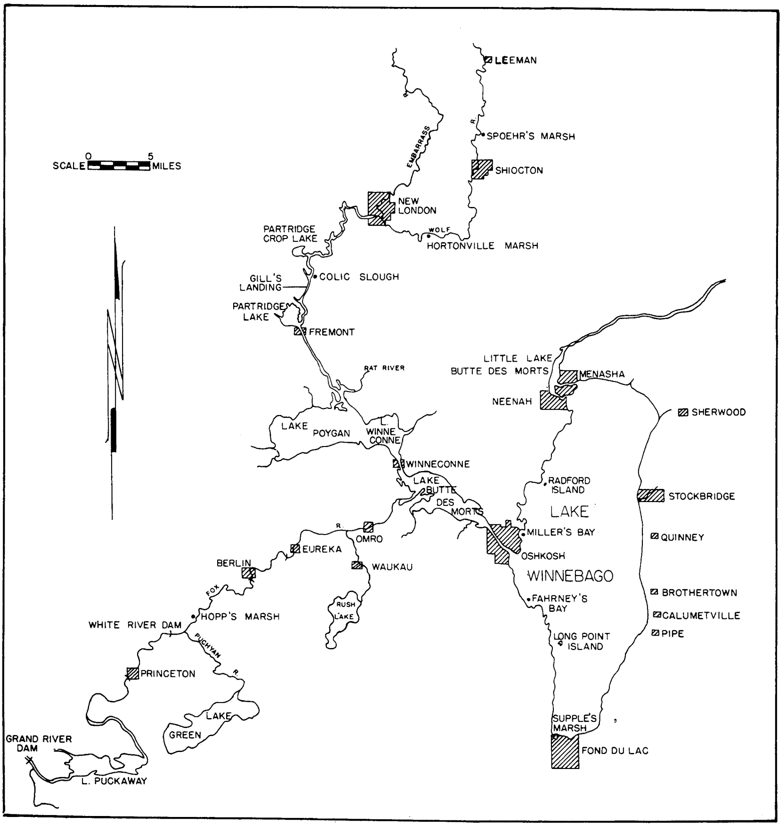

FIGURE 1. Lake Winnebago: area involved in the study.

central Wisconsin (Wirth, 1959). Prior to 1955, no information on the size of the white sucker population in Lake Winnebago was available. In 1954, an accelerated program to remove freshwater drum, *Aplodinotus grunniens* Rafinesque, was initiated along with a study to evaluate the effect of removal on the freshwater drum and other fish species populations (Priegel, 1971). A sample of white suckers was obtained in 1963 to determine age and rate of growth data. Such data for the white sucker in this extensive water area are lacking as well as data for suckers in other parts of Wisconsin.

MATERIALS AND METHODS

The 340 white suckers used in this study were collected during October, 1963 with either 12-foot otter trawls, 30-ft. trawls or AC shocker units.

Total lengths to the nearest tenth of an inch were recorded for all fish. Weight to the nearest hundredth of a pound, sex and degree of maturity were also recorded. Three scales were impressed on cellulose acetate slides by a roller press similar to that described by Smith (1954). Examination and measurements of scales were made with a microprojector at a magnification of 44X. The distance from the focus to the margin of the scale and to each annulus was measured to the nearest tenth of an inch along the dorsoventral diameter as described by Spoor (1938). The validity of the annulus as a year mark for this species was established by Stewart (1926), Spoor (1938), and Beamish and Harvey (1969).

A body-scale relationship was determined from the measurement of 340 white suckers grouped into one-inch total length intervals from 6.0 to 22.9 in. Calculations of length at each annulus were made from measurement of the dorsoventral diameter applied in the formula:

$$L_1 = C + S_1 /S(L-C)$$

where L_1 is the length of the fish at the time of each annulus formation, C is the length of the fish at the time of scale formation, S_1 is the length of the dorsoventral diameter of the scale at each annulus, S is the length of the dorsoventral diameter at capture and L is the total length of the fish at time of capture. Sex and state of maturity were determined for all fish as described by Spoor (1938).

Individual catch reports for each trap net lifted and trawl haul made were maintained by the commercial fishermen and state crews. The number of all other fish species, including the white sucker, were recorded for each individual lift or haul (Priegel, 1971).

RESULTS AND DISCUSSION

Commercial Harvest

The white sucker is not considered an important commercial fish in Lake Winnebago. Prior to 1958, white suckers were included with the freshwater drum when weighed and sold at the dock. In 1958, when the white sucker harvest began to show an increase, the suckers had to be sold separately since the mink ranchers who were purchasing the freshwater drum for mink food did not want the suckers mixed with the drum, since suckers require cooking before feeding to the mink in order to destroy the enzyme, thiaminase, which causes a loss of fur.

The numbers and poundage of white suckers removed with trap nets and trawls continued to increase through 1961 (Table 1).

TABLE 1. THE TOTAL AND AVERAGE CATCH PER TRAP NET LIFT AND TRAWL HAUL OF WHITE SUCKER TAKEN IN LAKE WINNEBAGO DURING THE OPEN WATER SEASON, APRIL-NOVEMBER, 1955-66.

	Trap Nets		Trawls		
Year	Total Number Fish Caught	No./Lift	Total Number Fish Caught	No./Haul	Total Pounds
1955	635	0.2	---	---	*
1956	1,107	0.3	---	---	*
1957	3,556	1.0	363	0.8	*
1958	3,364	0.8	174	0.7	5,049
1959	2,155	0.7	362	0.7	. 9,048
1960	3,726	1.6	2,687	3.5	11,229
1961	3,794	3.1	11,817	4.4	26,174
1962	2,652	2.9	28,191	4.9	13,808
1963	5,289	6.4	28,174	3.4	**
1964	2,815	8.3	28,400	3.6	**
1965	2,419	10.8	27,689	3.9	**
1966	2,243	8.0	7,104	2.1	**
Total	33,755	1.4	135,061	3.4	65,308

* Poundage included with other commercial fish removed
** White sucker returned to the water, no poundage recorded

However, this removal was minor compared to the poundage of freshwater drum removed during this period, 1.9 to 4.4 million pounds annually (Priegel, 1971). In 1962, state commercial fishing crews began to release all white suckers, as the value of this species as a forage fish was considered important to the walleye management program in this lake.

Release of suckers was made even though they were not utilized by walleyes in 1960 and 1961 (Priegel, 1963), during which time the white sucker population was low. Subsequent analysis of adult walleye stomachs in 1962 and 1963 also revealed that they were still not utilizing white suckers.

The walleye fishery in Lake Winnebago is the principal sport fishery (Priegel, 1970). Forage fishes — trout-perch, *Percopsis omiscomaycus* (Walbaum), and emerald shiner, *Notropis atherinoides* Rafinesque — were scarce in 1961, 1962, and 1963; and, it was felt that by returning the adult white suckers, a sizable spawning population could be maintained. Beginning in 1963, all commercial fishermen, state and private, returned the white suckers. Thus the catch rate shown in Table 1 does not indicate the total pounds of white suckers removed after 1961, as individual fish may have been recaptured throughout the fishing season.

Length-Frequency Distribution

The length-frequency range of the white sucker within each consecutive age group from III through VII overlapped so much that the length-frequency method could not be used to determine the age of the white sucker in Lake Winnebago (Table 2). Overlapping was evident for all age groups except I and II. Hile (1936) stated that length is a poor index of age; and this statement is certainly applicable to the white sucker in Lake Winnebago.

Age Composition

The fact that very few young fish, or old large fish were taken complicates this study of age and growth. Only 11 white suckers in age group I, and 12 in age group II (6.7% of the sample) were taken. Likewise age groups VI and VII accounted for only 5.6% of the sample (19 fish). Most of the fish were in age group IV (52.3%). It is very probable that the selectivity of the collecting methods used was responsible for the dominance of age group IV and lack of age groups I and II; however it is certainly not the entire explanation. Fish in these younger age groups should have been taken in the small, fine mesh otter trawls and with the electrofishing gear. A better knowledge of the life history of this species would undoubtedly have resulted in larger collections of these smaller, younger fish. In Muskellunge Lake, Wisconsin, gill nets were very selective and only the larger and more rapidly growing white suckers in the first few age groups were captured (Spoor, 1938)

TABLE 2. LENGTH-FREQUENCY DISTRIBUTION FOR 340 WHITE SUCKERS, LAKE WINNEBAGO, 1963.

Length Interval (inches)	Number of Fish	Average Total Length (inches)	No. Fish by Age group						
			I	II	III	IV	V	VI	VII
6.0-6.9	9	6.8	9						
7.0-7.9	2	7.1	2						
8.0-8.9	-	---							
9.0-9.9	1	9.8		1					
10.0-10.9	1	10.6		1					
11.0-11.9	2	11.8		2					
12.0-12.9	6	12.4		6					
13.0-13.9	4	13.4		2	2				
14.0-14.9	17	14.8			12	5			
15.0-15.9	27	15.6			12	15			
16.0-16.9	75	16.5			23	44	6	2	
17.0-17.9	76	17.4			4	55	15	2	
18.0-18.9	66	18.4			3	42	18	3	
19.0-19.9	44	19.3			2	17	20	4	1
20.0-20.9	7	20.8					3	2	2
21.0-21.9	2	21.3						1	1
22.0-22.9	1	22.4							1
Total	340		11	12	58	178	62	14	5
Percent			3.2	3.5	17.1	52.3	18.2	4.1	1.5

Age and Growth

The body-scale relationship may be expressed as:

$$L = 2.800 + 1.560 (R)$$

where L = total length in inches and R = anterior scale radium in inches X44. The overall body-scale relation is linear.

The average calculated lengths of males and females in different age groups of white suckers gave evidence of differences in growth rate. For this reason, the data for males and females were kept separate (Tables 3 and 4).

TABLE 3. CALCULATED TOTAL LENGTH OF MALE WHITE SUCKER AT END OF EACH YEAR OF LIFE, LAKE WINNEBAGO, 1963

Length Parameters	Number of Fish	Total Length (Inches) at End of Year				
		1	2	3	4	5
Length by age group						
I	6	6.8				
II	6	10.1	11.8			
III	30	6.6	13.6	16.2		
IV	86	6.2	12.4	15.7	16.8	
V	12	5.2	11.5	15.6	16.8	17.4
Grand average calculated total length (inches)	--	6.4	12.6	15.8	16.8	17.4
Increment of average (inches)	--	6.4	6.2	3.2	1.0	0.6
Growth summation of increment (inches)	--	6.4	12.6	15.8	16.8	17.4

TABLE 4. CALCULATED TOTAL LENGTH OF FEMALE WHITE SUCKER AT END OF EACH YEAR OF LIFE, LAKE WINNEBAGO, 1963

Length Parameters	Number of Fish	Total Length (Inches) at End of Year						
		1	2	3	4	5	6	7
Length by age group								
I	5	6.8						
II	6	9.7	12.9					
III	28	6.7	13.9	16.2				
IV	92	6.4	13.5	16.6	18.0			
V	50	6.0	12.2	15.8	17.5	18.6		
VI	14	5.9	11.7	16.0	17.8	18.6	19.3	
VII	5	7.9	11.8	16.1	18.6	19.7	20.6	21.6
Grand average calculated total length (inches)	--	6.4	13.0	16.2	17.8	18.7	19.6	21.6
Increment of average (inches)	--	6.4	6.4	3.2	1.6	1.0	0.8	1.0
Growth summation of increment (inches)	--	6.4	13.0	16.2	17.8	18.8	19.6	20.6

Two estimates of general growth are given in the bottom sections of Tables 3 and 4. One is based on the grand average calculated total lengths and the second, on the summation of the grand average annual increment of length. The present discussion is based on the sums of increments, since this curve should represent the average growth that white suckers might have, if the population was not subjected to selective destruction of individuals with the more rapid growth (Fig. 2).

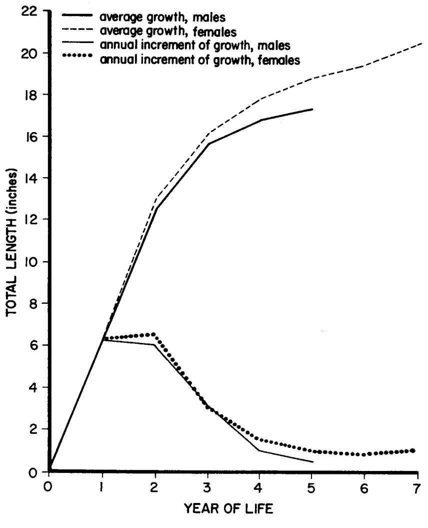

FIGURE 2. General growth in length and annual increment of growth in length of Lake Winnebago white sucker, 1963.

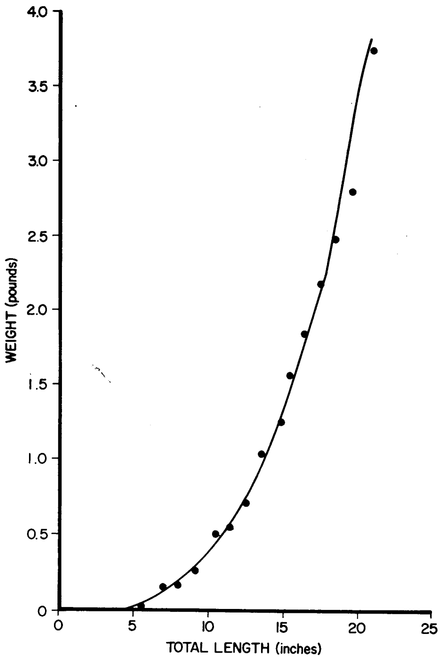

FIGURE 3. Length-weight relation of the Lake Winnebago white sucker, 1963. (Dots represent the empirical data and the smooth curve the calculated data.)

Comments on general growth and a comparison of the growth for the sexes are best made from Table 5 which was prepared from the data in Tables 3 and 4. The total length of the sexes at the end of the first year of life was identical, 6.4 in. At the end of the second year of life, the females had a 0.4 in. advantage; so also at the end of the third year of life. The advantage of the females increased from 1.0 in. at the end of the fourth year to 1.4 in. at the end of the fifth year.

TABLE 5. CALCULATED TOTAL LENGTHS AND LENGTH INCREMENTS OF MALE AND FEMALE WHITE SUCKERS OF LAKE WINNEBAGO IN DIFFERENT YEARS OF LIFE, 1963

	Males		Females		
Year of Life	Calculated Total Length (inches)	Increment (inches)	Calculated Total Length (inches)	Increment (inches)	Size Advantage of Females (inches)
1	6.4	6.4	6.4	6.4	0
2	12.6	6.2	13.0	6.6	+0.4
3	15.8	3.2	16.2	3.2	+0.4
4	16.8	1.0	17.8	1.6	+1.0
5	17.4	0.6	18.8	1.0	+1.4
6	----	---	19.6	0.8	-
7	----	---	20.6	1.0	-

Females not only grew faster, but also lived longer. No age group VI and VII males were taken. In Muskellunge Lake, Wisconsin, females grew in length more rapidly than the males after the fifth year of life (Spoor, 1938). In general, females grow faster, have a longer span of life and are usually larger than males (Schneberger, 1972).

The greatest increase in length for the males took place during the first year of life (6.4 in.) followed by an increment of 6.2 in. during the second year of life. For females, the greatest increase in increment took place during the second year of life (6.6 in.) while during the first year of life, females attained a length of 6.4 in., the same length gain as males. Both sexes increased in length by 3.2 in. during the third year of life and increments of growth for each sex decreased considerably thereafter (Table 5). At the end of the third year of life, males and females had attained 90.8 and 78.6% of their growth, respectively.

Growth of Lake Winnebago white sucker was greater for a given age-group than that reported from other areas of the United States. At the end of the fifth year of life, Lake Winnebago white suckers had attained a length of 17.4 and 18.8 in. for the males and females, respectively. In Muskellunge Lake, Vilas County in northeastern

Wisconsin, white sucker males and females had attained a length of only 8.6 in. (Spoor, 1938). The Minnesota statewide average for this species at this age was 14.9 in. (Kuehn, 1949). The Ohio statewide average at this age was 17.0 in. (Roach, 1948). Female white suckers in Lake Winnebago attained a length of 20.6 in. at the end of the seventh year of life; however, only 4 female fish over 20 in. was taken. The largest female fish was 22.4 in. long.

Age at Maturity

Only those females showing eggs in the ovary were considered mature and the males were considered mature if the testis showed the characteristic whitish-gray color. Since all fish were collected during October, no difficulties were encountered in distinquishing between immature and mature fish.

The average age at maturity was considered as that age at which 50% of the fish reach maturity (Table 6). All male white suckers in age group II (6 fish) were mature and all male fish in the older age groups were mature. Only 6 female white suckers were taken in age group II and 80% were mature. All females in the older age groups were mature.

TABLE 6. SEX COMPOSITION OF AGE GROUPS OF LAKE WINNEBAGO WHITE SUCKERS AND (IN PARENTHESES) PERCENTAGE MATURE, 1963

Age Group	Number of Males	Number of Females
I	6	5
II	6 (100)	6 (80)
III	30 (100)	28 (100)
IV	86 (100)	92 (100)
V	12 (100)	50 (100)
VI		14 (100)
VII		5 (100)
Total	140 (96)	200 (97)

The average total length at which more than 50% of the males are mature is 12.6 in. and it was 13.0 in. for the females. In Muskellunge Lake, Spoor (1938) found that some females matured at age III and 57% were mature at age VI at a length of 9.6 in. He also reported that none of the males matured until age IV (17%) and at age V, 75% were mature at a length of 8.6 in.

Length-Weight Relation

Length-weight relation was calculated from fish grouped by one-inch total length intervals from 5.0 to 20.9 in. There was no significant difference between sexes, so all fish were combined. The length-weight relation of Lake Winnebago white suckers is expressed by the regression:

$$\text{Log } W = -5.5263 + 3.2197 \text{ Log } L$$

where W = weight in pounds, and L = total length in inches.

The agreement of the calculated and empirical weights was satisfactory (Fig. 3). Calculated growth in weight (Table 7) was determined by applying calculated lengths (sum of the average increments of length) of Tables 3 and 4 to the length-weight relation. The annual increments of weight for the males and females

TABLE 7. CALCULATED WEIGHTS AT THE END OF EACH YEAR OF LIFE OF LAKE WINNEBAGO WHITE SUCKERS, 1963

	Males		Females	
Year of life	Calculated Weight * (pounds)	Increment (pounds)	Calculated Weight * (pounds)	Increment (pounds)
1	0.16	0.16	0.16	0.16
2	0.76	0.60	0.84	0.68
3	1.57	0.81	1.70	0.86
4	1.93	0.36	2.31	0.61
5	2.15	0.22	2.77	0.46
6	----	----	3.15	0.38
7	----	----	3.68	0.53

* Weights are from the general length-weight relation and correspond to lengths at the end of year of life on the general growth curve

increased regularly during the first three years followed by a gradual decrease except for females which showed an increase in weight from the sixth to seventh year of life. The annual weight increments for males and females were essentially the same for the first three years after which time the females attained a greater weight advantage. Females at the end of the fifth year weighed 2.77 lbs compared to 2.15 lbs for the males.

SUMMARY

Age determination and growth histories were calculated by the scale method from a sample of 340 white suckers.

Body-scale relation is expressed by the formula:

$$L = 2.800 + 1.560 (R)$$

where L = total length in inches, and R = anterior scale radium in inches X44.

The length-frequency method to determine the age of white suckers in Lake Winnebago was not practical because of great overlapping of the age groups.

Few young fish (age groups I and II) and older fish (age groups VI and VII) were taken. Age group IV accounted for 52.3% of the sample.

Difference in growth rate for the sexes was noted. The advantage of the females increased from 0.4 in. at the end of the second year to 1.4 in. at the end of the fifth year.

Growth of white sucker from Lake Winnebago was greater than that reported from other waters.

The average age of maturity was considered as that age at which 50% of the fish reach maturity. Males and females were considered mature at the end of the second year of life. All males and females were mature in the older age groups.

Length-weight relation is expressed by the formula:

$$\text{Log } W = -5.5263 + 3.2197 \text{ Log } L$$

where W = weight in pounds, and L = total length in inches.

The annual increments of weight for the males and females increased regularly during the first three years followed by a gradual decrease. The annual weight increments for males and females were essentially the same for the first three age groups after which the females attained a greater weight advantage.

ACKNOWLEDGMENT

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A COMPARISON OF THE GROWTH RATES OF BLUEGILL (*LEPOMIS MACROCHIRUS)* IN LAKE WINGRA AND LAKE MENDOTA, WISCONSIN

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ABSTRACT

Adult bluegill grew faster in Lake Mendota than in Lake Wingra. The mean lengths for three-, four-, and five-year-old Lake Mendota fish were 135, 163, and 181 mm, respectively. The corresponding values for Lake Wingra fish were 125, 142, and 147 mm, respectively.

Small fish from the two lakes (one- and two-year-old fish) had similar growth patterns and grew at a rate similar to that of fish from other Wisconsin lakes. The decline in the growth of Lake Wingra fish was attributed to the disappearance of large predators and the successful reproduction of pan fish.

INTRODUCTION

Preliminary observations on fish of Lake Wingra and Lake Mendota suggested marked differences in the growth rates of bluegill. Lake Wingra has been characterized recently as having stunted or slow-growing centrarchids. Thus a comparison between bluegill in the two lakes should be analyzed in relation to the ecology of the lakes. Body growth as determined by annual marks on the scales was used as a basis for comparison. Growth in length and weight at different ages was considered important for later studies. The scale method is a well-established technique (Van Oosten 1929, Hile 1941, Schuck 1949, Regier 1962, Snow 1968, and Stucky and Harold 1971).

Study Sites

Lake Wingra and Lake Mendota are located in Dane County at Madison, Wisconsin. Lake Mendota is the larger lake with an area of 3938 hectares and a mean depth of 12 m. The study area is located in the littoral zone along Picnic Point at University Bay, which supports a bed of aquatic macrophytes dominated by *Myriophyllum spicatum.*

Lake Wingra has an area of only 140 hectares and a mean depth of 3 m. Its aquatic vegetation is dominated by a mixture of *Myriophyllum spicatum* and *M.s.* var. *exalbescens*. While the fish populations of the two lakes do differ, bluegill are abundant in both.

MATERIALS AND METHODS

Fish were collected from Lake Wingra with a bottom trawl (Otter trawl) from the limnetic area. The mouth of the trawl was 5 m wide and 1 m high. Meshes were 3 cm stretch measure. Tows were 20 minutes long at 1 m/sec.

Fish from Lake Mendota were caught in the littoral zone with an electro-fishing unit (220 v AC, 60 HZ). Stunned fish were gathered in a fixed net behind the shocker described by Neill (1971). The net mouth was 1.5 X 1.8 m.

Although fish were caught inshore in Mendota and offshore in Wingra, samples are believed to be representative of populations in the two lakes. Baumann (1972) reported marked daily inshore-offshore movements of bluegill in Lake Wingra. In addition, although fish were caught from Lake Wingra in 1969-70 and from Lake Mendota in 1971-72, differences in growth were not greatly biased by different sampling years.

Scale Samples

Scales were selected from underneath the tip of the pectoral fin below the lateral line. Scale impressions were made at room temperature on acetate plastic sheets. A micro-projector was used to examine the enlarged (X40) images of the scales. Criteria for annulus recognition have been reported by Ricker (1942) and Regier (1962). The twelve criteria given by Regier (1962) were used.

The anterior radius and the radii to the I, II, III, IV and V annuli were measured to the nearest mm from two scales per fish and averaged. The relation between body length and anterior scale radius for Lake Wingra (Fig. 1) and Lake Mendota (Fig. 2) were fitted by the least squares method. The best fit equations were (1) $L = 25.26 + 0.83\ S$ for Lake Wingra, and (2) $L = 13.26 + 0.88\ S$ for Lake Mendota, where L = total body length (mm) and S = anterior scale radius (X40).

Equations (1) and (2) were used to determine length at each annulus by methods described by Ricker (1968), with corrections suggested when the regression did not pass through the origin.

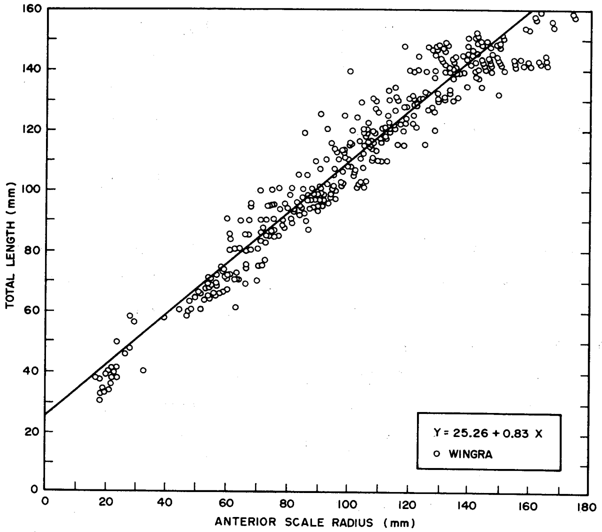


FIGURE 1. Relationship of total length (mm) and scale radius (X40) for bluegill from Lake Wingra. Data from 1969 through 1970.

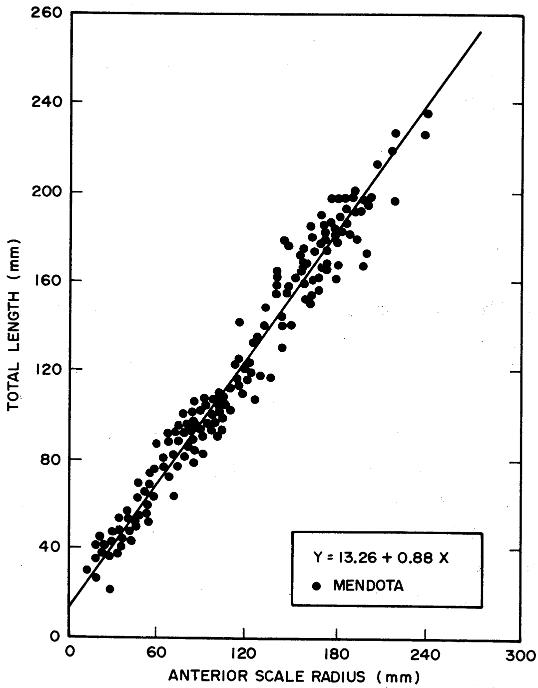


FIGURE 2. Relationship of total length (mm) and scale radius (X40) for bluegill from Lake Mendota. Data from 1971 through 1972.

RESULTS

To enable conversion of growth in length to growth in weight, the relation between fish length and weight was determined from 412 fish (80 young-of-the-year) from Lake Wingra, with average length 101 mm (range 27-160 mm) and 244 fish (45 young-of-the-year) from Lake Mendota, with average length 112 mm (range 22-231 mm). The length-weight relationships were described as (3) $\log W = -3.788 + 2.57 \log L$ for Lake Wingra, and (4) $\log W = -4.99 + 3.21 \log L$ for Lake Mendota, where W = weight in grams.

Annual Growth Pattern

Calculated lengths and weights of older bluegill from Lake Wingra differed greatly from those from Lake Mendota (Fig. 3, Table 1). In the first and second year of life, bluegill from the two lakes were similar in size but by the fifth annulus fish from Lake Mendota were almost three times heavier than those from Lake Wingra (Fig. 3). Estimates from the two years of sampling in each lake were similar. Fish from Lake Mendota were also heavier than fish of the same length from Lake Wingra, as indicated by the exponent of their length-weight relationships — 3.21 for Lake Mendota and 2.57 for Lake Wingra.

The differences in growth of bluegill between the two lakes is dramatized in a modified Walford plot (Walford 1940, Fig. 4b). Logarithmic values of weight at age t + 1 were plotted against the logarithmic values of weight at age t. Data were fitted with a straight line by the least squares and W_∞ was estimated. W_∞ is the weight at which $W_{t+1} = W_t$, i.e. the point where the regression line passes through the 45 degree line in Fig. 4b. W_∞ was 65 g for Lake Wingra and 300 g for Lake Mendota. L_∞ values were calculated from a standard Walford plot and equaled 166 mm for Lake Wingra and 236 mm for Lake Mendota (Fig. 4a).

Growth Compared with Reports from Other States

Previous studies conducted on growth of bluegill in Wisconsin were summarized by Snow et al. (1962) and Snow (1968). Studies on bluegill in other states were also reported by Ricker (1942), Bennett (1948), Lewis (1950), and Sprugel (1953). Data on the growth rates of bluegill in several states are also available in Carlander 1950, 1953.

TABLE 1. CALCULATED LENGTHS AT EACH ANNULUS AND LENGTHS AT CAPTURE OF BLUEGILL FROM LAKE WINGRA AND LAKE MENDOTA.

Age	Mean total length at capture (mm)		Number of fish		Estimated total length (mm) at time of annulus formation									
					Annulus									
					I		II		III		IV		V	
	Wingra	Mendota	Wingra	Mendota	W*	M**	W	M	W	M	W	M	W	M
I	59	98	123	70	50	40								
II	108	145	111	47	47	48	83	115						
III	131	171	45	51	49	47	91	98	125	151				
IV	145	185	51	24	47	43	94	88	128	134	145	170		
V	149	191	2	7	40	38	82	78	122	119	139	155	147	181
Grand Mean					L = 47	43	88	95	125	135	142	163	147	181
Total number of fish			332	199										

* Lake Wingra ** Lake Mendota

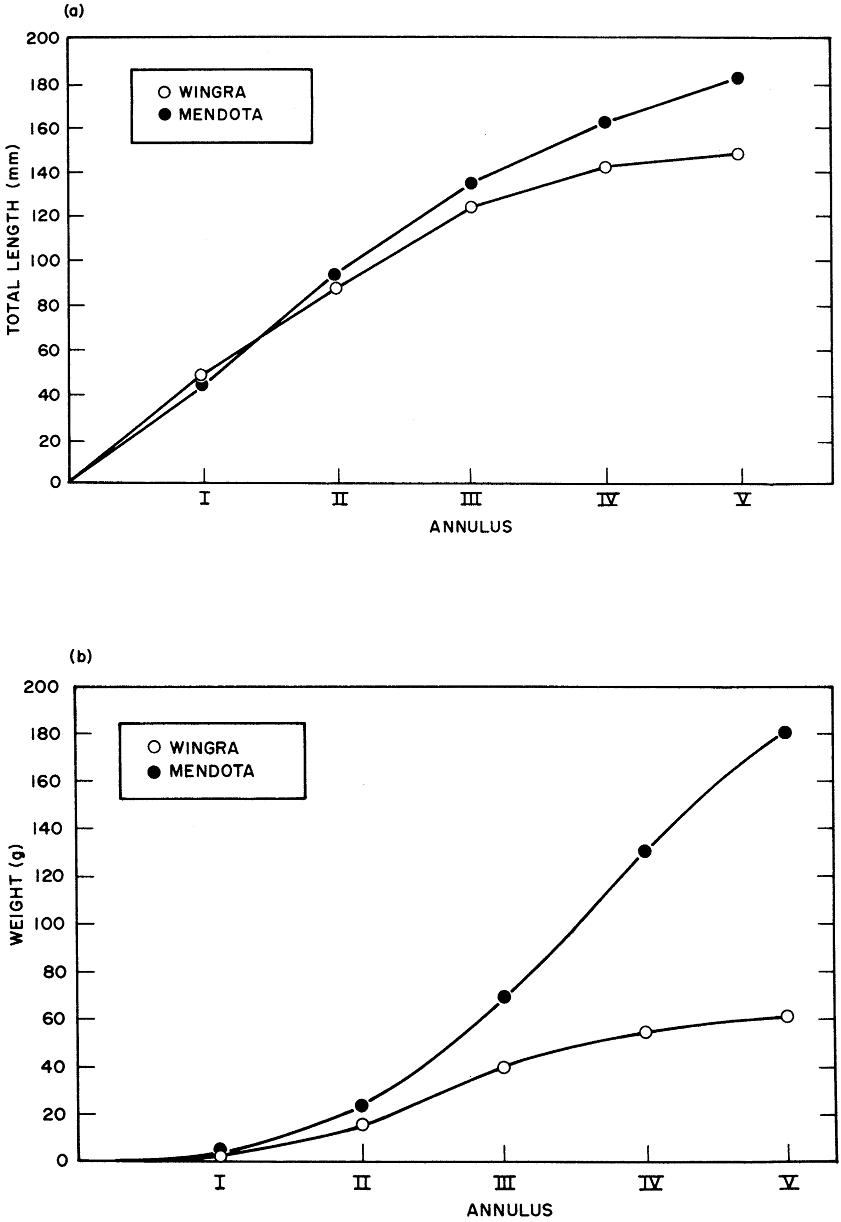


FIGURE 3. Relationship of (a: upper) total length and (b: lower) weight at each annulus for bluegill from Lake Wingra and Lake Mendota. Data from 1969 through 1972.

Data summarized by Lane (1954) indicated slower growth in the first two years of life for bluegill from Illinois, Iowa, and Indiana than that observed in Lake Wingra and Lake Mendota. But again, the growth of older Lake Wingra fish was generally slower than growth observed in these states to the south.

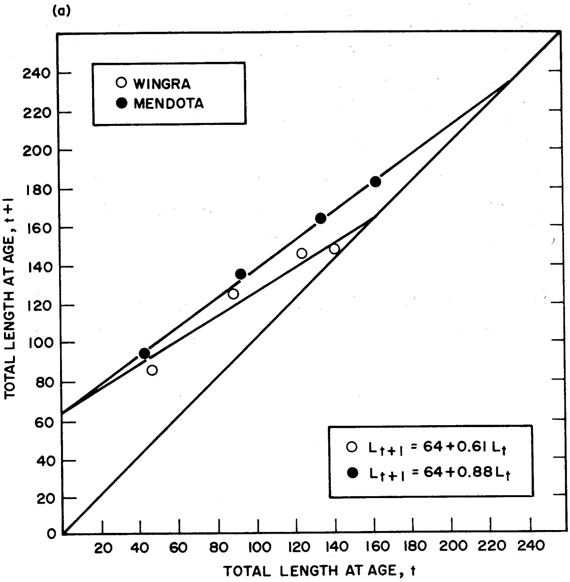
In comparison to bluegill from other Wisconsin lakes, growth is slow in Lake Wingra and fast in Lake Mendota. Lake Wingra fish at annulus I and II were similar in length to those from Lake Okoboji, Iowa, but were not similar at annulus III and IV.

Data of Lake Mendota bluegill show that their growth in length exceeds that of bluegill from Adams Lake, Bass Lake, Big Lake, Center Lake (from the second through fourth years), Cline Lake (through the fourth years), High Lake, Howard Lake and Maniou Lake of Northern Indiana, summarized by Ricker (1942). Growth of Lake Mendota bluegill also exceeds that in Illinois and Indiana lakes, reported by Carlander (1950). It is also greater than that in Spring and Poorest Lakes of Indiana, Kiser Lake and Lake Meander of Ohio, but slower than that in Missouri's Clear Lake, reported by Lane (1954).

DISCUSSION

Bluegill from Lake Wingra and Lake Mendota during the first two years of life grow at similar rates and at rates equal to or better than from other lakes. After the second year of life bluegill from Lake Wingra grow much slower than bluegill from Lake Mendota.

The history of Lake Wingra and its fish during the last 70 years is of interest. Helm (1958) reported that in 1902 the Lake Wingra population was dominated by black crappie (*Pomoxis nigromaculatus*). From 1903 to 1944 other fish, such as white crappie (*Pomoxis annularis)* and yellow bass (*Morone interrupta*) were dominant. A decline in the number of large predators from 1922 to 1958 was accompanied by successful reproduction and survival of pan fish. The decline of predators has been attributed to several factors: unsuitability of the habitat for spawning, introduction and resulting large carp population, and other factors, discussed in detail in Helm (1958). It is important to examine the growth history of bluegill during the period 1922-1958. Schloemer (1939) and Helm (1958) have indicated that bluegill enjoyed significantly high growth rates during that period, higher than that of Lake Mendota fish.



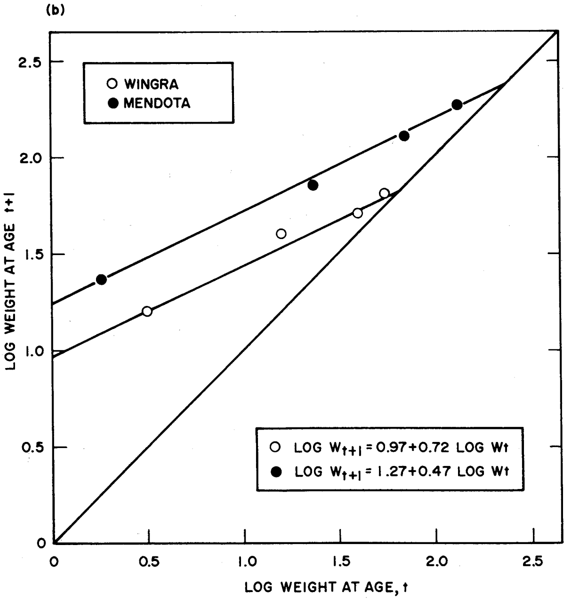


FIGURE 4. A comparison of growth in length (a: upper) and growth in weight (b: lower) for bluegill in Lake Wingra and Lake Mendota, by the Walford and a modified Walford plot.

The decline in the growth rates of bluegill from the 1950s to the present has been accompanied by drastic changes in the Wingra Lake, which can be summarized as follows:

1. A decline in large predators such as northern pike and northern long-nose gar
2. A reduction in the carp population by seining
3. The increase in the density of the vegetation (Helm 1958)
4. An increase in the population density of pan fish, especially bluegill
5. The disappearance of large invertebrates, such as *Hyalella*, reported to be abundant in the lake at that time.

These changes have apparently not occurred in Lake Mendota.

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OPOSSUM SHRIMP (*MYSIS OCULATA RELICTA* :LOVÉN) DISCOVERED IN STORMY LAKE, WISCONSIN

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Opossum shrimp (*Mysis oculata relicta* Lovén) were found in Stormy Lake during a study of food habits of the coho salmon *(Oncorhyncus kisutch)* (McKnight and Serns, 1974). Since 1934, *Mysis* had been known only in three inland Wisconsin lakes: Big Green (Green Lake County), Trout (Vilas County) and Black Oak (Vilas County), according to Juday and Birge, 1927, and Couey, 1934. There is also an unconfirmed report of *Mysis* in Lake Geneva in Walworth County (Pennak; 1953, Pennak, personal communication).

Stormy Lake in northeastern Vilas County (T 41 N, R 9E; S 1, 11 and 12) is a soft-water, landlocked, ice-block type of lake. The lake's maximum depth is 19.2 m; the median depth is 5.8 m; the volume is 2.09 X 10^{10} 1, and the surface 211.2 ha. The methyl purple alkalinity is 15.0 mg/1. Midsummer dissolved oxygen gradually declines as depths increase over 13.7 m; while 9.1 to 13.7 m depths have cool (10.6-19.4 C) water with some dissolved oxygen (3.7-8.9 mg/1); at 14.3 m and deeper the water is anoxic. The Lake's bottoms are predominantly sand, gravel, and rubble in shallow zones with mainly muck in deeper waters. Aquatic vegetation is sparse, but *Nuphar variegatum, Potamogeton Robbinsii, Sparganium, Typha, Eleocharis palustris,* and *Drepanocladus* are present (McKnight, unpublished data).

Stomachs from Stormy Lake coho salmon captured by nets or electro-fishing gear in the fall of 1969 and the summer and winter of 1970, contain *Mysis.* Individual coho contained remains from as many as 98 *Mysis* organisms.

Stormy Lake is considerably shallower than the other Wisconsin lakes with *Mysis.* Maximum depths for Big Green, Trout and Black Oak Lakes are 69.8, 35.1 and 25.9 m respectively. With thousands of years of geo-isolation and limited oxygen in the hypolimnion, the Stormy Lake *Mysis* may be a unique strain. A strain with tolerance to low oxygen concentrations could be an important consideration to fisheries personnel considering transplanting this excellent fish food to other small to medium lakes with marginal oxygen conditions.

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TRANSCENDENTAL MEDITATION IN THE SCHOOLS... RELIGION OR SCIENCE?

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It is difficult these days to find a school which practices the tradition of reading the Bible as a part of the morning prelude to the "Three Rs." Yet the Illinois State legislature has recently given a standing ovation to the founder of the Science of Creative Intelligence (SCI), His Holiness, Maharishi Mahesh Yogi. His appearance in Springfield served to acknowledge his thanks for the Assembly's adoption of House Resolution No. 677, the latter encouraging the spread of Transcendental Meditation (TM) in the schools and colleges of Illinois. Copies of the resolution have been forwarded to the Superintendent of Public Instruction and to Deans of Education in the Illinois State University System.

Prominent, scientific journals[1] as well as a host of popular magazines[2] have seen fit to publish articles on the subject of TM. Since most of them are written by authors who advocate meditation, one is left with the impression that this new version of Yoga is well worth the attention of scientists and schoolmen. There is no doubt that educators in particular are groping for answers in problematic areas like drug abuse and school discipline. In Eastchester, New York, for example, a superintendent of schools has welcomed SCI and TM to the curriculum expressing little doubt that such programs will result in positive effects on the school population.[3] The Science of Creative Intelligence, an offshoot of TM, is projected as a viable program for welding together the interdisciplinary efforts of school and college curricula. Several symposia, funded in part by H.E.W., have already been organized to investigate the potential of SCI in the public schools.

Perhaps the most amazing thing about TM is its apparent, spontaneous acceptability. There are few, if any, articles challenging meditation *a la Maharishi*. It is about time that someone takes a closer look at this latest American "sacred cow." TM people claim that their program is independent of religion. Is it? Has the practice of TM been validated by science as some writers suggest? What do we really know about TM?[4]

TM and Religion

There is no question that transcendental meditation is a derivitive of the practice of Yoga in India. Meditation is widely practiced in that country in many forms all of which conform, more or less, to the Vedic traditions of union ("Yoga" means "union") with God. When Guru Mahesh published his own translation and commentary on the *Bhagavad-Gita,*[5] the Vedic Bible, as a part of an international program for spiritual regeneration, he carefully pointed out how other commentators on the Gita had erred. His own translation favors a much more simplistic path to union, while other commentators have elected the path of anti-materialism often assuming the role of the recluse in their practice of Yoga. The path of the recluse, the Yoga of Knowledge, is long and demanding.

Maharishi Mahesh favors the path of action known as Karma Yoga. His version is compatible with any role in life, and union with God is quickly achieved by the practice of transcendental meditation. He often acknowledges the inspiration of his own teacher, Guru Deva, who died shortly before Mahesh's plan for a worldwide movement began to take shape. His method is such that it can easily be learned by contacting the Student's International Meditation Society (SIMS) which is currently sponsoring a dedicated band of teachers, known as "Initiators," who in turn are teaching TM throughout the United States and Canada. The men from SIMS play down the religious aspect of their work which makes it more palatable for schoolmen and others who might be "turned off" to religion. Initiators have been contacted who have scant knowledge of the *Bhagavad-Gita,* although their free, public lectures are replete with phrases taken directly from that source. The free lectures are rather inoffensive, canned talks on some nebulous, natural philosophy designed by Mahesh who has carefully told his young teachers what, and what not, to say. Instead of union with God, the initiators speak of "turning the attention inward to the source of thought." When asked about the nature of "the source of thought", it is quickly passed off as a function of the mind, an experience, which defies verbal description. The public is told, "It's just a simple, natural, mental technique."

Having attended two public lectures, interested individuals are given the opportunity to become initiates to TM, if they are willing to pay the fee involved and promise to abstain from experimental drugs of all kinds prior to instruction. The TM movement is anti-drug, a strong point in its favor.

The initial training session requires a private meeting with a SIMS instructor. During this session a mantra, a so-called "meaningless sound," is presented to the initiate. The mantra is an important key to transcending thought, according to TM people. The initiation session takes the form of a ceremony not unlike a religious ritual. There is an altar of sorts, candlelight and incense. The initiate brings an "offering" of fruit and flowers as well as a new handkerchief. Although the ritual of initiation is called "traditional" by initiators who have been questioned on this point by skeptics, there is little doubt that its practice has an effect on the learner and he is apt to relate it to other religious ceremonies of his experience. Substitute a priest for the initiator and a communion wafer for the mantra and one might easily imagine attendance at Mass. From a religious vantage point, one could support TM as a new form of evangelism with a scientific tinge. If it provides a medium for the cessation of drug abuse, who really cares what it is called? It is no better, nor worse, than any other theology and certainly cannot be judged by science.

TM and Science

Transcendental meditation has been presented by its advocates throughout the world as a "simple, natural (or mental) technique," not dependent on any faith or belief. Skeptics are welcomed. It is supposedly a practice that produces an awareness of the mind's own natural inclination to "transcend" or "go beyond thought to the source of thought." Transcendental meditation is often described as a practice which was lost to the world in the land of its origin . . . India. We are told that this practice gives full rest to the "nervous system" and is therefore frequently touted as the best form of relaxation. The relaxed state is defined in medicine and science generally as that state where the *muscles* are fully relaxed, such a state being further confirmed by the appearance of associated brain wave patterns.[6]

In recent years, researchers have become very interested in TM, since they can easily obtain willing subjects at many of the large Universities which are equipped with appropriate laboratory measuring devices. The investigation which has received the greatest notoriety is that of Robert K. Wallace.[7] Wallace is himself a meditator and is currently the President of the Maharishi International University. His Ph.D. dissertation on the physiological effects (really correlates) of TM was completed at

U.C.L.A. in 1970. Charts extracted from his study and those coming from studies made in collaboration with Herbert Benson[8] of the Harvard Medical School are prominently displayed at TM lectures given by SIMS. These charts are used mainly as window dressing by the young TM teachers, since most of them are woefully unprepared to explain physiological matters in depth.

What are the findings coming from TM research? In general, the researchers believe that they have accounted for a so-called "fourth state" of consciousness, the transcendental state, which was probably originally inspired by Maharishi in his commentary on the *Bhagavad-Gita* published in 1967. It seems that they have simply attempted to confirm something that Maharishi knew about all along. The "fourth state" they say is characterized by "restful alertness" and is therefore distinctly different from wakefulness, sleep and the dream state. By *rest* they mean physiological relaxation; by *alertness* they imply that the mind is ready to jump into action with a vigor not identifiable in other states.

Studies conducted thus far with TM subjects have produced approximately ten types of physiological data.[9] Not all subjects have been measured in all ten areas and three of the studies reported the use of only 20-40 TM subjects. No comparison has been made between TM subjects and other subjects who have been trained by other methods. Ordinarily, the TM subjects are introduced to the laboratory; they sit for a while without meditating; then there is a period of meditation; and finally they are tested at rest after the meditation period. Records taken from these three periods are compared with each other for each of the subjects tested. The researchers cannot be sure how well their subjects can actually perform TM. They know only that they have had the training provided by SIMS.[10]

The measures most commonly mentioned in connection with the Wallace-Benson[11] studies are the body's use of oxygen and the skin's ability to resist an electrical current. During meditation, the use of oxygen decreases and is identifiably different, when compared with simple rest such as sitting. The skin resistance test is similar to a "Lie Detector" test. During TM there seems to be a significant difference in the resistance of the skin to electricity, indicating that the subject is relaxed in the physiological sense. Reporting in the *American Journal of Physiology,*[12] Wallace et al. stated that "the possibility exists that these changes represent an integrated response that may well be induced by *other means*" (my emphasis).

Had Wallace and Benson done their homework, they would have found that this is indeed the case. The practice of progressive relaxation, for example, has been known in medicine and physiology as well as psychology since the 1930s and its methodology has been reported in almost every major journal of those fields. In his review of the literature leading to his dissertation, Wallace completely missed the classic works of Edmund Jacobson and others who have been studying relaxation and tension in man for more than half a century.[13] Jacobson has found nothing that might be described as "restful alertness." In fact he has shown again and again that subjects well trained in relaxation, particularly in the vocal and visual muscular systems, cease to think as we know it altogether, when they are relaxing. "Alertness" would necessarily have to produce changes that are measurable in the muscles and such changes would never be characterized as "deep relaxation." None of the current batch of TM studies has reported muscular data and yet all of them have assumed that their subjects were well relaxed during TM.

Researchers like Jacobson who have been engaged in medical studies of relaxation often use biofeedback. During biofeedback training subjects learn to pick up signalization from their bodies first with the assistance of electronic apparatus and later without it. Modern headache therapy uses this method to help chronic sufferers learn to control the musculature of the forehead.[14] It works. Unlike the methods used in TM which are shrouded in mystery and metaphysical suggestion, the technique of progressive relaxation is thoroughly explained in the technical literature and has been used by physicians and educators for years. To get a complete idea about TM, one must contact Maharishi in person. He has not written about the method in either of his books but only the benefits that he believes will result.

The most sophisticated device known to science for testing low voltages in muscle tissue is one developed by Jacobson during the 1930s with the full cooperation of the Bell Telephone Co.[15] A transistorized version is now available which enables scientists to extract brain wave measurements and muscle tension measurements simultaneously. Since TM advocates are attempting to "reach the source of thought" and generally and mistakenly relate thinking to the brain, they have altogether neglected the role of muscle in their work. There is no reason to believe that TM subjects are enjoying the benefits of relaxation. They may be mildly relaxed, however, which is a far cry from their claims thus far. We know literally nothing about the state of the muscles during TM, because this kind of data is missing in TM research.

What Really Happens During TM?

Considered in the context of theology, the "experience" of TM has a legitimate place in religion. Just as one might be "saved" by the evangelist, so one might "find the source of happiness" during TM. As far as we know, such experiences are much the same. Although controlled studies of those who experience salvation through evangelism have probably not been tested in the physiology laboratory, we often observe dramatic changes in the lives of those who experience religion in a very personal way, including personality changes and improved emotional health. During prayer, for example, the physiologist might find the kind of changes that have been reported for TM subjects.

Stripped of its religious veil, what might actually be happening during transcendental meditation? The clue we get is supplied by Maharishi himself, who has frequently compared TM with a bubble of air rising from the depths of a pond. As it ascends it grows increasingly larger and finally bursts when it reaches the surface. The experience of transcending begins with the bubble at the surface and follows its path to the floor of the pond where it finally reaches the point of its creation. To transcend we then enter the world of the non-bubble, that creative force that transcends the idea of a bubble.

In Vedic tradition, according to Maharishi, the tongue is regarded as an organ of action. The tongue, along with the entire muscular apparatus responsible for speech, must manipulate air in order to produce sound. The Sanskrit word for breath is "atman." But "Atman" is also the term which signifies the "World Soul." Therefore when the tongue, an organ of action, interacts with the breath, it is in touch with the World Soul which permeates all Nature. In the *Bhagavad-Gita,* Lord Krishna (God) declares "I am Om." The syllable "Om" is a mantra frequently employed in the singing chants of the Yogi. The World Soul is explained as a never-changing, constant being. The tongue, an organ of action, is capable of an infinite variety of movements and is therefore ever-changing. The Yogi attempts to join the field of action with that of inaction and when successful, union with the World Soul or Atman takes place. There are many ways (paths) to achieve union in the practice of Yoga including transcendental meditation, the particular route espoused by Mahesh.

The TM technique begins with an audible sound or syllable called a mantra, literally a Holy sound or song capable of ridding the mind of evil. But instead of chanting the mantra overtly, it is imagined rather than pronounced during TM. Thus the world of inner speech (talking to oneself) is engaged. Naturally, inner speech is inaudible to others but it nevertheless utilizes the same speech apparatus including the speech muscles.[16] When you pronounce the word "cat" covertly the same muscles are used as you would ordinarily use in pronouncing "cat" overtly. Studies in both relaxation and psycholinguistics confirm this phenomenon.[17] A. N. Sokolov[18] of the Soviet Union acknowledges the work of Jacobson in his writing.

The TM novice proceeds in inner speech, pronouncing his mantra with less and less muscular force. He is told that such inner speech activity is simply a more refined level of thinking but he is not told that thinking as we know it also requires muscle, however miniscule it may be. The novice "experiences" the mantra freely in his imagination and is told not to concentrate, the mantra serving him merely as a point of departure for mind wandering.

Finally he arrives at the point where the mantra is pronounced with such refinement that it would take a delicate instrument, such as the E.M.G., to detect the corresponding muscular action in tenths of millionths of volts. Then he "transcends." He ceases to think. The muscles simply relax. In studies which have measured the contractions of the speech musculature, the finding has been repeatedly that verbalized thought is literally impossible without muscle action.[19] Further, during TM the eyes are closed and a quiet spot is recommended. This eliminates interesting stimulation to the eyes and ears, although one may employ visual imagery continuously with the eyes closed and in such instances the eye muscles would be active. Although the Yogis do not consider the eyes to be organs of action, we know from studies in relaxation that they are every bit as active in their own way as the tongue. The Yogi practicing TM attempts to focus the eyes at the tip of the nose to bring them under further control. In this way they may also be brought into contact with the breath or "Atman." This is simply inhibition of sensation.

When one set of muscles relaxes, as for example the speech muscles, this non-action has an effect on surrounding muscle groups and is called the "Spread of relaxation." It is not unrealistic to suppose that during TM with the speech muscles relaxed the eye muscles also occasionally relax which would then literally "clear the mind", since neither aural nor visual imagery would be possible.

This condition often produces the onset of sleep which has been reported by Wallace and Benson in their TM studies.[20]

Instructions to TM beginners depend upon a dialogue with the teacher, a process known as introspection and abandoned by psychology due to its susceptability to bias and suggestion. During teaching sessions the novice might actually be convinced of his "TM experience" or that he "has reached the source of thought" due to the unwitted suggestions of his instructor, the ceremonious nature of the ritual explained above notwithstanding. What may actually be occurring is an experience in self-hypnosis or auto-suggestion. In fact the whole field of TM as described in Maharishi's book *The Science of Being and the Art of Living*[21] is very much like the many approaches one might read about in paperbacks on self-hypnotism. Judging the performance of the learner is a difficult task at best, since the teachers from SIMS are not trained to observe the process of relaxation and must depend upon what the novice reports which may also be very inaccurate without specific training. Such a dialogue between teacher and learner is bound to be confounded with suggestion. Maharishi states in his commentary on the *Bhagavad-Gita* that the "inner state of such a man (the learner or novice meditator) cannot be judged by outer signs." When a learner begins to judge his own practice he is probably influenced by the verbal remarks of his teacher and may finally agree to the description of the experience given by the teacher, whether he has the experience or not. Since the learner has made a small investment in TM he will look for signs that he is improving or get further suggestions from his teacher at sessions following the initial ceremony. He may report, as some meditators have indeed reported, that such things as swimming, energy and sexual prowess have improved as a result of TM. He may even abandon experimental drugs. This latter point is very important and is currently under study by Herbert Benson of Harvard.

In summary we may conclude that TM, considered in its proper theological setting, is a practice aimed at the betterment of man and cannot be judged or accounted for in science. The scientist's explanation of TM exposes the practice as mildly relaxing but certainly cannot be compared with very precise methods such as progressive relaxation and biofeedback therapy. Many of the methods of TM are mysterious and ritualistic. The fact that SIMS describes its method as "a simple mental technique" easily learned by all is attractive to Americans who continuously look for shortcuts to happiness and health. Very often such shortcuts have been disappointing. We recall the youth who gazed disdainfully in the mirror a few weeks after his Charles Atlas kit arrived and are reminded of the wisdom of P. T. Barnum who knew the value of showmanship. We have no doubt that TM offers a naturalistic approach to religion where traditional religion has failed and may actually become a counterforce in problems associated with drug abuse. This alone might account for the enthusiasm of the Illinois legislature. It would seem that its acceptability in the curriculum of the public schools is legally as unwarranted as reading a daily passage from the Bible.[22]

NOTATIONS

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CHILDREN'S ORIENTATION TOWARD THE WORLD OF WORK

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INTRODUCTION

The need to provide elementary school children with educational experiences relative to the World of Work has been given lip service for several years. In 1962, Wrenn wrote

> The elementary school and the junior high school have more urgent need in the immediate future than in the past for stressing vocational information and vocational counseling for a portion of their student population (Wrenn, 1962, p. 150-151).

More recently, publishers have developed materials to introduce the child to a greater variety of jobs. Traditionally, elementary school textbooks, such as readers and social studies texts, have described occupations and jobs centered on the service and professional areas. Tennyson and Monnens, in 1963, surveyed readers for grades 1 through 6 published by 6 different companies. They found greatest emphasis on the professional, managerial, and service occupations. According to the 1960 census, these occupational groups comprised only 19.9% of the working force in the United States; the 1970 census indicated 33.5%. The occupations of a sales, clerical and operative nature were listed in the 1960 census at 42% and in the 1970 census at 55.3%. Occupations of this nature were slighted in the readers. According to Tennyson and Monnens, no reader presented a true picture of the World of Work, probably because the authors are more familiar with the professional fields of work. Nevertheless, this one-sided view of the World of Work does not provide children with a total picture of their occupational options.

Frasher and Walker in 1972 compared the roles, relationships, activities and relative importance assigned to male and female story characters in readiness, first and second grade readers. Males predominated as main characters in all series, whereas female occupational roles were limited, distorted and stereotyped.

Historically, jobs have been handed from father to son. In the twentieth century, however, with the educational opportunities and advantages available to all youth, this pattern has changed. Knowledge gained during the early years is put to use in the adolescent years when decisions related to career selection, preparation and first employment are made. Pressures from society often force an adolescent to make a career decision before he is ready: colleges request a student to indicate a major; parents urge an adolescent to become involved in the World of Work; the military offers the choice of an occupation to all who enlist. Over and over, the adolescent is reminded that these decisions are waiting to be made!

Vocational theorists have debated the basis upon which one makes vocational choices. The majority of theories have been based on research conducted among adolescents and adults. For example, Super's rather comprehensive theory is based on his research with 9th grade boys (Super, 1960). Current introduction into the World of Work at the elementary school level is thus an extrapolation from adolescent/adult theory.

The KULDAU OCCUPATIONAL DEVELOPMENT INVENTORY (KODI) was developed as a means of assessing the orientation which children at the upper elementary school levels have developed toward the World of Work. An instrument which measures such orientation would prepare elementary school personnel to assist children in acquiring basic knowledge for later vocational choice and decisions.

PURPOSE

The purpose of this study was three-fold: to discover 1) if children in grades 4, 5 and 6 have developed attitudes toward the World of Work, 2) if the instrument under development would differentiate these attitudes into three factors (Interpersonal Relations, Success Orientation, and Security Orientation); 3) if the variables under study (*grade level, sex* and *community setting*) influenced the children's responses to these three factors.

METHOD

The KODI was administered by the authors to over 1000 children in grades 4, 5 and 6 in three community settings in a city in Wisconsin. The 40-item forced choice instrument had a reading grade level of 4.7 as measured by the Dale-Chall Test for

Readability. Transparencies for each item were projected on a screen and read orally to the children. The three community settings were defined as:

> *Inner City* (IC): Schools which qualified for and were receiving Title I funds, were located within the central business area of the city, and served children residing within the central business area of the city;
>
> *Working Blue Collar* (WBC): Schools which were judged by the administrators to draw the majority of their students from homes in which the chief wage earner was employed in an occupation which required less than two years post-high school training as listed in Volume II of the DICTIONARY OF OCCUPATIONAL TITLES;
>
> *Professional White Collar* (PWC): Schools which were judged by the administrators as drawing the majority of their students from homes in which the chief wage earner was employed in an occupation which required more than two years post-high school training as listed in Volume II of the DICTIONARY OF OCCUPATIONAL TITLES.

Schools included in this study were said to draw at least 75% of their students from the community setting described.

Each of the 40 items in KODI was statistically analyzed by using the three-way analysis of variance. This approach made it possible for the three variables (*grade level, community setting, sex*) to be extracted and studied to discover the effect each had on the development of orientation toward the World of Work. "The three way anova permits the comparison of several groups' performance and the evaluation of the variations in performance shown by the subjects" (Bruning and Kintz, 1968, p. 72).

Such analysis in the present study reveals the relationship between and within the variables, considered singly and in combination, thereby making a total of seven variables. The three single variables include 1) *grade,* 2) *community setting* and 3) *sex* with the combination variables including the relationship between 4)*grade* and *community setting,* 5) *grade* and *sex,* 6) *community setting* and *sex,* and 7) *grade, community setting* and *sex.*

RESULTS

Table I contains 11 items that measure the importance of Interpersonal Relations (Factor I) in the child's orientation to the World of Work. The *sex* of the child is the single most important variable that influences this factor, with 8 of the 11 items meeting or exceeding the 0.05 or 0.01 level of significance. The second most important single variable is *community setting*, with 7 of the 11 items meeting or exceeding the 0.05 or 0.01 level of significance. However, when comparison was made between the variables, the impact of *grade* combined with *community setting* was the most significant with 6 out of the 11 items meeting or exceeding the 0.01 level of significance. Only when the impact of *grade* combined with *sex* was analyzed did no significant results occur. On two items (no. 5 and 30) all three variables combined were influential in determining how a child responded to the inventory.

TABLE 1. FACTOR I. INTERPERSONAL RELATIONS. ANALYSIS OF VARIANCE FOR GRADE, SEX, AND COMMUNITY SETTING FOR EACH INVENTORY ITEM

Item No.	Grade (A)	Community Setting (B)	Sex (C)	AB	AC	BC	ABC
2			4.77*	4.35**			
5		11.54**	6.71**				4.14**
8		22.34**	15.90**	8.23*		8.38*	
10	8.54**	7.84**	6.95**	6.92**			
15							
16	3.46*	38.84**	35.68**	6.84**		5.59**	
22		10.10**	4.72*	3.79*			
24	4.78**		7.49**				
28		8.67**					
30	11.95**	3.09*					3.37**
39		2.89*	16.68**				

*p <.05

**p <.01

Table 2 indicates that Factor II (Success Orientation) contains 12 items. The most influential single variable is *grade* with 7 of the 12 items meeting or exceeding the 0.05 or 0.01 level of significance. The second most influential single variable is *community setting* with 6 of the 12 items meeting or exceeding the 0.01 level of significance. The most important combination of variables was *grade* and *community setting*, with 6 out of the 12 meeting or exceeding the 0.05 or 0.01 level of significance.

TABLE 2. FACTOR II. SUCCESS ORIENTATION. ANALYSIS OF VARIANCE FOR GRADE, SEX, AND COMMUNITY SETTING FOR EACH INVENTORY ITEM

Item No.	Grade (A)	Community Setting (B)	Sex (C)	AB	AC	BC	ABC
3	3.93*	35.81**	7.64**	7.45**			
11							
14	5.06**	14.36**	3.81*	2.50*			
16	3.46*	38.84**	35.68**	6.84**		5.59**	
20	4.10**						
21	5.41**						
23					4.27**		
25							
32	14.26**	49.32**					
34				2.63*	3.56**		
35	11.39**	19.66**		8.29**			
37		8.39**		3.22**			

*p <.05

**p <.01

TABLE 3. FACTOR III. SECURITY ORIENTATION. ANALYSIS OF VARIANCE FOR GRADE, SEX, AND COMMUNITY SETTING FOR EACH INVENTORY ITEM

Item No.	Grade (A)	Community Setting (B)	Sex (C)	AB	AC	BC	ABC
4	5.18**	2.97*					
10	8.54**	7.84**	6.92**				
12	8.01**	14.07**	4.93*				
14	5.06**	14.36**	3.81*	2.50*		5.59**	
16	3.46*	38.84**	35.68**	6.84**			
17	12.40**	25.46**					
19		19.10**	14.58**			3.61*	
32	14.26**	49.32**					
35	11.39**	19.66**		8.29**			
40	5.97**	70.84**			4.00*		

*p <.05

**p <.01

Factor III (Security Orientation) contains 10 items as shown on Table 3. The single most influential variable is *community setting* with 10 out of the 10 items meeting or exceeding either the 0.05 or the 0.01 level of significance. The second most important single variable is *grade* with 9 out of the 10 items meeting or exceeding either the 0.05 or the 0.01 level of significance. When combined variables are viewed, *grade* and *community setting* has 4 out of the 10 items meeting or exceeding either the 0.05 or 0.01 level of significance.

DISCUSSION

Whether a child views Interpersonal Relations on the job as important is influenced directly by the sex of the child. The type of community setting plays only a slightly less important role in this orientation. The child's grade becomes important only when it is related to the type of community setting of the school.

The Success Orientation factor was designed to determine whether individuals felt that the criteria of success were based on education and flexibility. Grade level seemed to influence the response of the child, when Success Orientation was taken into consideration. The child's community setting was only slightly less important. Community setting and grade not only operate independently but in combination. This finding strengthens the concept that the community and the grade level of the child greatly influence his/her views of success. The latter point could relate to whether or not a child views school as necessary for success.

The Security Orientation factor has the greatest number of items reaching or exceeding the 0.05 or 0.01 level of significance for single variables of the three factors studied. Whether a child is materialistically oriented or not, and whether he/she is passive or self-directed, is influenced by the community setting and grade level of the child. The sex of the child also plays a role of importance in the Success Orientation. Generally speaking, each single variable independently influences the child's orientation to security, i.e., the community setting influences whether the child views himself/herself as a passive or as a self-directed individual along with whether materialism is important or not.

In conclusion, it can be stated that: Children in grades 4, 5, and 6 have developed attitudes toward the World of Work. These attitudes are related to, or take into consideration Interpersonal Relations, Success Orientation and Security Orientation. These three factors were influenced differentially by grade, sex and community setting.

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ENVIRONMENT FOR DISCOVERY — THE OWEN SURVEY OF WISCONSIN

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David Dale Owen, United States Geologist, directed the first extensive geological surveys of Wisconsin and adjacent areas during the field seasons of 1839, 1847, 1848 and 1849. While reports were made to Congress on the 1839 and 1847 surveys, it is the 638 page "Report of the Geological Survey of Wisconsin, Iowa and Minnesota," issued in 1852, which describes and illustrates the geology in great detail, and which also gives a vivid picture of the harsh environmental conditions under which the work was accomplished. Wisconsin did not undertake a State Geological Survey until 1853, but between 1820 and 1850 22 State surveys had been established—one of them in Indiana, where Owen had been appointed its first State Geologist in 1837, when he was 30 years of age.

The nurturing environment of this young geologist was quite different from the wilds of the Northwest in which he and his assistants mapped bedrock, drift, mineral resources, and landforms under conditions which were frequently harrowing. David Dale Owen was born in Scotland, the son of wealthy philanthropist and social reformer Robert Owen. In the opinion of the father, "environment — was the only medium whereby the character of the individual could be bettered" and it was "vitally important that human beings be surrounded with circumstances favorable to their development" (Lockwood, 1905).

Robert Owen considered that there were four phases of the environment—home, social, industrial, and educational—and he spent a fortune to bring about improvements in all of these for the working classes. At the same time, he saw to it that his own children were uncommonly well educated for the time, i.e. the early part of the nineteenth century. It is strange, though, that he gave little attention to the *natural* environment which became the chief interest of his two sons, David and his younger brother Richard. Following their early education under private tutors and in schools founded by their father for the children of workers in his cotton mill, the boys were sent to schools in Switzerland and Glasgow, where they studied French, German, chemistry, and natural philosophy, which included physics and geology.

Meanwhile, in order to achieve greater scope for his ideas of social reform, Robert Owen purchased the Rappite community of Harmonie, on the Wabash River in Indiana, and recruited several hundred followers (including his two older sons) to join him there in 1825 in a "community of equality, based on communally held property, strong emphasis on education, and rejection of doctrinal religion" (Lane, 1966). The social experiment failed after two years, but the community, rechristened New Harmony by Owen, remained to become "the greatest scientific center in America" (Lockwood, 1905). Robert Owen had already left New Harmony when David and Richard, aged 20 and 18 respectively, fresh from their European schooling, arrived in the colony in 1827 to teach and to conduct experiments. There they became acquainted with William Maclure, who earned the title "Father of American Geology" by producing the first geological map of the eastern United States, in 1809. Maclure had left Philadelphia to join Robert Owen in the New Harmony experiment because he saw such rapid moral decay in the cities that he believed the only salvation for civilization lay in a return to rural life and changes in the education system (Lane, 1966). He established the school system in New Harmony, which became a model for schools throughout the Country (Lockwood, 1905). Maclure left the colony soon after David and Richard arrived, but his library and natural history collection were available for study, and must have whetted David's interest. In 1831 he went to London to study chemistry and geology, and after two years abroad he returned to New Harmony, set up his science laboratory in the old Rappite granary which later became headquarters for the United States Geological Survey, and there he assembled the collections of Maclure and Thomas Say for study. During the winter, he gave a series of 40 scientific lectures for the townspeople (Lane, 1966). It was probably a desire to improve his background in morphology and anatomy for paleontologic studies that led him to the Medical College of Ohio in 1835. He received his M.D. in 1837 but for the record he never practiced medicine, although his knowledge must have been called into use during some of the surveys. Feeling the need for field experience, he took time off from his medical studies in the summer of 1836 to serve as field assistant to Dr. Gerard Troost, State Geologist of Tennessee, a Hollander who had been a member of Maclure's scientific colony in New Harmony. Lane (1966) calls David Dale Owen a link between the older generation of geologists, Maclure and Troost, and a younger generation who received much of their geologic training by association with Owen on several state and federal geological surveys.

The first assignment came as soon as he had completed his medical training. In 1837 Owen was appointed the first State Geologist of Indiana and began a field survey across southern Indiana, the report of which became, in 1838, the first of 45 publications to his credit. He continued the Indiana survey in 1838, but refused it in 1839 in favor of an assignment as United States Geologist—the second man to hold that title.This assignment resulted from a change in federal law, which for the first time permitted the sale of public mineral lands, but only after their value had been estimated.

The first area to be surveyed was the lead district of the present day southwestern Wisconsin and adjacent parts of Illinois and Iowa. The assignment was to explore each quarter section, about 11,000 square miles, and to complete the work before winter. Although the directive was framed in February, the appointment of the geologist in charge was not made until July 31, and Dr. Owen did not receive notification until August 17. The assembling of the required field group and the successful completion of the survey in such a short time (by November 24) have been described by George P. Merrill as a "feat . . . never equalled in American geologic history" (Lane, 1966). How did he accomplish this? By rounding up every assistant he could find in New Harmony and 139 more in St. Louis, where he outfitted the expedition. On the journey by boat up the Mississippi River, he lectured each day on geology and mineralogy, using samples he had taken along. The whole crew was divided into 24 groups of 5 to 6 men, each to survey 7 to 8 sections a day. Each group had an "intelligent head" (Lockwood, 1905) to look after the work, and each had its own district, with every section to be visited, samples collected from it, and mapping to be done. Dr. Owen traveled from camp to camp, studying the work accomplished. Each camp had its own hunters to provide food. The survey was completed in little more than two months, and the final report by June, 1840.

Seven years later Dr. Owen was again appointed by the General Land Office to make a survey of the Chippewa Land District—about 46,000 square miles, mostly in Wisconsin. After completion of this 1847 reconnaissance, Owen was directed to make a general survey of the Northwest Territories—chiefly Wisconsin, Iowa and Minnesota "and incidentally a Portion of Nebraska Territory" (Owen, 1852). The summers of 1848 and 1849 were devoted to this survey, again with a crew of assistants, and then for two years Owen worked on the collections and completion of the final report—638 pages, 27 plates illustrating fossils, 16 plates of cross-sections, 2 geologic maps, and numerous wood-cuts from original sketches in the field, many of them by the two Owen brothers. The monumental volume of 1852 includes reports by several assistants, Dr. J. G. Norwood, Colonel C. Whittlesey, and Dr. B. F. Shumard, and a Memoir on the fossil vertebrates from Nebraska by Joseph Leidy. A glance at the maps, the sections, and the illustrations, and a perusal of the descriptive geology impresses one with the diligence and astuteness of these men, who mapped drift and illustrated kettle and kame topography before the idea of continental glaciation had been conceived. The first fossil finds were made in southwestern Wisconsin, the base of the Paleozoic was determined, and correlations with eastern United States and European strata were established. The crystalline and volcanic rocks were described and illustrated in detail. About 40 new species of invertebrate fossils were described, and four new genera of trilobites, including the zone markers *Dikelocephalus* and *Crepicephalus* of the Upper Cambrian Series. There was ample opportunity for discovery, because these men were not only surveyors, they were explorers. Little geologic work had been done in the area. Increase Lapham had produced a geologic map of Wisconsin in 1844, and George Featherstonhaugh, Owen's predecessor as United States Geologist, had made the first list of Wisconsin Territory's mineral resources in 1836. But for the most part it was new territory.

As Owen noted, in his October 30, 1851 letter of transmittal to the Commissioner of the General Land Office in Washington, the chief object of the survey was strictly business and practical (to classify and evaluate the mineral lands), but "Scientific researches, which to some may seem purely speculative and curious, are essential as preliminaries to these practical results" (Owen, 1852). He went on to say that these researches had not been pushed, except in leisure moments, so that the contributions to science "which a liberal policy forbade to neglect" were a "voluntary offering, tendered at little or no additional expense to the Department." It was also noted that the normal work-day was from 12 to 15 hours.

It was claimed by Owen that the geologic map of the territories surveyed was the most extensive ever reported by any geologist or geological corps in this country (four times the size of New York). Strangely enough, he did not recommend the setting aside of any lands as a mineral reservation. The Lake Superior iron ores were not discovered until quite some time later, and it is only in the present decade that Wisconsin has become known as a copper-producer. But the lead ores sites were known and noted on his map.

Some of Owen's most interesting remarks deal with the conditions under which he and his party worked. They remind us that, although man may be causing deterioration of the environment, he has made many improvements, too. Let me quote:

"A circumstance which to some may seem trivial, will delay, to a considerable extent, the settlement of a portion of the district. It is the prevalence, especially on the Upper Wisconsin, Chippewa, St. Croix and Black River countries, and thence north to Lake Superior and to the British Line, of venomous insects, in such insufferable quantities, that, at certain seasons, they destroy all comfort and quiet, by day or by night. Among the pineries of Northern Wisconsin, and more or less throughout the whole of the above designated region, the buffalo-gnat, the brulot, and the sand-fly, to say nothing of gigantic musquitoes, carry on incessant war against the equanimity of the unfortunate traveller. I and other members of the corps, when unprovided with the necessary defence, have had our ears swelled to two or three times their natural size, and the line of our hats marked, all round, by the trickling blood. It was often necessary to rise many times, in the course of the night, to allay the fever of the head, by repeated cold bathings; and at some of the worst spots, we could scarcely have discharged our ordinary professional duties at all, without the constant protection of musquito-netting, worn over our head and face." (Owen, 1852, pp. 22-23)

He noted, however, that even in marshy areas, health was better than expected, because the long, bracing winters of the northern latitudes excluded many of the diseases of more southern climates. But exposure in almost impassable swamps did lead to illness in the party—each member in 1849 was struck by "obstinate intermittents." And then, rather casually, comes the statement, "We lost, by death, but one man, of cholera, at Muscatine, in Iowa in July, 1849."

Somewhat more linage is given to an accident "which came near having a fatal termination" because of the bowsman's loaded rifle, laid "with the muzzle imprudently pointing, in a direct line, towards myself.—A sudden jerk of the boat caused the discharge of the rifle. Had not the breech of the other gun chanced to lie slantingly across the muzzle of the discharged piece, this Report, in all probability, would have been completed by someone else than its present author." As it was, the diverted ball shattered the brass and stock of the second gun and the flying shrapnel struck one man in the face and the kneecap, so that "for many days (he) could scarcely step in or out of the canoe." Dr. Owen's coat was perforated in a dozen places, and three fragments passed through and severely lacerated the deltoid muscle of his left arm.

A sudden squall in 1850 dashed Dr. Norwood's bark canoe on shore and smashed it, and the principal assistant barely escaped death. A constant worry was failure of provisions, because of unforeseen and unexpected delays, and sometimes difficulty in interpretation of poor maps. "We have frequently, notwithstanding the utmost prudence, exhausted the last pound of eatables, and travelled a day or more, without breaking our fasts. On one occasion, a single pigeon supplied a corps of three men during three days . . . but only one . . . was ever reduced to a state of exhaustion and emaciation from hunger"—for three days he had only a few wild berries.

In general, the Indians encountered proved to be friendly, but it was difficult to obtain guides to conduct the party on some trips into comparatively unknown territory, such as that of the Red River of the North.

But the assigned territory *was* explored, and some additional lands, too. Not only was the geology described, but also the soils, the plants, and their relationship. The birds observed in Wisconsin and Minnesota were listed. The vertebrate fossils found in the Nebraska Badlands were sent to Dr. Joseph Leidy at the Philadelphia Academy of Natural Sciences for study and description, while Dr. Owen gave his attention to the invertebrates, working on them and writing his report at his laboratory in New Harmony, which remained the headquarters of the United States Geological Survey until 1856, when it was moved to the new Smithsonian Institution in Washington.

Through those years, New Harmony was a Mecca for geologists. Sir Charles Lyell and his wife visited the Owens there in 1846. From among the residents of New Harmony, seven states chose their State Geologists, and eight men served in these positions. One of Owen's sub-assistants on the Wisconsin Survey was F. B. Meek, who with Hayden headed some of the later surveys of the west for the United States Geological Survey. When David Dale Owen died, in 1860, he was succeeded as State Geologist of Indiana by his brother Richard, who had been head of a Sub-corps on the Wisconsin Survey. Until shortly before his death, David Owen was serving three states as

State Geologist—Kentucky, Arkansas, and Indiana. Lane (1966) concluded that no other historical site in the United States had as much significance for the geologist as did New Harmony, Indiana. There, certainly, is an example of a nurturing environment for geologists. It is probably fair also to conclude that the geological survey of no other single area led to the influence and training of so many people in geological methods as did the three surveys that Owen led into Wisconsin.

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TO COIN MONEY, REGULATE THE VALUE THEREOF . . . EMIT BILLS OF CREDIT

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The title words are taken from ARTICLE 1. Sections 8 and 10, of the Constitution of the United States. Our purpose is to explain the meaning those words had at the time the Constitution was written.

TO COIN

The verb coin means to make coins. It does not mean to write or to print notes or bills on paper. So, the phrase "to coin money" simply means to make coins; and nothing more.

If the writers of the Constitution had wanted the Congress to have the power to issue notes to serve as media of exchange, they would have included the phrase "to emit Bills of Credit" after the phrase "to coin money." That was the meaning of the phrase in The Articles of Confederation. That was the limited meaning of the phrase intended in ARTICLE 1, Section 10, of the Constitution.

MONEY

The word "money" has its origin in the Latin word "moneta" which means a mint. It also means a coin. The words *monetary* and *monetize* are derived from the Latin "moneta."

In the Old English the word for mint was "mynet." Also, in the same Old English "mynet" meant the coins which were made at the mint. As the Old English spelling changed with time, the word "mynet" meaning mint became "mynit," then "mynyt," and finally "mint." And the Old English word "mynet" meaning coins, was changed to "moneye" in the Middle English and later to "money" in Modern English.

The word "money" is now used for any or all items which serve as media of exchange. That is why people may not know the correct meaning of the word.

To avoid confusion, we should use the word "money" to mean coins and only coins. Other items of currency, such as United States Notes and Federal Reserve Notes, should be called what they are. All the items collectively should be called currency as a general name for the items which serve as media of exchange. But each item should be called what it is.

REGULATE THE VALUE THEREOF

The above phrase is to many of us an unclear statement. It does not tell us how or when the value of the coins should be regulated. We are not able to ask the writers of the Constitution just what they meant by that statement, so let us, by studying the practices in vogue at that time, try to deduce their meaning.

The Constitution did not say "to fix the value thereof"; likewise, it did not say "to regulate the alloy thereof."

The alloy of a coin is not the exchange value of the coin, but rather the metal substance of the coin. The exchange value is a person's idea of the things for which the coin can be exchanged.

The verb "to regulate" means to adjust, and "value" means, in this case, the exchange value of the coins. So, we must determine to what and, most importantly, when the exchange value of the coins should be adjusted.

The phrase "to regulate the value thereof" cannot mean to regulate, to adjust, or to change the number of grains of the metal in the coin, because after the coin is made the number of grains of the metal cannot be changed without destroying the coin. The exchange value of foreign coins can change without in any way changing or destroying the coins, just as the exchange value of a bushel of wheat can change without adding to or taking away any of the wheat from the bushel.

The meaning of the phrase "to regulate the value thereof" can best be understood, if we connect it closely with the phrase "and of foreign coin" which follows it in the Constitution.

We know from our history how the value of foreign coins was regulated at that time. It was adjusted to the market value of their metal content at the time the coins were received as a payment. The metal content of the coins remained the same, but the exchange value of the coins increased or decreased according to the market value of the metal in the coins.

Because the amount of the exchange value of coins, especially gold and silver coins, may increase or decrease according to the market value of the metal in the coins, it was proper for the writers of the Constitution to give the Congress the power to regulate or adjust the amount of the exchange value of the domestic coins to the amount of the market exchange value of their metal content after the coins were minted, in the same manner as was being done at that time with foreign coins.

We should keep in mind that when the United States government first made gold and silver coins, it did not make the coins for its own use, i.e., as payments for its expenses. It made the coins for the people who brought in the gold and silver for the purpose of having the metal made into coins for *their* own use, as payments to the government and to others. The coins simply were standardized gold and silver pieces, the metal contents of which were warranted by the United States government.

The coins did not belong to the government but to the persons who brought the metal to the mint. The coins belonged to them in the same manner as the gold and silver had belonged to them. They had no more wealth after the gold or silver was made into coins than they had before. The only difference was that the metal was changed into pieces more suitable to serve as media of exchange.

When the coins would be brought to the Government as a payment, let us say, for taxes, the writers of the Constitution wanted the government officials to have the right to adjust the value of the coins to the current market value of their metal content. That value then would be the amount that would be accepted as the payment.

When the phrase "and of foreign coin" is closely connected to the phrase "regulate the value thereof" it tells us that the writers of the Constitution wanted the Congress to have the power to regulate the value of domestic coins as they were already doing with foreign coins. That is, the exchange value of the coins was to be adjusted to the market value of their metal content *at the time* they are either received as a payment or given out as a payment.

That was the power the Congress already had regarding foreign coins under The Articles of Confederation. That is the only honest way that gold and silver coins can be used as media of exchange.

It has been proven to be the only practical way, because as long as those rules were applied to the gold and silver coins, those coins stayed in circulation. Otherwise, the coins either disappeared from circulation, i.e., were hoarded or the market value of the metal content was less than the face value of the coins. In that event the gold or silver in the coins could just as well have been copper and/or nickel.

However, Congress did not follow the intentions of the writers of the Constitution. In 1792, when it first authorized the minting of the first gold and silver coins, it fixed the exchange value, i.e., the legal tender value, of the coins at the mint. That was a serious mistake. In 1794, when the first coins were minted, the market value of the metal in the coins was already above the legal tender value set by the government. The result was that very few United States minted coins circulated as media of exchange.

EMIT

The word "emit" means to issue, to give out, or to print and send into circulation. The writers of the Constitution did not give Congress the power to emit bills of credit. But that is exactly what Congress did, when it authorized the issuance of our present United States notes and our present Federal Reserve notes.

BILLS OF CREDIT

Bills of credit are notes which are authorized by a governmental body and intended to circulate as media of exchange. They are a special kind of notes. They are written promises to pay money that the issuer does not have.

The *Articles of Confederation* forbade Congress to "emit bills [of credit] unless nine States assent to the same." ARTICLE 1, Section 10, of the United States Constitution states "No State . . . shall emit Bills of Credit." Thus, we see that the Constitution did not give Congress the power to emit bills of credit, even in a limited way, as the *Articles of Confederation* had done; and the Constitution specifically forbade the States to emit bills of credit.

Why would the writers of the Constitution refuse to give the Congress the power to emit bills of credit and also forbid the States to do it? The answer is that they had experience with bills of credit issued by the Continental Congress and by the 13 States. Remember, bills of credit were promises to pay money which the issuer did not have. When notes are issued to pay money the issuer does not have, we are sometimes told that the notes are accepted by the people on faith. The opposite is true. It is because the people do not have faith in those notes, that government officials must declare such notes to be legal tender. Thus people and governmental bodies are forced to accept them as payments for debts, even if the payment is an unjust settlement of a debt. Such unjust settlements of debts took place on a large scale in Germany in 1923.

When notes can be issued with promises to pay money that the issuer does not have, there is no limit to the amount that can be issued. And when too many of such notes are issued, an inflation of the currency takes place, the results of which are abnormally higher prices. That was what the writers of the Constitution had experienced with the bills of credit issued by the Continental Congress and the 13 States.

As long as our government officials abided by the Constitution and refrained from emitting bills of credit, there was no government made inflation of the currency in our country. However, in 1862, the Congress began to issue notes with promises to pay money which the government did not have. Since then the banking system has issued and continues to issue promises to pay money, which it also does not have. Inflations, deflations, and ever increasing interest bearing debts are the results.

CONCLUSION

Today, we have no gold and/or silver coins in circulation. We have a serious inflation of the media of exchange. We have enormous government debts. And we have many laws, controls, and regulations made by confused government officials because we and they do not fully understand these words in the Constitution "to coin money, regulate the value thereof — emit bills of credit."

IDENTIFICATION OF WISCONSIN TUBIFICIDAE AND NAIDIDAE

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INTRODUCTION

Oligochaete worms of the families Tubificidae and Naididae are common and frequently abundant in freshwater habitats, but there exists very little information concerning the life histories and ecology of even the commonest species. In fact, we do not have even an adequate inventory of the aquatic oligochaete fauna for most regions of North America. This unfortunate situation is apparently the result of a widely held notion that aquatic oligochaetes are difficult to identify to the species level. This *was* true, for older keys often required dissection of specimens or examination of serial sections, and failed to include many species which we now know to be common. However, taxonomic studies by Brinkhurst during the 1960s resulted in the production of keys (Brinkhurst 1964, 1965, Brinkhurst and Jamieson 1971) which make possible the identification of specimens mounted whole on microscope slides. Thus, while most older publications dealing with aquatic oligochaetes were primarily systematic, there has been a recent emphasis on natural history, ecology and pollution tolerance of various species. Keys for the identification of common aquatic worms are presented here with the hope that they will stimulate and facilitate more studies of this sort on the lakes and streams of Wisconsin.

While several keys to North American Tubificidae and Naididae have been published in the past decade, we feel that it is valuable to present these keys for regional use because those currently available consider many species unlikely to occur in the inland waters of the upper midwest (Brinkhurst 1965, 1967; Brinkhurst and Jamieson 1971); fail to include a few species now known to occur in the waters of Wisconsin; are unnecessarily unwieldy for a restricted area, since they do not proceed directly to the species level (Brinkhurst and Jamieson 1971); have had only a very limited distribution (Brinkhurst 1967, Hiltunen 1970, 1973); or use terminology or nomenclature inconsistent with that in the recent world monograph of Brinkhurst and Jamieson (1971). The keys presented here proceed directly to the species level and include only species known from the inland waters of Wisconsin (Howmiller, 1974, and unpublished records of Loden). Records of Wisconsin aquatic oligochaetes have come from collections in lakes representing a considerable range of environmental conditions (cf. Howmiller 1974) but rather few collections from running water habitats have been studied. It is thus likely, particularly for the naidids, that investigations in streams will turn up species not included in our keys. When such specimens are encountered, it will be necessary to consult Brinkhurst and Jamieson (1971) or other taxonomic references cited in the bibliography of this paper.

The keys are meant for identification of worms mounted whole on microscope slides. Magnification of up to 440X is required and higher magnification is occasionally convenient. Amman's lactophenol[1], Turtox CMC, or a mixture of the two are suitable mountants. Amman's lactophenol seems to clear specimens more quickly, but CMC allows more freedom in handling of slides, since it hardens. A mixture allows one to exploit the best features of the two. For more detailed taxonomic studies, or when specimens will be made part of permanent collections, a resinous mounting medium is recommended.

Characteristics Used in Identification of Tubificidae

Tubificid oligochaetes typically bear setae arranged in four bundles, two dorso-lateral and two ventro-lateral, on each segment except the first (Fig. 1a, 1b). The form of the setae provides the most valuable features for identification of most species. Most tubificids have setae which are bifid (two-toothed) distally, though the sizes and arrangement of the teeth vary greatly between species (Fig. 2a-h). Many species have pectinate setae (Fig. 2i-p), hair setae (e.g. Fig. 2t), or both, in dorsal bundles. Other unusual shapes occur and are often highly characteristic of the species which bear them (e.g. Fig. 2q-s, u).

Unfortunately, many tubificid species cannot be identified by characteristics of the somatic setae alone. This category includes 10 of the 17 species in this key and some of the most commonlv occurring species. Identification of these species requires sexually mature specimens for the examination of genital structures.

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[1]20 g phenol crystals, 16 ml lactic acid, 20 ml distilled water, and 31 ml glycerol. A small amount of aniline blue may be added.

Some species have setae on the ventral side of one or two segments (X-XI) reduced in number and specially modified for reproductive purposes. Where somatic setae are not sufficiently distinctive these penial (e.g. Fig. 2v) or spermathecal (e.g. Fig. 2x, y) setae provide valuable characteristics for identification.

Variously shaped penis sheathes (Fig. 3a-1), generally borne on segment X or XI, are used in the identification of mature specimens of some species.

Collections often include large numbers of unidentifiable immature worms. Most workers separate these into two groups based on the presence or absence of hair setae. When sufficient numbers of mature individuals have been identified from a given habitat, it is often possible to come to a reasonable conclusion concerning the specific identity of the immatures with hairs, those without hairs, or both.

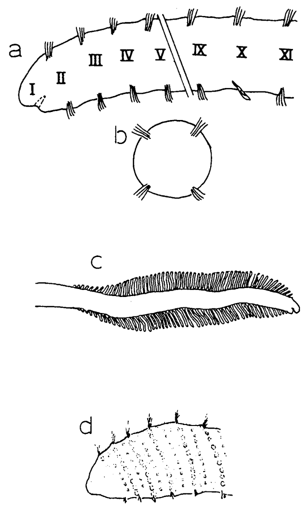

FIGURE 1. Portions of the body of tubificids; a) longitudinal side view of a generalized tubificid showing the method of numbering segments. Setae are borne on all segments except the first (I). b) cross-sectional view of generalized tubificid showing dorso-lateral and ventro-lateral bundles of setae. c) posterior end of *Branchiura sowerbyi* showing dorsal and ventral gills. d) anterior end of *Peloscolex multisetosus* showing characteristic papillation of body wall. DRAWINGS ARE NOT ALL TO SAME SCALE.

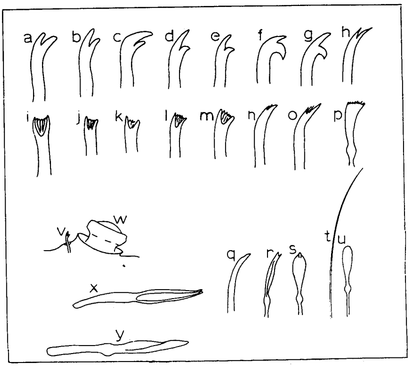

FIGURE 2. Setae of Tubificidae: a-h) various bifid setae; a,b) as of many *Limnodrilus* species, c) anterior of *L. udekemianus,* d) anterior ventral of *Ilyodrilus templetoni,* e) anterior ventral of *Tubifex tubifex,* f) posterior ventral of *Peloscolex multisetosus multisetosus,* g) posterior ventral of *P. m. longidentus,* h) ventral of *Aulodrilus limnobius,* i-p) various pectinate setae; i) *Peloscolex multisetosus,* j,k) *Tubifex tubifex,* 1) *Ilyodrilus templetoni,* m) *Potamothrix hammoniensis,* n,o) *Aulodrilus pluriseta,* p) *A. americanus.* q) simple anterior seta of *Aulodrilus americanus,* r,s) lateral and facial view of flattened dorsal seta of *A. limnobius,* t,u) hair and dorsal "oar shaped" setae of *A. pigueti,* v,w) penial seta and penis of *Potamothrix moldaviensis,* x) spermathecal seta of *P. moldaviensis,* y) spermathecal seta of *P. hammoniensis.* DRAWINGS NOT ALL TO SAME SCALE.

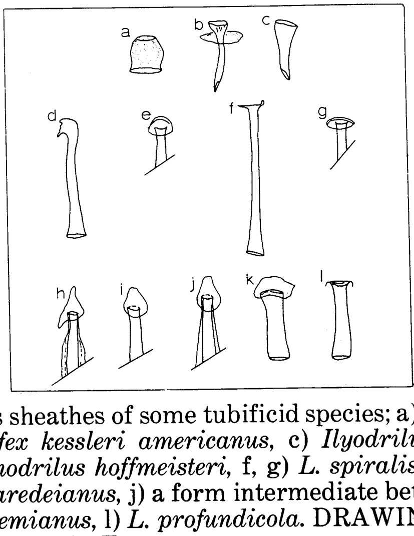

FIGURE 3. Penis sheathes of some tubificid species; a) *Tubifex tubifex,* b) *Tubifex kessleri americanus,* c) *Ilyodrilus templetoni,* d,e) *Limnodrilus hoffmeisteri,* f, g) *L. spiralis,* h) *L. cervix,* i) *L. claparedeianus,* j) a form intermediate between h and i, k) *L. udekemianus,* l) *L. profundicola.* DRAWINGS NOT ALL TO SAME SCALE.

KEY TO TUBIFICIDAE

Known from the Inland Waters of Wisconsin

1 Posterior segments of worm bearing prominent gill filaments (Fig. 1c) .... *Branchiura sowerbyi*

1' No gill filaments on posterior segments 2

2(1') Hair setae present in anterior dorsal bundles 3

2' Hair setae absent 10

3(2) Body wall bearing papillae in two rows on each segment; row of large papillae in line with the setae, row of smaller papillae in between (Fig. 1d) . .*Peloscolex multisetosus* 4

3' No papillae, body wall naked 5

4(3) Posterior ventral setae with distal tooth as short or shorter than the proximal tooth (Fig. 2f)..... *Peloscolex multisetosus multisetosus*

4' Posterior ventral setae with distal tooth longer than the proximal tooth (Fig. 2g)............... *Peloscolex multisetosus longidentus*

5(3') Dorsal bundles behind segment VII with hair setae and oar-shaped setae (Fig. 2t, u), no pectinate setae .... *Aulodrilus pigueti*

5' No oar-shaped setae, anterior dorsal bundles containing pectinate setae.. 6

6(5') Pectinate setae with reduced distal tooth and only one or two intermediate teeth which are about the same size as the distal tooth (Fig. 2n, o)................................ *Aulodrilus pluriseta*

6' Pectinate setae having both lateral teeth considerably larger than the intermediate teeth (Fig. 2j-m)........................... 7

7(6') Mature specimens bearing modified genital setae . . . *Potamothrix* .... *hammoniensis*[1]

7' No specialized genital setae; mature specimens with cuticular penis sheathes (Fig. 3a-1)................................. 8

8(7') Penis sheathes short, tub shaped (Fig. 3a) .... *Tubifex tubifex*

8' Penis sheathes elongate, tapering distally 9

9(8') Penis sheathes narrowly conical but with a broad base, distal end pointed, opening lateral (Fig. 3b) . . . *Tubifex kessleri americanus*

9' Penis sheathes conical (often wrinkled in whole mounts); opening lateral, oblique or terminal (Fig. 3c) ...... *Ilyodrilus templetoni*

10(2') Anterior setae simple or with distal tooth much reduced (Fig. 2q), posterior dorsal setae broadly palmate (Fig. 2p) ..... *Aulodrilus* .... *americanus*

10' Anterior setae distinctly bifid, no palmate setae 11

11(10') Anterior ventral setae with distal tooth much thicker and longer than the proximal and set at nearly a right angle to the shaft (Fig. 2c), mature specimens with penis sheathes as in Fig. 3k .... *Limnodrilus udekemianus*

11' Anterior ventral setae with distal tooth as thin or thinner than the proximal and shorter, equal, or only slightly longer than the proximal tooth 12

12(11') Dorsal setae of median and posterior segments broadly flattened just below teeth (Fig. 2r, s), anterior dorsal and ventral setae with distal tooth much thinner and shorter than the proximal (Fig. 2h) .... *Aulodrilus limnobius*

12' No broadly flattened setae in dorsal bundles, anterior dorsal and ventral setae with the distal tooth at the least only slightly thinner and shorter than the proximal 13

13(12') Mature specimens bearing modified genital setae in the region of segment X; these spermathecal setae relatively large and broad (Fig. 2x); may also have fleshy penes with accessory penial setae (Fig. 2v, w) on segment XI .... *Potamothrix moldaviensis*

13' No specialized genital setae; mature specimens with cuticular penis sheathes in the region of segment XI 14

14(13') Fully mature specimens with penis sheathes at least thirty times as long as width at base 15

14' Fully mature specimens with penis sheathes no longer than fifteen times width at base 16

15(14) Penis sheathes with thick two-layered walls, narrowing and the walls becoming thinner abruptly just below the head, head of penis sheath triangular, not bilaterally symmetrical (Fig. 3h). .... *Limnodrilus cervix*[2]

15' Penis sheathes with thin walls, the sheath not narrowing abruptly near the head, head of sheath pear shaped and bilaterally symmetrical (Fig. 3i) .... *Limnodrilus claparedeianus*[2]

16(14') Penis sheathes relatively long, 300-900 μ when fully developed.17

16' Penis sheathes short, 200-300 μ when fully developed 18

17(16) Head of penis sheath a hood turned at a sharp angle to the shaft (Fig. 3d, e) .... *Limnodrilus hoffmeisteri*

17' Head of penis sheath a broad plate which is slightly upturned at one point (Fig. 3f, g) .... *Limnodrilus spiralis*[3]

18(16') Anterior ventral setae with distal tooth much longer and thicker than the proximal and set at nearly a right angle to the shaft (Fig. 2c), penis sheathes as in Fig. 3k...... *Limnodrilus udekemianus*

18 Anterior ventral setae with distal tooth at most slightly longer and typically somewhat thinner than the proximal (Fig. 2a, b), penis sheathes as in Fig. 31 .... *Limnodrilus profundicola*

NOTATIONS CONCERNING TAXONOMIC PROBLEMS

[1]*Potamothrix hammoniensis, P. bavaricus* and *P. bedoti* would all key out to this point. These are morphologically very similar and one or more of them occur in Wisconsin. Howmiller (1974) reported *P. hammoniensis* from Lake Geneva but the report was based upon few specimens and some judgment was involved in the identification. As mentioned by Brinkhurst and Jamieson (1971) there is considerable variation in form of spermathecal setae within this species. *Potamothrix hammoniensis* has been reported only twice before from North American (Brinkhurst 1967, Howmiller and Beeton 1970). *Potamothrix bavaricus* has been more frequently found but Timm (1972) feels that all records should be referred to *P.* (as *Euilyodrilus*) *bedoti.* Timm (1970, 1972) and Hrabe (1967) distinguish between *P. bavaricus* and *P. bedoti* on the basis of differences in placement and form of the spermathecal setae. Brinkhurst (1965) believes that *bedoti* was established on the basis of unusual specimens of *bavaricus* and thus considers *bedoti* a synonym of the latter (Brinkhurst and Jamieson 1971).

[2]In many North American collections, it is difficult to distinguish between *Limnodrilus cervix* and *L. claparedeianus* on the basis of penis sheath morphology (Figs. 3h, i). Specimens with sheaths intermediate in form (Fig. 3i) are often more common than those considered characteristic of either of the two species. It would seem that, in these cases, they do not form separate populations and recognition of this should be made by reporting the presence of specimens appearing to be *cervix* - *claparedeianus* intermediates.

[3]Brinkhurst (1965, Brinkhurst and Jamieson 1971) considers this form to be a variant of *L. hoffmeisteri* and treats the name *spiralis* as a synonym. Cook and Johnson (1974) have suggested that *spiralis* may be a hydrid between *L. hoffmeisteri* and *L. claparedeianus* but some authors (cf. Kinney

1972) treat it as a distinct taxon. We recognize *L. spiralis* because, in addition to being morphologically distinct, some evidence indicates that it may be ecologically different from typical *L. hoffmeisteri* and that it may occur with *L. hoffmeisteri* where *L. claparedeianus* is apparently not present (Howmiller 1974, and unpublished observations of Loden).

Characteristics Used in Identification of Naididae

The morphology of the setae of naidids is similar to that of tubificids. One difference in the terminology is that the setae associated with the hairs in the dorsal bundles are referred to as "needle setae". These are not necessarily needle-shaped, but, depending on the species, may vary in appearance from hair-like to sigmoid bifid structures resembling the ventral setae.

Features present in many naidids which do not occur in tubificids include eyespots (normally found in *Nais*, *Arcteonais* and *Stylaria*; Fig. 4d,e) elongation of the prostomium to form a proboscis (*Stylaria*, *Arcteonais*, some *Pristina*; Fig. 4b, d, e), and rather elaborate posterior gills (*Dero*, Fig. 4c).

All the species of Naididae may be identified from immature specimens. As these worms typically reproduce asexually, mature specimens are found only infrequently. These may be recognized by swelling of the body in the clitellar region (V-VIII) and, in some species, by the presence of genital setae.

Specimens frequently consist of chains of zooids which develop and separate from the parent worm to become new individuals. When worms are preserved, the zooids often separate, creating difficulty in determining the number of worms in the original sample. Useful indicators to determine if a particular specimen is a fragment of a worm include the shape of the prostomium, the segment on which the dorsal setae begin, and the shape of the anterior ventral setae. In the genus *Dero* the posterior zooid will have a complete set of gills, while an anterior fragment will usually have the gills missing or incomplete.

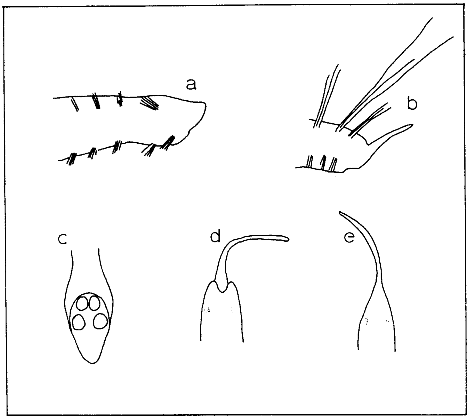

FIGURE 4. Portions of the body of some Naididae; a) anterior end of *Amphichaeta leydigii,* b) anterior end of *Pristina longiseta leidyi,* c) posterior end of *Dero (Dero) nivea,* d) anterior end of *Stylaria lacustris,* e) anterior end of *S. fossularis.* DRAWINGS NOT ALL TO SAME SCALE.

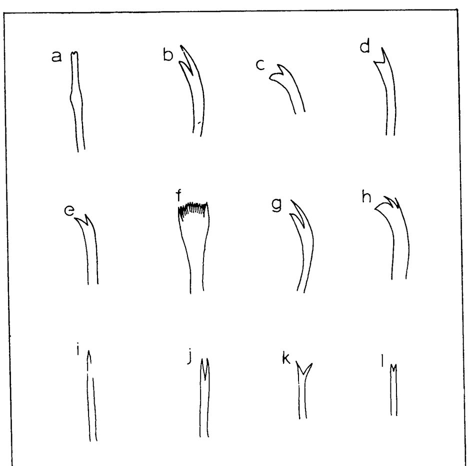

FIGURE 5. Setae of some Naididae; a) needle seta of *Ophidonais serpentina,* b) anterior seta of *Paranais frici,* c) *Piguetiella michiganensis,* d) needle of *Dero (Dero) digitata,* e) needle of *Dero (Aulophorus) furcatus,* f) palmate needle of *Dero (Aulophorus) vagus,* g) needle of *Haemonais waldvogeli,* h) seta of ventral side of VI, *Vejdovskyella intermedia,* i)needle of *Nais simplex,* j) needle of *N. elinguis,* k) needle of *N. communis,* l) needle of *N. variabilis.* DRAWINGS NOT ALL TO SAME SCALE.

KEY TO NAIDIDAE

Known from the Inland Waters of Wisconsin

1 Dorsal setae present 3
1' Dorsal setae absent 2

2(1') Setae of II 130 μ or greater in length ... *Chaetogaster diaphanus*
2' Setae of II less than 130 μ in length ... *Chaetogaster diastrophus*

3(1') Hair setae present in dorsal bundles 7
3' Hair setae absent 4

4(3') Dorsal bundles consist of one broad, simple-pointed or slightly cleft seta (may be absent in many segments) (Fig. 5a) .... *Ophidonais serpentina*
4' Dorsal setae distinctly bifid 5

5(4') Dorsal setae start in segment III (Fig. 4a). (These are very small worms, frequently found in plankton samples.) .... *Amphichaeta leydigii*[1]
5' Dorsal setae start behind segment III 6

6(5') Dorsal setae start in segment V (Fig. 5b) .... *Paranais frici*
6' Dorsal setae start in segment VI (Fig. 5c). .... *Piguetiella michiganensis*

7(3) Dorsal setae start in segment II (Fig. 4b) .... *Pristina longiseta leidyi*[2]
7' Dorsal setae start behind segment II 8

8(7') Posterior end modified to form caudal gills[3] 9
8' Gills absent 12

9(8) A pair of non-retractile palps associated with gills 11
9' Palps absent 10

10(9') Branchial fossa extended behind gills (Fig. 4c) .... *Dero (Dero) nivea*
10' Branchial fossa not extended; distal tooth of needle seta longer than proximal (Fig. 5d) .... *Dero (Dero) digitata*

11(9) Needles palmate (Fig. 5f) .... *Dero (Aulophorus) vagus*
11' Needles bifid; distal tooth shorter than proximal (Fig. 5c) .... *Dero (Aulophorus) furcatus*

12(8') Dorsal setae start from approximately XVI (Fig. 5g) .... *Haemonais waldvogeli*
12' Dorsal setae start from V or VI 13

13(12') Prostomium formed into a proboscis 14
13' Proboscis absent 16

14(13) Dorsal bundles with 1-3 hair setae 15
14′ More than 5 hair setae per dorsal bundle, arranged in a fanshape .... *Arcteonais lomondi*

15(14) Proboscis arises from an invagination of the prostomium (Fig. 4d) .... *Stylaria lacustris*
15' Proboscis arises from the tip of the prostomium (Fig. 4e)....... .... *Stylaria fossularis*

16(13') Hair setae strongly serrated, more than three per bundle 17
16' Hair setae usually smooth, less than three per bundle 18

17(16) Posteriorly from VI ventral setae one per bundle; a thickened seta normally present in VI (Fig. 5h) ...... *Vejdovskyella intermedia*[4]
17' Posteriorly from VI ventral setae more than one per bundle, no thickened setae present.................. *Vejdovskyella comata*

18(16') Needle setae simple-pointed (Fig. 5i) ....*Nais simplex*
18' Needle setae bifid 19

19(18') Teeth of needle setae elongate, parallel (Fig. 5j) ...*Nais elinguis*
19' Teeth of needle setae shorter.............................. 20

20(19') Teeth of needle setae divergent (Fig. 5k); ventral setae of II-V resemble those of posterior segments .... *Nais communis*
20' Teeth of needle setae more closely applied (Fig. 5l) .... *Nais variabilis*[5]

NOTATIONS CONCERNING TAXONOMIC PROBLEMS

[1]The genus *Amphichaeta* has been inadequately studied. Jarl Hiltunen (pers. comm.) believes that more than one species of worm resembling *A. leydigii* may be present in collections from Wisconsin. The differences among the specimens are ignored in this key pending future studies of this group.

[2]Harman and McMahan (1975) have recently completed a study of this species, which may now be more correctly referred to as *Pristina leidyi.*

[3]Incomplete specimens of *Dero* will not key out.

[4]Brinkhurst (Brinkhurst and Jamieson 1971) considers *Vejdovskyella intermedia* to be a junior synonym of *V. comata* because of the merging of characters. Populations have been found in Wisconsin which show the distinctive characters which Sperber (1948) described and these two species have thus been separated in the present key.

[5]*Nais variabilis* is an extremely variable species and may be virtually indistinguishable from *N. communis* (Brinkhurst 1966, Brinkhurst and

Jamieson 1971) or *N. elinguis* (Loden, unpublished data).

The taxonomic problems to which we have referred in our notes reflect, to some extent, the limited number of characters which these soft-bodied animals offer the taxonomist who bases his analyses on morphological grounds. Some of these problems may be solved by biochemical approaches (cf. Milbrink and Nyman 1973a and b) but ecologists will also be able to make important contributions, "For where is the species that has no ecological reality?" (Brinkhurst and Jamieson 1971). We hope that the field biologist or ecologist contemplating work with the aquatic oligochaetes will not be dismayed by minor taxonomic problems such as those we have alluded to. Without ecological knowledge the taxonomists' judgments will not be put to the final test.

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†ADDENDUM

On 18 June, 1976 Dr. Richard P. Howmiller died from injuries sustained in a vehicle accident. His untimely death is a tragic loss to the scientific community, and his outstanding achievements will be remembered for years to come. This paper is published posthumously.

GEORGE JOHNSTON: FIRST SETTLER IN OSHKOSH

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Oshkosh

It is commonly thought in Oshkosh that the first white settler was Webster Stanley, who, in the fall of 1836, built a cabin northwest of present day Bowen Street and Bay Shore Drive. Stanley's arrival is memorialized by the name of Webster Stanley Junior High School and by a monument on the southwest corner of Bay Shore Drive and Bowen Street. An examination of available evidence, however, indicates Webster Stanley was not the first white settler of Oshkosh, George Johnston was.

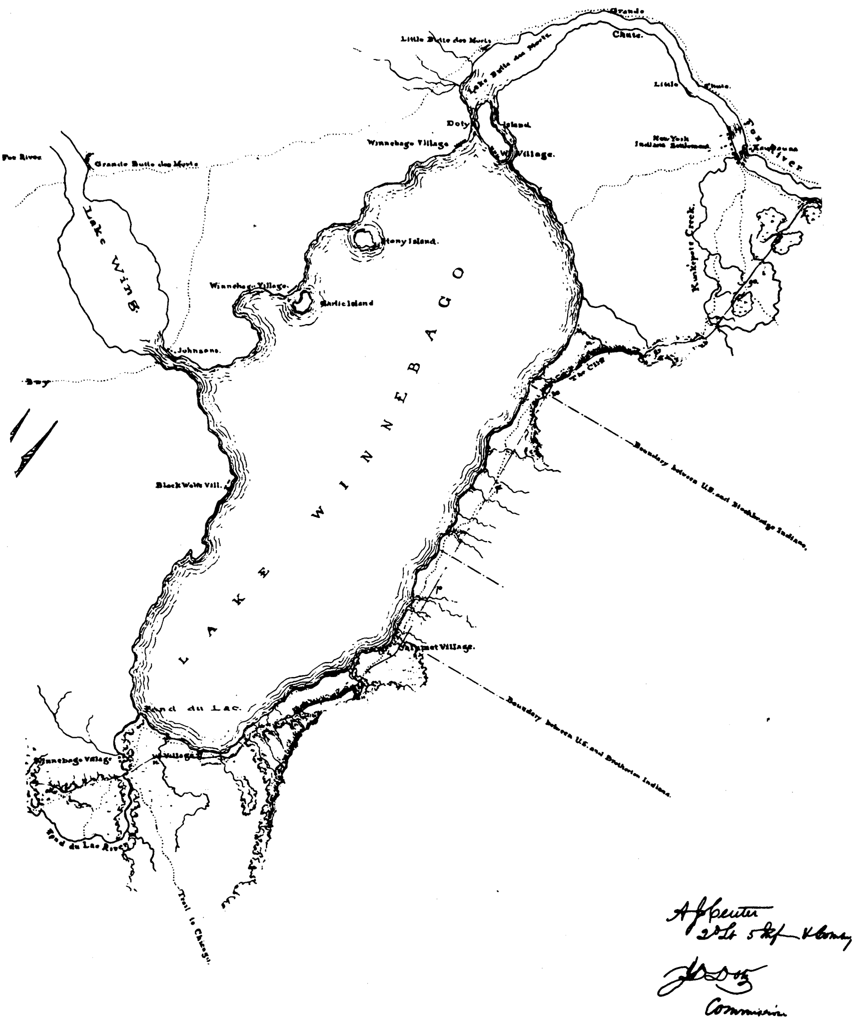
The first white settlement in present Winnebago County, Wisconsin, occurred in 1818 when Augustin Grignon and his junior partner, Louis B. Porlier, built a fur trading post on the north shore of Lake Butte des Morts. Grignon and Porlier were Green Bay fur traders working for John Jacob Astor's American Fur Company. The Butte des Morts trading post was located a short distance east of the present day unincorporated village of Butte des Morts.[1]

Historians acknowledge that the second settlement in Winnebago County occurred about 1830 in the "Algoma" vicinity at the foot of Lake Butte des Morts. The first settler in the second settlement appears to have been George Johnston, whose cabin, tavern and ferry are indicated on a map of the mail trail between Forts Howard, Winnebago and Crawford, drawn by 2nd Lt. Alexander J. Center from field notes made in the fall of 1832 (Fig. 1). The map also indicates the only other human habitations in the Oshkosh vicinity in 1832: Pesheu's band of Winnebago Indians opposite Garlic Island, and Black Wolf's Winnebago village in the present day Town of Black Wolf.[2]

The third settlement occurred in the fall of 1836, when Chester Gallup and his son-in-law, Webster Stanley, built their cabins on the north bank of the upper Fox River on the point of land between the mouth of the upper Fox and the shore of Lake Winnebago.[3]

Despite the facts of settlement stated above, historians of Winnebago County and of the city of Oshkosh have insisted that Webster Stanley and Chester Gallup, co-founders of the third settlement in the county, were the first settlers of what later became the city of Oshkosh. Richard Harney, quoted frequently, states his reasoning as follows:

N° 3.


Grande
Chute.
Little Butte des Morts
Lake Butte des Morts
Little
Chute.
Fox River
Doty
Island
Winnebago Village
W. Village.
New York
Indians Settlement
Fox River
Grande Butte des Morts
Lake Wing.
Stony Island.
Winnebago Village.
Garlic Island
Kunkepots Creek
Johnsons.
The Clif
Black Wolfs Vill.
LAKE WINNEBAGO
Boundary between U.S. and Stockbridge Indians.
Calumet Village.
Fond du Lac.
Winnebago Village
Village
Fond du Lac River
Boundary between U.S. and Brothertown Indians.
Trail to Chicago.
Commissioner

> The first permanent settlers in Winnebago County, *in its American occupation*, were the (Webster) Stanleys and the (Chester) Gallups, who settled at the present site of Oshkosh in 1836. *Those who preceded them were temporary occupants, either connected with the old French-Indian occupation, or in the employment of the government, and moving with the Indians from place to place.* That settlement which produces substantial results in the progress and improvement of a country was now to commence.[4]

William A. Titus is the most skeptical of the Webster Stanley-first settler of Oshkosh thesis. He declared "Webster Stanley in 1836 . . . became, probably, the first permanent settler (of Oshkosh)," but in the very same paragraph he conceded thoughtfully that "James Knaggs, a half-breed, was running a tavern and a ferry," and was "living on the Oshkosh site before Stanley came, so perhaps it may be said more accurately that the latter was the first white settler."[5] Had Titus examined the ownership of Knaggs' properties more closely he would have found that James Knaggs was the third, not the first, owner of the house, tavern and ferry, and that the original builder-owner was George Johnston.

After a careful examination of the available evidence we find the Harney interpretation to be in error. We have found that the first settler was indeed George Johnston, who built and occupied a home and operated a tavern and a ferry for several years after the summer of 1830 at "Algoma" on a site which is included in the south end of Riverside Cemetery on the Northeast Bank of the upper Fox River in present day Oshkosh.

Dr. Lyman C. Draper, first superintendent of the State Historical Society of Wisconsin (1854-1886), interviewed Louis B. Porlier at Butte des Morts shortly before Porlier died. Speaking of his recollections of fur trading and pioneer days in Winnebago County, Porlier discussed a mail trail established in 1826 between Fort Howard at Green Bay and Fort Crawford at Prairie du Chien, and described the fact that the orginal mail trail downstream from Omro ran through a swamp and over a floating bog, yet had a firm enough footing for a horse and rider to reach a boat landing within some 200 yards of the north shore of Lake Butte des Morts on which the pioneer settlement of Butte des Morts had been built. Porlier then recalled that:

> In 1833 another trail was chosen for the mail route, crossing what is now called Coon's Point in Ward five in Oshkosh (i.e., vicinity of 20th century Rainbow Park). George Johnston of Shantytown (an urbanized area of Green Bay on the east side of the river between the

site of Camp Smith and the Fox River) and father of William Johnston the Indian interpreter, desiring to take advantage of this fact, erected that season one or two log houses at Algoma opposite Coon's Point (i.e., vicinity of Riverside Cemetery); bringing his family up (from Shantytown) he commenced business as ferryman and tavern-keeper.[6]

Porlier's narrative expressed uncertainty as to why George Johnston, after going to the extensive labor of building a home for his family, a tavern-warehouse and a ferry, sold the whole property to Robert Grignon after operating it for only a very short time:

> For some reason, possibly the unprofitableness of the business, he soon sold out to Robert Grignon, who employed young Augustin Grignon, a natural half-breed son of the old trader, to manage the business for him. In 1835 he (Robert Grignon) sold to James Knaggs, a Pottawattomie half-breed, who had been in the Grignon-Porlier trading company's employ at Point Boss for six years (on the Wisconsin River south of Wisconsin Rapids).[7]

Another eyewitness of the first building by white men in Oshkosh was Juliette (Mrs. John) Kinzie, wife of the U. S. Indian Agent at Portage, Wisconsin. Mrs. Kinzie, the first woman to ride by horseback on the mail trail from Green Bay to Portage in the late fall of 1831, reports in her classic book *Wau-Bun:*

> When we reached Knaggs (at Algoma on Lake Butte des Morts)... the cosy little room in which we found Mrs. James Knaggs and the bright fire were most cheering objects; and we ... did ample justice to her nice coffee and cakes, not to mention venison steaks and bear's meat.

Juliette Kinzie was far less enthusiastic about her accommodations for the night as she described the tavern-warehouse building next door;

> The old building next door to Knagg's residence in which we slept consisted of one room, bare and dirty. A huge chimney, in which a few brands were burning, occupied nearly one side of the apartment. Against another was built a rickety sort of bunk. This was the only vestige of furniture to be seen. The floor was thickly covered with mud and dirt... Next morning we cheerfully took our breakfast and were ferried over the river to continue on the trail from that point to Bellefontaine, twelve miles distant from Fort Winnebago.[8]

Lt. Center's map published in 1833 is entitled "Route of the Military Road from Fort Crawford to Fort Howard via Fort

Winnebago." It demonstrates beyond reasonable doubt that George Johnston preceded Webster Stanley on the site of Oshkosh and had already built the cabin, tavern and ferry at least as early as the summer-fall of 1832, when Lt. Center's surveying party passed this way.[9]

Richard Harney's account of the founding of the second settlement in Winnebago County at Algoma is similar to Porlier's statement, although Harney located Johnston's buildings on Coon's Point rather than across the river from it, as Porlier recalled. Harney for some unknown reason identified the year as 1835:

> George Johnson, [Johnston] father of William Johnson, [Johnston] the Indian interpreter, built two log houses, established a ferry and opened a tavern at Coon's Point in 1835. He subsequently sold the whole establishment to Robert Grignon and William Powell. They afterwards sold the same to James Knaggs, a half-breed.[10]

A sifting and winnowing of the testimony of Louis Porlier, Juliette Kinzie, Martin Mitchell, Richard Harney and the map of Lt. Center seems to reveal that the first buildings in the Algoma area were placed there sometime within the years 1829 and 1832. The above authorities also agree that the original builder of these log buildings and ferry was George Johnston of Shantytown (Green Bay) and agree further that Johnston's property was purchased subsequently by Robert Grignon and William Powell, probably in 1831 or 1832.

While the date of Johnston's building is open to some doubt, as is the year in which Grignon and Powell bought Johnston's property, logic suggests that it was at least as early as the spring of 1830. We are inclined to think that the fall of 1829 or earlier is less probable, since Johnston's appointment as sheriff of Brown County did not expire until December 31, 1829. Since frequent and rapid communication between the sheriff and the county judge was often important, then as now, Johnston would not have been free to leave Green Bay and begin another business, several days distant, until his term as sheriff had expired. By the spring of 1830, however, he would be freed for the ferry and tavern business at the Algoma crossing at Lake Butte des Morts.

Normally the dates and other facts of ownership of land can be traced through deeds, mortgages, probate records, tax records, etc., on file in a county courthouse. In this case, proof of ownership is clouded by the fact of squatter occupancy and squatter sales. Johnston's buildings and ferry had been constructed with actual or tacit permission of the Menominee Indians who owned the land north of the Fox River and Lake Butte des Morts until it was sold to the U. S. Government on August 29, 1836 at the Treaty of the Cedar. Johnston's action appears to have been regarded benevolently by the Augustin Grignon family, the original white settlers in Winnebago County, because when Johnston sold the ferry, tavern and residence after only a short occupancy he sold to Robert Grignon. Furthermore, when James Knaggs, a former Grignon employee, bought the ferry and tavern from Robert Grignon, he was enabled to do so by virtue of a loan from Marie Grignon, widow of Robert Grignon's brother, Charles.

The U. S. Government survey of Section 10, Township 18 North, Range 16 East, 4th Meridian in Wisconsin Territory in which Johnston's property lay was made by David Giddings on January 24, 1839 and the government survey map was published by the U. S. Surveyor General's office at Dubuque, September 28, 1839. The above described land was offered for public sale April 7, 1840 by order of a proclamation dated 7 December, 1839. The Wisconsin Territorial *Local Office Tract Book* (44: 81/1/1) in the Library of the State Historical Society of Wisconsin contains an entry showing that James Knaggs bought lots four and five (73.34 acres) in Section 10, Township 18 North, Range 16 East at the Green Bay Land Office for $1.25 per acre on April 4, 1840.

Since Knaggs purchased his land on April 4, 1840 before the land was available at public sale on April 7, 1840, we conclude that he and his predecessors (George Johnston and Robert Grignon) had all been squatters at the sufferance of the Menominee Indians and had no legal title to the property prior to Knaggs purchase of the land from the U. S. Government. Marie Grignon apparently loaned Knaggs the money to purchase his property, taking a mortgage as security. The mortgage was paid off on November 2, 1842; Knaggs' land patent on this property is dated on September 1, 1946. Part of Knaggs' land was included in the original boundaries of the city of Oshkosh, according to Brown County Register of Deeds, *Deeds*, L, 319; *Mortgages* I. 13-14.

If George Johnston was the first settler at Oshkosh, who and what kind of man was he? Bella French [11] says Johnston was born in Rockingham County in the Shenandoah Valley of Virginia in 1784. When he left home as a young man, he apparently went to Detroit in Michigan Territory and in 1810 married Phyllis Jane Fearson from Kentucky. When the War of 1812 broke out, he enlisted as a second lieutenant in Captain Richard Smyth's company of volunteer cavalry of the Territory of Michigan, a detachment of Major Witherell under the command of Brigadier General Hull, then commanding the army at Detroit. Johnston's pay was $33.33 per month plus a subsistence allowance of about $4.00 per day.[12]

In the War of 1812 Fort Mackinac was captured and Fort Dearborn at Chicago was evacuated in the very early days of the war, and on August 16, 1812, General Hull was forced to surrender Detroit and his entire garrison, including George Johnston. Lt. Johnston was among the American prisoners of war who were sent to Fort George in Upper Canada. He was parolled March 6, 1813 and on June 13, 1813 received three months of army pay from the regimental paymaster of the U. S. 13th Infantry, then in the field in upstate New York, by order of Major General Lewis, C.O., 13th Infantry. He was promoted to first lieutenant at the same time and served until his one year enlistment expired.[13]

Johnston arrived home in Detroit on October, 1813, and on October 22, 1813, enlisted as a second lieutenant in Captain Isaac Lee's company of cavalry of the Legionary Corps, Michigan Militia commanded by Lt. Colonel Richard Smith. This time both he and his horse enlisted and served 182 days; Johnston was paid $200 and his horse an additional $72.80 for "horse hire". Discharged in the spring of 1814, Johnston is said to have joined Captain James Oderen's company of Michigan Volunteer "Mounted Men" and to have served to the end of the War of 1812. The informality of his final discharge, i.e., simply departure for home without benefit of formal discharge papers, was to delay his efforts shortly before his death in 1851 to qualify for "bounty land," i.e., 160 acres of land granted to eligible veterans of the War of 1812. His widow in Green Bay ultimately was granted the land, but it was more because U. S. Senator Lewis Cass still remembered Johnston personally from Michigan Territorial days than because of the completeness of his military records.

According to Bella French, Johnston took part in the War of 1812 Battle of Brownstown, where he was mentioned favorably in the army reports, and on being exchanged as a prisoner at Fort George he joined the army of William H. Harrison and participated in the Battle of the Thames. Miss French declares further that:

> At the close of the War of 1812 Johnston was appointed sutler and stationed in 1818 at Fort Howard, Green Bay. He built a house opposite where Astor afterwards was located (i.e., on the west side of the Fox River) and his place was known for many years as the "Green Tree House," from a magnificent old elm which stood in front of his

door . . . Captain George Johnston was a brother-in-law of Major William Whistler of Fort Howard.[14]

In addition to running the Fort Howard sutler's store, the *Territorial Papers of the United States* reveal that George Johnston was appointed sheriff and constable for Brown County on October 27, 1818 by Michigan Territorial Governor Lewis Cass. Johnston was reappointed periodically as sheriff and constable of Brown County, serving until December 31, 1829.[15]

Governor Cass also appointed him on June 12, 1819 to the office of lieutenant in the Michigan Territorial Militia. He was promoted to captain on September 6, 1822 and served on active duty as a captain of volunteer militia from Brown County in both the Winnebago Indian (Red Bird) Disturbance of 1827 and the Black Hawk War of 1832.[16]

Johnston's civic involvement included appointment as a supervisor of highways in and for the township of Green Bay, and voting and service as one of four inspectors in election of a Michigan Territorial Delegate to the U. S. Congress which were held at Green Bay in September of 1821, 1823 and 1825. Johnston also voted on June 30, 1825, in an election of a Brown County member to serve in the Michigan Territorial Council.[17] In 1823 he was a member of the Green Bay School Board. The Board found suitable quarters for a school, hired Amos Carter as tutor, and instructed him to teach in English and not to mention the subject of religion. Johnston paid $12.00 per quarter for the education of his three scholars but received $7.60 in return for delivery of three cords of wood for heating the schoolroom.

In the 1820s he became sufficiently prominent among Green Bay people that he was invited to sign four different petitions to the U. S. Congress. The first petition was an appeal on December 12, 1821 of 58 Green Bay and Fox River residents who objected to the date of July 1, 1796 as the time at which their occupancy of lands had to have commenced for such land claims to be valid. The petition explained:

> Your petitioners for the most part emigrated at an early period from Canada or are the descendants of such emigrants . . . They continued according to established custom to occupy and cultivate, with the assent of the tribe interested, such portions of Indian land as their necessities required . . . They trust that . . . they will not be expelled from those possessions upon which the subsistence of some of your petitioners depends . . .

Other prominent Green Bay and Fox River men who signed the above petition were Jacques Porlier, Augustin Grignon, Pierre Grignon, Robert Grignon, Charles Grignon, Charles Reaum, Jacques Vieau and Robert Irwin.[18]

The second petition which Johnston signed was dated September 28, 1824 asking Congress to create a new (Wisconsin) territory from the portion of Michigan Territory west of Lake Michigan. On this occasion he was the third signer after such prominent early Green Bay personalities as Robert Irwin and Henry Baird. The fifty signers from Green Bay also suggested that the capital of the new territory should be established at Green Bay in Brown County. While this petition in 1824 was a little premature, Congress in 1836, only twelve years later, granted the wishes of residents west of Lake Michigan by creating Wisconsin Territory.[19]

Virtually the same petition for the creation of a Wisconsin territorial government was sent to Congress in September, 1829, Johnston this time being numbered among the thirty signers from Green Bay. Two days later he was among 37 Green Bay signers of a petition to Congress asking that the federal government build a canal between Lake Winnebago and Kaukauna around the twenty miles of rapids on the lower Fox River and a canal at Portage between the Fox and Wisconsin Rivers.[20]

Church records sometimes help to identify a person's presence in an area and also may reveal something of his probable philosophy and behavior. For example, George Johnston is listed in the Green Bay Episcopal Church records for 1826 as having received two votes for vestryman, probably indicating he was an Episcopalian.[21] This presumption is strengthened by a recollection of Henry Merrell that he was a charter member of a Masonic Lodge in 1823:

> Some of the leading citizens of Green Bay, as well as the men of the fort, wished to organize a Lodge of Free Masons in the Northwest. This group of men met at George Johnston's home on December 27, 1823, to write up a petition . . . which Johnston and nine others signed. A lodge of free and accepted Masons was organized at Fort Howard and was named Menominee. It lasted until 1830.[22]

The possibility that Johnston was quite tolerant is indicated by his contribution to a travel fund of Father Badin, the Catholic priest in Green Bay, who was going to Detroit. Shortly afterward, Johnston, on June 14, 1831, pledged to contribute $5.00 to Father Mazzuchelli "for the purpose of erecting a Catholic church at the settlement of Green Bay".[23] An atmosphere of religious toleration in the Johnston house is probably indicated by the fact that his son, T. J. Johnston, became Catholic Vicar General of Texas.

It was noted earlier that Johnston's appointment as sheriff of Brown County expired on December 31, 1829. Whether he had sought reappointment is unknown, although Ebenezer Child's "Recollections" say that the Brown County Representative to the Michigan Territorial Legislature, Robert Irwin, Jr., "procured the appointment of his father, Robert Irwin, senior, as sheriff in place of Johnston," but an interesting incident then occurred:

> Irwin had twenty days to qualify; but a few days after the arrival of his appointment, a man by the name of Hempstead was to be hung for murder, and Major Irwin refused to qualify before the culprit was executed as he did not wish to signalize his advent into office by hanging a fellow-being. Johnston refused to serve in this case, for he had been sheriff a number of years, had not before been called on to execute a man for a capital offense (furthermore, he hadn't been reappointed sheriff) and he declared that his last act should not be one of that character.[24]

Judge James Duane Doty, according to Childs, solved this impasse by appointing Ebenezer Childs sheriff. Childs qualified, carried out the execution and served as Brown County sheriff under both Michigan Territorial Governor Cass and Wisconsin's first territorial governor, Henry Dodge.

During the Winnebago Indian Disturbance of 1827, sometimes called the Red Bird Uprising, Michigan Territorial Militia Captain Johnston enlisted and led a company of Green Bay volunteer militia in support of a small detachment of Fort Howard troops commanded by Major Whistler, 2nd U. S. Infantry.[25] Major Whistler's force marched by order of General Atkinson from Green Bay to Portage and fortified themselves on a hill just east of the upper Fox River which several years later became the site of Fort Winnebago.

At approximately the same time another force of 500 men from Jefferson Barracks at St. Louis commanded by General Atkinson had moved to Prairie du Chien and then toward Portage from the southwest, and a force of four companies of the 5th Infantry commanded by Colonel Snelling had returned to Fort Crawford from their fort at St. Paul, Minnesota. General Henry Dodge came north from the lead mines area with mounted volunteer militia and additional volunteer militia was set in motion from Galena and Prairie du Chien. The rapid concentration of overwhelming military force which converged on the heart of the Winnebago country from three directions, coupled with the failure of their Indian allies to appear so astounded the Winnebagoes that they concluded that fighting the Americans would not only be useless, but would probably result in the total destruction of the Winnebago Tribe. Accordingly, the chiefs selected "sacrificial goats" in the persons of Chief Red Bird and an accomplice in the murders of some whites near La Crosse which had precipitated the uprising, to sacrifice themselves in behalf of the tribe by surrendering to the Americans.

As one of the company commanders in Major Whistler's camp at the Portage, Captain Johnston undoubtedly witnessed the climactic event of the Winnebago Disturbance of 1827 when Chief Red Bird and his accomplice walked into Whistler's camp to the accompaniment of conspicuous Winnebago ceremony, to surrender themselves in behalf of the Winnebagoes on September 3, 1827.[26]

Major Whistler promptly transferred them to General Atkinson who sent the prisoners to Fort Crawford enroute to St. Louis. With the disturbance over, Johnston's militia company returned to Green Bay for mustering out in late September, 1827.

George Johnston's second tour of duty as a Michigan territorial militia captain came in the late spring of 1832 with the outbreak of the Black Hawk War. Jesse F. Johnston, his son, wrote a letter to his brother, Rev. T. J. Johnston of San Antonio, the Catholic Vicar-General of Texas, that:

> Colonel George Boyd (then Indian Agent at Green Bay) offered father a commission in June, 1832, as a captain in an Indian force of more than 300 composed of two bands of Menominees . . . The first was led by (Chief) Oshkosh, the commissioned officers being Augustin Grignon and Lieutenants Charles Grignon and Robert Grignon. The second band had Grizzly Bear as chief (so termed by Colonel Samuel C. Stambaugh) and was officered by Captain George Johnston and Lieutenants William Powell and James Boyd, son of the Indian Agent.[27]

Four records exist of Johnston's service in the Black Hawk War, each adding an additional fragment to the mosaic of his career. Augustin Grignon of Butte des Morts, speaking of the Menominee Indian companies of volunteer militia under the command of Colonel Stambaugh, declared "we started from the Bay and proceeded to Great Butte des Morts and there crossed over to the present place of Robert Grignon [whose farm extended from Eagle Street and Lake Butte des Morts in present day Oshkosh, south to

Ninth Street and west to beyond Highway 41]. From there we went to Portage . . .".[28]

Moses Strong, author of *The Indian Wars of Wisconsin*, in describing the forces arrayed against Black Hawk's Sauks, wrote, "the Menominee Indians . . . over 300 . . . were divided into two companies, one commanded by Charles A. Grignon, the other by George Johnston and both under command of Colonel Stambaugh . . .".[29]

The "Recollections of Colonel Ebenezer Childs", who lived for many years in Green Bay before moving to La Crosse, agrees that "the Menominee Indian corps in the Black Hawk War was commanded by Colonel Stambaugh aided by Captains George Johnston and Augustin Grignon". Colonel George Boyd's papers add that "Lieutenant Johnston with the Menominee Company under his command was in the 'fight' at the final battle with Black Hawk on the Mississippi thirty miles north of Prairie du Chien".[30]

Johnston's military service record for the Black Hawk War shows that his company of Menominee Indians commenced their service on 20 July, 1832, marched under orders of General Atkinson, were part of the battalion under the command of Colonel Samuel C. Stambaugh, and were mustered out at Green Bay on 28 August, 1832.[31]

We know only a little about George Johnston's business, his civic or other activities from the fall of 1832 until his death in 1851. However, in 1835 there were unclaimed letters in the Green Bay Post Office for an extended period addressed to Mrs. George Johnston, possibly indicating that the Johnston family may have been living away from Green Bay. The best guess seems to be that they were probably at Neenah (Winnebago Rapids) in 1835 where Johnston appears to have had a federal job running the Menominee Indian grist mill. According to Oshkosh early settler W. W. Wright:

> We arrived at Winnebago Rapids in the fall of 1836 and found a grist and saw mill, a blacksmith shop and a number of log dwelling houses, all built by the Government for the use of the Menominee Indians. The grist mill was run by a Mr. Johnson (familiarly known as Colonel Johnson) . . . He received six hundred dollars a year for tending the mill, from the government . . . By special invitation, my father and I took dinner with Colonel Johnson, and shortly after we embarked, as our boat had been safely carried over the falls.[32]

The 1840 Census of the U.S.A. listed a George Johnston family living in Brown County. An 1841 record in the Brown County

Register of Deeds shows that George Johnston loaned $100 to Samuel S. Johnston, secured by a promissory note and mortgage to 80 acres of land. The Brown County record states further that the above note was paid in full on August 16, 1843, and the mortgage cancelled.[33] A notation in the *General Index: 1839-1845* of the Brown County Register of Deeds, 1, indicates George Johnston was a justice of the peace judge in 1844 and possibly before and after that day, in the Town of Howard.

Our last record of Johnston prior to his death in 1851 was an effort he began on November 30, 1850, to qualify for a federal land grant of 160 acres given to War of 1812 veterans by an act of Congress passed September 28, 1850. George Johnston, then aged 67 years and a resident of Green Bay, is reported by Notary Public Samuel Ryan to have appeared before him for the purpose of swearing by affidavit to details of his military service in the War of 1812. The Johnston application was allowed by the U.S. Commissioner of Pensions. Records of the former General Land Office now in the National Archives show that Military Land Warrant #17539 was issued on May 20, 1852 to Phyllis J. Johnston, widow of George Johnston. On September 25, 1852, she sold this warrant to Timothy Vaughan of Marquette County, Wisconsin, who, on October 2, 1852, used it to locate the NW 1/4 sec. 14, T. 15 N., R. 10E. in the Menasha Land District in Wisconsin.[34]

On February 13, 1851, the Green Bay *Advocate* carried the following obituary:

> George Johnston died at Green Bay February 6, 1851, aged 67 years. Colonel Johnston was one of the early settlers of Green Bay. He was the first sheriff of Brown County 1818-1829, having been appointed by Governor Cass at the organization of Brown and Crawford Counties which then comprised the State of Wisconsin.

Johnston's attending physician, Dr. W. H. Bodgete, listed the cause of death as "apoplectic disease," which we today call a stroke or heart attack.[35]

In retrospect the question still remains as to why Mitchell, Harney, Lawson and other Nineteenth Century historians felt that Webster Stanley was the first settler in Oshkosh in 1836 when George Johnston had built his cabin, tavern and ferry on the city of Oshkosh site between 1830 and 1832. There seem to be at least three necessarily speculative answers, the foremost being that the Nineteenth Century historians of Oshkosh probably never knew that James Knaggs, whose importance they dismissed as a mere "half-breed", was the third rather than the first owner of the house-tavern-ferry at Algoma.

A second answer is that the White-Anglosaxon-Protestant-Yankee businessman in Winnebago County's third settlement at the mouth of the upper Fox River had strong feelings of ethnic, religious and sociological disdain for the French-Canadian and "half-breed" Catholic fur traders at Algoma and Butte des Morts. For verification, reread Harney's language quoted on page 200.

Probably the most compelling reason for ignoring evidence of earlier settlement was the fact that the Yankee settlement at the mouth of the river grew so rapidly after 1846 that it was able to include the portion of Algoma on the northeast bank of the Fox in the 1853 incorporation of the city of Oshkosh and annexed the remaining portion of Algoma on the west bank by act of the Wisconsin Legislature in 1856. Observers who were impressed by the far greater business and residential growth in the Yankee settlement after 1846 in contrast to the slower development in the same period at Algoma, might understandably reason that if the nucleus of the city's later development had been in the Yankee settlement, the first resident in that settlement must, therefore, be the first resident of the city, despite historically demonstrable facts to the contrary.

A strong psychology of manifest destiny on the part of the Yankee frontier businessmen in the city of Oshkosh appears to have caused them to brush aside any facts of earlier settlement by people who, in their opinion, had a lesser civilization-producing capacity than their own. Ironically, this happened despite the fact that George Johnston was a Virginian of Scotch extraction, an Episcopalian, a Mason, the first merchant in Oshkosh, and was a man who had a far better military record in behalf of the United States than any other man in town.

NOTATIONS

1. "Recollections of Augustin Grignon," State Historical Society of Wisconsin, *Collections*, III: 197-295.

2. The "Algoma" vicinity in the 1830s included the lands on both sides of the upper Fox River at the foot of Lake Butte des Morts. Such present day sites on both sides of the river as the Paine Art Center Arboretum and Riverside Cemetery, as well as Rainbow Park, were in the "Algoma" vicinity. The copy of Lt. Center's map was made from Center's map in the Manuscripts and Maps Section, State Historical Society Wisconsin.

3. Mitchell, Martin, and Joseph H. Osborn. *Geographical and Statistical History of the County of Winnebago, Wisconsin,* 65-66, Oshkosh: Markham and Felker, 1856.

Harney, Richard. *History of Winnebago County,* 97-98, Oshkosh: Allen and Hicks, 1880.

4. Harney, op. cit. 97-98; emphasis supplied. Other historians who have accepted the above interpretation crediting Webster Stanley with being the first settler include:

Lawson, Publius V. *History of Winnebago County,* I, 170; 501. Chicago: C. F. Cooper and Co. 1908.

Oshkosh City Directory, 1857, 1866, etc.

Titus, Wm. A. (ed.). *History of the Fox River Valley, Lake Michigan and Green Bay Region.* II, 672. Chicago: S. J. Clarke, 1930.

Western Historical Co., *History of Northern Wisconsin,* 1122. Chicago: Western Historical Co., A. T. Andreas, Proprietor. 1881.

5. Titus, op. cit. 672.

6. State Historical Society of Wisconsin, *Collections,* XV, 440-441. While Porlier said the mail trail was shifted to Algoma in 1833, Lt. Center's map shows Johnston was already in business there in 1832.

7. S.H.S.W., *Collections* op. cit. 440-441.

8. Kinzie, Juliette A. *Wau-Bun,* 312-313. New York: Derby and Jackson, 1856. (Menasha: George Banta Co., 1930). It is hard to reconcile Mrs. Kinzie's date of 1831 for her visit to the Knaggs home with the Center map reporting Johnson there in 1832. It may be that, since *Wau-Bun* was not written until the 1850s, Mrs. Kinzie's memory for dates might be in error.

9. The original copy of Lt. Center's map and field notes, according to A. E. Smith, *History of Wisconsin,* I, 473, 1973, are in the Records of the Office of Geography, National Resources Division, Cartographic Branch, R. G. 324, National Archives. The vicinity of Lake Winnebago and the site of Oshkosh are mapped on manuscript sheet No. 3.

10. Harney, op. cit. 97. The Michigan Legislative Council passed acts in 1827 and 1833 providing for licensing and bonding of operators of public ferries (*Laws of Michigan Territory,* III, 1070-1072). However, a letter to the author on 4/22/75 from the State Historical Society of Wisconsin reports that "while the papers of the Brown County Circuit Court include a dozen or so bonds given ferry operators between the early 1820s and 1840 when Winnebago County was created, none of these ferries operated in the Lake Butte des Morts area."

11. French, Bella. *The American Sketch Book: History of Brown County, Wisconsin,* 55. Green Bay: American Sketch Book Co. 1876.

12. Military Service Records, National Archives (GSA), Affidavit of Phyllis J. Johnston, November 21, 1851, to Commissioner of Pensions, Department of Interior, re: claim to bounty land.

13. Military Service Records: War of 1812: Michigan Territorial Volunteer Militia, Johnston, George.

14. French, Bella. op. cit., 55-56.

15. Carter, C. E. (ed.). *Territorial Papers of the United States.* X, 879; XI, 384, 578. Washington: USGPO, 1943.

16. Carter, op. cit. XI, 308, 896.

17. Carter, op. cit. XI, 199, 200, 201, 209-210, 456, 460-461, 467, 481, 896, 898, 916, 917.

18. George Johnston's name usually was spelled with a "t", although he himself as well as his acquaintances occasionally wrote it Johnson. In this citation, for example, the reference in Carter XI, 190 and 201 spells the name as Johnson but two other references by the same source on p. 199 and p. 200 and 201 describing the same election and listing the same four inspectors, spell the name as Johnston. Richard Harney's reference (10) to Johnston always spells it without the "t", i.e., Johnson.

19. Carter, op. cit. XI, 578, 591.

20. Carter, op. cit. XII, 63, 71.

21. State Historical Society of Wisconsin, *Collections*, XIV, 163, 452.

22. S.H.S.W., *Collections*, VII, 1876. Henry Merrell, "Pioneer Life in Wisconsin", 377.

23. S.H.S.W., *Collections*, XIV, 163, 170-171, 452.

24. S.H.S.W. *Collections*, IV, Ebenezer Childs, "Recollections of Wisconsin Since 1820", 182. See also Bella French, op. cit., 68.

25. Records of the 1820s and 1830s report two different George Johnstons, one a resident of Green Bay and the other of Sault Ste. Marie. Four circumstances prove beyond reasonable doubt that the Sault Ste. Marie Johnston was a different man from the Green Bay resident.

> The Sault Ste. Marie George Johnston was a half Chippewa whose father had been a fur trader at Sault Ste. Marie and Mackinac and whose sister was the first wife of the famous Indian agent and author, Henry R. Schoolcraft. "Meingun", as he was familiarly called, was a fur trader around Lake Superior and in northwestern Minnesota in the 1820s and a sub-agent of the Sault Ste. Marie Indian Agency at

LaPointe between 1826 and 1833. By contrast, the Green Bay George Johnston was a Virginian who was brother-in-law of Major William Whistler at Fort Howard, sheriff of Brown County 1818-1829, militia captain, etc. The decisive fact is that both men voted in two different elections for Michigan Territorial Delegate to the U.S. Congress. The elections, of course, were held on the same day in Green Bay and Sault Ste. Marie and it would have been humanly impossible for one man to have been in both settlements on the same day, because of the travel distance between these communities.

26. Peter Lawrence Scanlon, *Prairie du Chien: French, British, American.* Menasha: George Banta, 1937.

27. French, Bella. op. cit. 79-80. See also S.H.S.W. "Grignon's Recollections", *Collections*, III, 294.

28. S.H.S.W. *Collections*, III, 294.

29. S.H.S.W. *Collections*, VIII, 276.

30. S.H.S.W. *Collections*, IV, 186; XII, 279, 281, 288.

31. U. S. Military Service Record: Black Hawk War: George M. Johnston.

32. W. W. Wright. *Oshkosh Daily Northwestern*, January 22, 1897, p. 3, col. 2. Richard Harney, op. cit. 98, says the Winnebago Rapids miller was Col. David Johnson.

33. Brown County *Mortgages*, II, 98-100.

34. Letter to author dated May 19, 1975, from J. L. Hargett, Asst. Dir. Gen. Archives Division, National Archives and Records Service, Washington, D. C.

35. George Johnston's obituary titles him Colonel but search of his army service records in the National Archives has produced no record of any federal military service following his mustering out from the Black Hawk War in 1832. However, since Captain Johnston had held a military status both in the War of 1812 and in the Michigan Territorial Militia in 1819-1832, it may have been that he continued to hold a military status after 28 August, 1832. This possibility is difficult to check as the records of the Wisconsin National Guard do not start until after the Civil War.

It may also have been that Johnston's title of Colonel was merely honorific. W. W. Wright's recollection from 1836 that Johnston "was familiarly known as colonel . . . " plus the fact that it would have been most unusual for a man to have been promoted from captain to colonel between 1832 and 1836 even in the militia in the absence of a military emergency seems to support the conclusion that the title was honorary.

In any case, the French inhabitants of Green Bay usually referred to him as *Le Grand Sheriff.*

LIMNOLOGICAL OBSERVATIONS OF A WISCONSIN SPRING-FED FARM POND

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ABSTRACT

Limnological characteristics of a small, spring-fed trout pond located near Madison, Wisconsin, are reported. Extreme vertical stratifications of oxygen and temperature were observed except when high winds promoted mixing. The measured productivity of the pond (30g 0_2 /M^2/day) is among the highest values reported for unpolluted waters. Chemical-biological features of the pond, including nutrient limitation, are discussed.

INTRODUCTION

During the summer of 1968 a survey was made of the chemical limnology of several types of farm ponds commonly found in southern Wisconsin. Of the ponds studied, spring-fed ponds, which are often stocked with trout, exhibited some atypical physico-chemical properties compared with other ponds and lakes in the area. A brief description of the features of one of these ponds, designated Otteson Pond, is discussed here.

METHODS

Both soluble orthophosphate and total phosphate were analyzed according to Standard Methods (1971) by the stannous chloride procedure. Total phosphorus samples were digested with a potassium persulfate. The brucine method (Standard Methods, 1971) was used to determine nitrate nitrogen. Atomic absorption spectroscopy was used to analyze calcium (Bentley, 1967). Dissolved oxygen and temperature were read *in situ* with a YSI Model 54 Oxygen Analyzer. Additional information on the environmental procedures has been presented by Sonzogni (1969).

Characteristics of the Pond

Otteson Pond, located about 15 miles south of Madison, Wisconsin, is representative of the type of cold water ponds found in the area. It has an average depth of about 2 m, a surface area of approx. 0.3 hectares, and steep side slopes. The spring feeding the pond is about 25 m from the pond, the flow being on the order of 380 1/min (water residence time about 10 days). Otteson Pond water was quite clear and supported a dense bottom flora composed principally of *Chara*. The pond was stocked with brook trout.

RESULTS

Some typical summertime chemical characterstics of the spring water and of the pond surface water are shown in Table 1. The high alkalinity, calcium concentration, specific conductance and nitrate concentration of the spring water, as well as the low phosphorus level, reflect to a large extent the characteristic ground water of the area. Of interest is the difference in specific conductance, alkalinity and calcium concentration between the spring and the pond, apparently the consequence of the precipitation of the dissolved minerals (viz. calcium) within the pond. Biological processes play an important role in this precipitation, as evidenced by the marl encrusted *Chara* which lined the bottom of the pond. *Chara* is well known for its ability to precipitate very large quantities of calcium carbonate (Curtis, 1959; Fassett, 1972).

Except when modified by an unusually high wind stress the pond was thermally stratified. Extreme vertical gradients of dissolved oxygen (DO) were also observed, with the concentration difference between the surface and the bottom recorded to be nearly 10 mg/1 at times. An example of an oxygen/temperature profile which was typical of normal, summer daytime conditions (mostly sunny with low wind velocity) is shown in Fig. 1. Highest DO concentrations (frequently in excess of 20 mg/1) were always found near the bottom. Thus, daytime oxygen profiles in the ponds studied were the inverse of oxygen profiles commonly found in lakes and lake oriented ponds. Similar profiles may be expected to occur in other ponds with large benthic populations of photosynthesizing organisms similar to the *Chara* mats which lined the bottom of Otteson Pond.

It should be noted that the trout stocked in these ponds were able to live without acute physiological effects in a habitat which had

TABLE 1. CHEMICAL CHARACTERISTICS OF THE POND SYSTEM[1]

Water Sample	Soluble Ortho P	Total P	Nitrate	Calcium	Specific Conductance	pH	Total Alkalinity
	mg/1 P	mg/1 P	mg/1 N	mg/1	μ mhos/cm at 25C		mg/1 as $CaCO_3$
Spring	< 0.02	<0.03	6.6	71.0	785	7.5	299
Pond	< 0.02	<0.03	5.6	26.5	555	8.4	244

[1]Based upon samples collected on 8/24/68, except for calcium (7/26/68).

marked vertical DO gradients. The grossly supersaturated DO found in the pond, especially near the bottom, might be expected to produce embolism in these fish. However, no mortality of the fish was noted during the course of the study which could be attributed to environmental conditions within the pond.

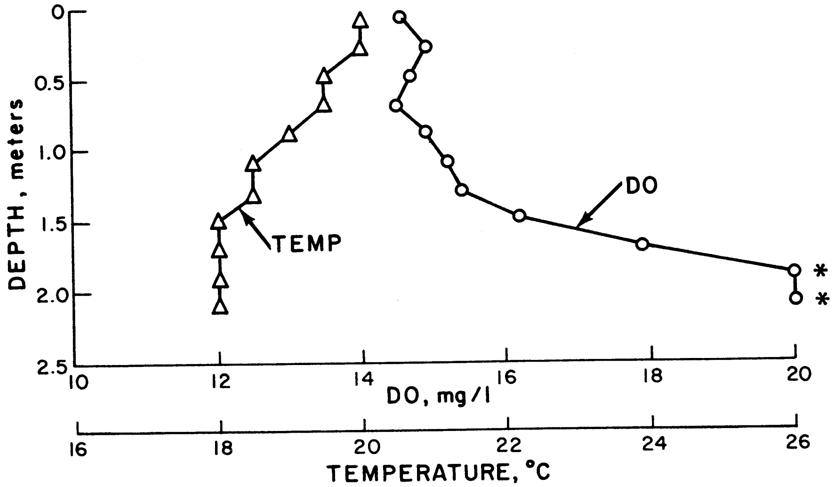

FIGURE 1. Dissolved Oxygen (DO) and temperature (T) profile showing the stratified conditions of Otteson Pond on August 13, 1968 (11:15 A.M., E.D.S.T.)

*Actual concentration greater than 20 mg/1 (above the calibrated range of the oxygen analyzer).

TABLE 2. GROSS PHOTOSYNTHETIC PRODUCTIVITY (PG) AND TOTAL COMMUNITY RESPIRATION (R) ON AUGUST 24-25, 1968.

Uncorr. for Diffusion		Corr. for Diffusion	
Pg	R	Pg	R
g 0_2 /m²/day		g 0_2 /m²/day	
21.6	22.8	30.6	4.6

Results uncorrected (k=0 g 0_2 /m³/hr at 0 percent saturation) and corrected (k=1 g 0_2 /m³/hr at 0 percent saturation) for diffusion.

Primary Productivity of the Pond

Because of the small wind fetch of the pond, only during very windy conditions was the pond observed to destratify. Such was the case in late August (1968) when a cold front passed through the area producing winds of about 30 mph, a wind velocity sufficient to mix the pond. Because of the mixed condition at this time it was possible to make a rough estimation of pond productivity based on a single sampling station, by the free water method of Odum and Hoskin (1958). The metabolic rates which were determined, both corrected and uncorrected for diffusion, are presented in Table 2. Oxygen measurements made at other times during the summer indicated that large diurnal oxygen changes, and consequently high metabolic rates, were not uncommon.

Gaseous diffusion corrections were made according to the method of Odum (1956), with a diffusion constant of 1.0 g 0_2 /m^3/hr at 0 percent saturation. Such a constant approximates an upper limit to diffusion, based on diffusion constants determined for similar environments (O'Connor, 1958; Odum, 1960; Odum and Wilson, 1962; Copeland and Duffer, 1964), so that comparing results corrected for diffusion with those uncorrected should provide the range between which the true values are likely to be found.

The gross photosynthetic productivity estimated for Otteson Pond, even disregarding oxygen diffusion, was within the range reported for some of the most highly productive aquatic environments. For example, extremely productive polluted environments such as waste stabilization ponds and sewage lagoons are reported to have gross photosynthetic production rates ranging from 14 to 50 g 0_2 /m^2/ day (Bartsch and Allum, 1957; Copeland and Dorris, 1962; Minter and Copeland, 1962; Odum and Wilson, 1962; Copeland and Dorris, 1964). Enormously productive unpolluted waters of low organic content include environments such as coral reefs, saline grass communities and artesian calcareous springs. Gross photosynthetic productivities computed for these environments generally exceed 20 g 0_2 /m^2/day (Odum, 1956). Odum (1957) reported a gross photosynthetic productivity of 64 g 0_2 /m^2/day for a Florida spring. Odum and Hoskin (1958) reported the photosynthetic production of a turtle grass community in a Texas bay to be almost 30 g 0_2 /m^2/day. The gross photosynthetic productivity estimated for spring-fed Otteson Pond, even disregarding diffusion, falls within the range of highly productive aquatic environments. Such potential for high primary production should be considered in the management of similar spring-fed cold water ponds.

There is a tendency in some of the recent limnological literature to equate marl lakes with low-productivity waters. On the other hand, fisheries biologists in the upper Midwest generally find that hard-water lakes tend to have more primary and secondary productivity than do soft-water lakes that do not deposit $CaCO_3$ in the sediments. This study has shown that several small farm ponds which are marl-depositing are very highly productive, and therefore tends to support the general observations of the fisheries biologists in the upper Great Lakes states.

The nitrate nitrogen concentration was relatively high but not at toxic level in the pond system (Table 1). Phosphorus, however, was always less than 0.02 mg/1 P. However, as Odum (1956) has pointed out, low nutrient waters can still be productive as long as sufficient flow is maintained to replenish nutrients and remove waste products.

Limiting Nutrient

The data presented in Table 1 show that phosphorus is most likely to be the element limiting aquatic plant growth in this water. In order to verify this conclusion a series of algal bioassays were run. Generally, the rate of uptake of ammonia nitrogen by algae (in the dark) is four to five times faster for algae grown in a medium with surplus nitrogen as opposed to those grown in a nitrogen-deficit medium (Fitzgerald, 1968). Likewise, a considerable quantity of soluble orthophosphate can only be extracted from those algae which have a luxurious (surplus) supply of phosphorus (Fitzgerald and Nelson, 1966). Based on these general relationships, algae from the ponds have been tested to determine whether they have had

TABLE 3. EXTRACTED SOLUBLE ORTHOPHOSPHATE AND THE AMMONIA NITROGEN UPTAKE RATE IN THE DARK OF ALGAE SAMPLED FROM OTTESON POND

Type of Algae	Extractable P mg P/100 mg algae	Ammonia uptake μg N/10 mg algae/hr
Chara gathered off bottom	0.007	2
Chara gathered off bottom	0.003	1
Chara gathered off bottom	0.008	1

limited or surplus amounts of nitrogen and phosphorus available.

Table 3 shows that algae from the pond had very little extractable soluble orthophosphate. In these samples *Chara* was the principal algal species analyzed. Fitzgerald and Nelson (1966) concluded after testing many different types of algae (although not *Chara*), that when the amount of extractable soluble orthophosphate (as phosphorus) was below 0.08% of the total weight of the algae, growth of the algae was probably phosphorus limited. Hence, the growth of the *Chara* samples analyzed were most probably limited to some extent by lack of available phosphorus.

The *Chara* samples taken from the pond not only contained the least extractable phosphorus, but also had the slowest nitrogen uptake rate. By comparison to data obtained from algae and aquatic weeds by Fitzgerald (1968), surplus nitrogen was available. The results of these studies tend to support the conclusions that phosphorus was limiting *Chara* production in the pond.

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MAN'S HISTORIC ATTITUDE TOWARD THE ENVIRONMENT*

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GENESIS OF THE PROBLEM

Man's recent concern for the quality of the environment represents a belated recognition of a problem of long standing, in fact one which dates back to an early period in human history. As long as he was merely a gatherer, man's population was small and he, like all animal species, stressed the environment so slightly that easy adjustment was possible.

With his mastery of fire-keeping he acquired the capacity to control his environment, as no species ever had before. The anthropologist Coon[1] has put it very succinctly:

> The use of fire is the only open-and-shut difference between man and all other animals. Fire was the first source of power which man found out how to use which did not come from the conversion of food and air into energy inside his own body. In Early Pleistocene times he made beautiful tools and brought up his children without it. In Middle Pleistocene he used it only to warm his knuckles in the mouth of a cave. In Late Pleistocene times it made him a more efficient animal, and during the last eight thousand years he has found increasing uses for it, and burned ever greater quantities of fuel. Fire has been the key to his rapid rise in mastering the forces of nature, his conquest and partial destruction of the earth, and his current problems.

As a consequence of his mastery of fire, coupled with his handiwork as a toolmaker and the capacity, associated with his large brain, for sophisticated communication, the human species took on a position of dominance which enabled it to stablize the food supply, and thereby, to enhance its chances for survival as a species. It was possible, through control of fire, to escape the physiological limitations which originally restricted the species to a tropical habitat; this permitted it to spread through the temperate zones where there existed an abundant food supply. Man could indulge in

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the luxury of a small population explosion. Ten thousand years ago the planet earth carried perhaps five million persons.

The anthropological record reveals that man has been a predator throughout most of his existence. We cannot ever know the reality of his thoughts toward his environment, except by a hazardous extrapolation from present day paleolithic cultures. Such extrapolation suggests an ambivalence. On the one hand, nature was recognized as cruel and man must fight continually for survival, taking from nature that which was essential to survival. On the other hand, the environment was not an inexhaustible source of food, so man must not take more than he could decently consume. Perhaps an ethic developed which was protective of the female food animal accompanied by her young, as is practiced today among the Australian aborigenes.

When the agricultural revolution began about 10,000 years ago, it created substantial changes. As hunter and gatherer, the human species moved with the food supply. As agriculturist, the species abandoned its nomadic ways and became settled. The domestication of the cereal grains, flax, cotton, legumes, and fruits concurrently with the goat, sheep, cow, and pig led to both an abundance and a stability in the food supply. These circumstances permitted another increase in population. In fact, the combination of successful agriculture, stable food supply, and population increase ultimately led to the beginnings of urbanization in the river valleys of the Eastern Hemisphere.

Urbanization was accompanied by a strong element of specialization which allowed some humans to be divorced from activities required of generalists in a natural setting. There arose a political class, a priesthood, a peasantry concerned with water control, and scribes, smiths, tanners, weavers, and soldiers. As the urban system became more complex there was less opportunity for the understanding of nature as a total system and consequently, a tendency to seek for control of environmental factors through simplistic procedures.

The patterns developed in the urban centers of the ancient world were favorable to strengthening the position of the human species with respect to most other species. With the development of a stable agriculture in a reasonably stable political system, population growth could continue. An increased population in a stable rural-urban system capable of modest expansion led to an increase of leisure and the rise of sophisticated art, poetry, music, and philosophy. More often the increasing population created internal strains leading sometimes to colonization of unoccupied lands, frequently to warfare with less crowded neighbors. Generally, there was sufficient unsettled territory that the defeated who escaped enslavement could establish themselves on new lands.

As antiquity merged into the medieval ages the pattern saw little change, if anything a retreat. Life generally was hard and a man frequently lived out his life within a few miles of his place of birth. Then, possibly in the sixth century, there took place a revolution in agriculture which had profound implications. The heavy wheeled plow came into use in northern Europe. The scratch plow, so common in the Mediterranean basin where it was satisfactory on the light arid soils of the region, was unsuited to the heavy, wet sod of the north. A coulter made a vertical slice through the soil, a horizontal plowshare cut the roots beneath the sod, a moldboard then violently overturned the grassy mass of soil. This heavy implement, requiring the draught power of several spans of oxen, opened the fertile, well-watered soils of northern Europe to highly productive agriculture. The population increase which followed is testimony to the enlarged capacity for agricultural productivity. In time, the increased population exceeded that essential for agriculture, as witness a new wave of urbanization.

Through a period of several centuries there was not only a new level of specialization but a period of inventiveness which saw more efficient harnessing of animal, wind, and water power. Concurrently, the development of iron mines in northern Europe made available larger quantities of metal superior for weapons, armor, and cutting tools.

Improved productivity again stimulated population growth which in turn stimulated specialization, with improved productivity. It also stimulated the prosperity culminating in the era of the great navigations which opened a vastly increased knowledge of the earth.

By 1650 the world population had grown to perhaps 500 million. Thus in ten thousand years the human population had doubled nearly seven times, an average doubling time of about 1500 years (although the doubling time had certainly not been uniform, it had probably been shortening appreciably during the Christian Era). During the next 200 years (by 1850) the population doubled again to one billion. By 1930 (in 80 years) the population rose to two billion; by 1975 another doubling has taken place in only 45 years.

The rapid rise in population since 1650 occurred when science provided substantial application in technology, agriculture, and medicine. This spinoff from basic science has been particularly noteworthy during the past one hundred years.

HUMAN STRAINS ON THE ENVIRONMENT

Whenever a particular species undergoes a population explosion there is a serious strain on the environment which, if sustained, is certain to cause deterioration before readjustment to a new equilibrium state is reached. Normally, such population explosions are self defeating, since the increase in numbers quickly exceeds the capacity of the supporting food supply. In the meantime, an increase in numbers makes life easier for predators which undergo a belated but complementary population increase, which in turn leads to a decline in the prey, followed by a decline in predators.

With the human species such environmental self-regulation has failed. Although not well endowed physically to escape his natural enemies or to protect himself when cornered, man has, through his tool-using capacity, been able not only to defend himself but to become a major aggressor among his fellow creatures. Further, by the domestication of selected species of plants and animals he has been able to assure himself a reasonably stable supply of food and clothing.

Despite its benefits for the human species, agriculture leads to ecological catastrophe. In its most rigorous application, agriculture tends to create areas of a monoculture, an intensive husbandry of a single species, either plant or animal. In actual practice, animal husbandry avoids to a degree the extremes of plant husbandry because animal husbandry requires the availability of pasture or feed crop areas. When intelligently practiced, a combination of animal and plant husbandry can lead to a sustained, moderately well-balanced operation. Such practice is, unfortunately, observed too rarely. The slash and burn agriculture of primitive tribes represented an environmental strain of only minor severity, because the cleared area was comparatively small. In a few years, when soil exhaustion occurred, natural growth took over once more as the tribe moved elsewhere. Settled agriculture, particularly when supportive of an urban community, constitutes the creation of a largely synthetic environment in which normal natural processes have little chance of success. In fact, such agriculture displaces normal flora, and may in time lead to the exhaustion of the capacity of the soil.

Wise agricultural practices, however, are capable of maintaining soil fertility in such a manner that long time cultivation can be practiced. As Franklin H. King revealed in his book, *Farmers of Forty Centuries* (1911), the farmers of China, Korea, and Japan learned through experience the need to work with the land, not to fight it.[2] Through the use of manures and composts, and careful tillage practices they were able to maintain the productive capacity of the land through at least four millenia. In medieval Europe also a careful program of crop rotation combined with a fallow period was developed.

All too frequently, other farmers have not been so perceptive. In Northern Africa and the Middle East, with its light soils and arid climate, the popularity of the goat has been a disaster. This rugged animal, with its capacity to survive on marginal forage in a dry climate, has been a popular beast. It has been pastured on rugged terrain where it crops the grasses close to the ground and does extensive damage to roots with its sharp hooves. Denuded hillsides quickly become prone to serious erosion by wind. Even the small amounts of rainfall in these denuded areas lead to further erosion. In fact, there are some who believe the climate and terrain of northern Africa and western Asia became transformed to their present state as a consequence of an agriculture heavily oriented to raising goats and sheep.

Studies by Reid Bryson and his associates suggest that the Rajputan Desert of northwestern India is a consequence of such misuse of the land.[3] The meteorological data for this region do not fit the pattern of typical deserts (the air over the Rajputan contains as much moisture as the air above the Amazon Valley, or the Congo); on the contrary, every square mile in northwest India has five and one half tons of fine dust suspended over it, an amount greater than that above a smoky, dirty, foggy large city. Examination of archeological records for the region revealed that 4000 years ago it was a flourishing agricultural area inhabited by the Harappans. With the growth of the cities of Harappa and Mohenjo-Daro the area under cultivation was steadily expanded. As the grass cover was removed by plowing and grazing, the dust content of the atmosphere increased and desert-like conditions became apparent. By 1500 B.C. the Harappans disappeared, apparently because the land would no longer support their agriculture. In time, the land recovered sufficiently to attract a new wave of immigrants. Around 500 B.C. the region became sparsely populated by pastoral Aryans whose animals quickly cancelled the recovery and made the region the desert which it is today.

Such overgrazing is now evident elsewhere in the world. Among pastoral tribes in Africa, such as the Masai, cattle are prized not only as food but as a status symbol. Large acreages are being denuded by herds of gaunt, undernourished cows. With the obvious need for additional pasture, the wild lands of Africa are continually encroached with great hazard to the survival of the world's last pool of large wild mammals. In the western United States, cattle and sheep ranchers apply continuous pressure on the Department of the Interior to permit pasturage on government reserves, frequently to the point where the carrying capacity of the reserves is seriously exceeded.

All too frequently, the farmer has looked upon the environment as an enemy to be overcome, rather than as an associate to be understood. Lynn White attributes this attitude to the influence of Western Christianity. He considers the introduction of the heavy wheeled plow to have been a critical turning point. The power and violence with which it attacked the soil placed man in a new position of power over the environment. White says,[4]

> Man's relation to the soil was profoundly changed. Formerly man had been part of nature; now he was the exploiter of nature. Nowhere else in the world did farmers develop any analogous agricultural implement. Is it coincidence that modern technology, with its ruthlessness toward nature, has so largely been produced by descendants of these peasants of northern Europe?
>
> This same exploitive attitude appears slightly before A.D. 830 in Western illustrated calendars. In older calendars the months were shown as passive personifications. The new Frankish calendars, which set the style for the Middle Ages, are very different; they show men coercing the world around them — plowing, harvesting, chopping trees, butchering pigs. Man and nature are two things, and man is master. These novelties seem to be in harmony with larger intellectual patterns. What people do about their ecology depends on what they think about themselves in relation to things around them. Human ecology is deeply conditioned by beliefs about our nature and destiny — that is, by religion. To Western eyes this is very evident in, say, India or Ceylon. It is equally true of ourselves and of our medieval ancestors.

Perhaps White is guilty of oversimplification. The contempt for the natural environment is obvious in cultures other than medieval Christian. Nevertheless, his example represents a persuasive case history.

Urbanization has likewise been a prime cause of environmental deterioration, since the city, by nature, creates an alteration of the land which makes it generally unsuitable for survival of all but a small number of animal and plant species.

The concentration of large numbers of persons in comparatively small areas creates support problems of large magnitude. In addition to the input of vast amounts of food and energy, the city demands vast quantities of water which must be drawn from outside, sometimes from great distances. Vitruvius, the leading architect of Octavian Rome, gave major attention to the problem of water supply in *De Architectura.* The problem of disposal of human wastes becomes equally formidable. The usual solution has been the most obvious expedient of dumping into the nearest river. The problems of all large cities today, and most small ones, include those of water supply and disposal of human wastes.

Industrialization has intensified the deterioration of the environment. The effect has been two-fold: industrialization accentutates (1) the rate at which non-renewable resources are exploited, and (2) the production of waste materials which pollute the environment.

Modern industry has been a serious offender in the latter regard. Until the rise of the modern chemical and metallurgical industries, the waste materials discarded by industry or the consumer have been readily degradable materials. This is no longer true. Note the pollution problems caused by the discard of aluminum cans, plastic artifacts, synthetic detergents, chlorinated hydrocarbon insecticides, and polychlorinated biphenyls.

The stresses on the environment created by industrialization are illustrated by energy consumption. In the United States the annual per capita usage of energy in 1950 amounted to the equivalent of eight tons of coal. In Western Europe the figure was about 2.5 tons; in Japan about 1 ton; in the rest of Asia about 1/20 ton.[5] Imagine the situation, if underdeveloped nations achieve their goals of becoming industrialized.

An additional factor is the enormous increase in technological efficiency which has taken place in the twentieth century. Suppose we consider the whaling industry. Since World War I the industry has become highly efficient. Large ships serve as floating slaughter houses, remaining afield for months, exploiting the remaining breeding grounds. The sturdy harpooner no longer stands in the bow of a rowboat matching his skill with that of the huge mammal. Instead he aims a cannon-propelled harpoon with deadly accuracy; a harpoon carrying a charge designed to explode within the animal in order to subdue it instantly. The result is bringing certain species of whale close to extinction, and endangering all.

Population pressures combined with an efficient technology have had similar effects on other marine species. In looking at tonnage of Pacific sardines unloaded at U.S. ports one finds a rise from 50,000 tons in 1916 to 800,000 tons in 1936, the peak year. A decline set in after 1936, tonnage having dropped to 70,000 tons in 1955. Fisheries were abandoned in British Columbia in 1947, in Oregon and Washington in 1948, and in San Francisco in 1951.[6]

In the case of halibut, the largest flat fish, exploitation has seriously reduced the population of mature fish all around the Arctic Circle. Individuals may reach 600 pounds at maturity but growth is slow and sexual maturity is reached late. According to a 15-year study by Huntsman[7], the age pyramid of halibut population has changed from one with a significant population of 20-year old fish to one where small young fish predominate and individuals of age 10 and older are strikingly rare.

Let us also look at the effects of urban industrial expansion on the population of species not even a part of the commercial food market. Significant decreases in the territory of the prairie chicken and trumpeter swan have been documented, and the survival problems of the whooping crane are the subject of regular press reports.[8]

MAN'S ATTITUDE TOWARD THE ENVIRONMENT

Man has long recognized that the environment possesses a capacity for recovery in spite of mistreatment. He has exploited that capacity throughout the ages, rarely being concerned that there might be a point of no return. As long as population was small, and agriculture was not intensive, and more people lived on the soil than in the cities, and industrialization was at a low level, then such a casual attitude toward the capacity of nature for recovery was reasonably safe. With the kinds of change which have occurred since the seventeenth century, such attitudes have become an invitation to disaster. The rapid use of non-renewable resources, such as petroleum, lead, and copper, leaves our industrial civilization in a precarious state. The overstrain on the environment, exemplified by air pollution, water pollution, solid waste disposal, steady extinction of wildlife species, and lack of satisfactory recreational areas, suggests that man may already have reached the point where he is bringing about his own extinction.

From the beginning of recorded history there have been voices urging respect for nature. They have been countered by voices arguing that nature is the enemy of man, that man has the obligation to subdue nature, even that he can improve upon nature. In addition, there are the ambivalent souls who hold a respect, even love, for nature, yet find themselves trapped by circumstances which they feel helpless to condemn.

As is usually the case, Scripture provides quotations representative of both reverence for and opposition to nature. Classical mythology, with its large element of animism, takes a generally sympathetic view toward nature, although the practicalities of life in the ancient world frequently led to a gap between ethical teaching and practice. The pastoral writers of Rome, Cato the Censor, Columella, and Varro, extolled the rural life and reflected a reverence for nature but this was seldom heeded in practice. When Christianity gained ascendancy in the Roman Empire, it brought about a decline in the concept of equality between the species and claimed for man a position of uniqueness among creatures. Theological doctrine from Aristotle to the twentieth century sought roles for all species, which involved their usefulness to man.

A heretical position toward the view that nature exists for the benefit of man alone is observed in the thirteenth century. St. Francis of Assisi (1181?-1226) not only decreed for himself and his followers a life of humility and poverty but expressed a love for all of nature, inanimate as well as animate. Sun, wind, and fire were addressed as brothers; moon and water as sisters. Birds and beasts were exhorted to praise God and in St. Francis' eyes these creatures held a dignity seldom accorded them by human beings. However, his was largely a lone voice. His message had slight influence as men continued their exploitation of nature, frequently with the blessing of the theologians and the cheers of the humanists.

Literary men have represented all parts of the spectrum. Some, like Hawthorne, Henry James, and the early T. S. Eliot have looked upon nature as contributory to immorality, uncivilized, or as a symbol of disorder. James believed nature to be chaotic, whereas he held that man creates order. Manmade art provides meaning; nature by comparison is meaningless.

Other authors have treated nature with reverence. Some of them have treated nature as a refuge, an escape from the sordidness of civilization. Others have looked upon nature as an affirmation for the totality of life. For those who use nature as a refuge, the development of science, technology, and organized urban society are steps to be deplored. For the second group, these aspects of man's activity may be part of a continuum in which nature still has a significant role.

Herman Melville exemplifies the first type. In Ahab he characterizes not only the whaler seeking revenge, but the master and crew ruthlessly exploiting nature, but ending in their own destruction. Ralph Waldo Emerson, in turn treats nature as part of a grand design and this element is to be found in poets from Walt Whitman to Robert Frost.

The historian of the literature of nature, however, while he customarily emphasizes the professional writers such as the Emersons and Thoreaus, must not ignore the writers who are naturalists first and writers second because of a compulsion to share their love of nature, even to serve as a voice of protest for the protection of nature. I refer to such as John Muir, Aldo Leopold, and Rachel Carson. Each in his own way left an impact. Not only did they delight readers with the vividness of their honest style, but they played a most significant role in bringing action toward the permanent preservation of wilderness areas and protection of the environment.

It is natural that man has sought solace and renewal in nature. After all, he is scarcely 200 generations removed from his life as hunter and hunted in a natural competitive environment. Through most of human existence he has been a savage beast surviving through his understanding of a hostile environment. The veneer of civilization is very thin. Two hundred generations is scarcely sufficient to have produced genetic changes which would cause a deep attraction for urban mass culture. *Homo sapiens* developed as a creature of his environment during perhaps 30,000 hominoid generations and was evolving in a natural setting for even more generations before that. A mere 200 generations of civilized existence is scarcely sufficient to produce even minor changes in his natural interest in the environment. Any adverse attitudes must be cultural and therefore not deeply ingrained. It is not surprising that many of us still find renewal in a sunset, a waterfall, the song of a bird, the towering magnificence of a forest, the variety of a prairie. It is natural to wish to preserve these for still additional generations of *Homo sapiens*.

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EFFECT OF HANDLING AND METHYLPENTYNOL ANAESTHESIA ON SERUM GLUCOSE LEVELS IN GOLDFISH, *CARASSIUS AURATUS* LINNAEUS

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ABSTRACT

In comparison to "pre-stress" levels, goldfish anesthetized with methylpentynol and "handled" showed a significant increase in serum glucose level one day after handling, and apparent continued effects for the next three days. Fish handled but not anesthetized, and control fish which were neither anesthetized nor handled did not exhibit similar changes.

INTRODUCTION

Fish show a hyperglycemic response to stress stimuli. Studies by Chavin (1964) and Chavin and Young (1970) have reported that merely transferring goldfish between aquaria is sufficient stimulus to evoke a hyperglycemia lasting for several days (4 days in 1964 study; 2 days in 1970 study). A means for reducing such a marked change in the internal environment is desirable in order to maintain experimental fish closer to normal physiological levels. Methylpentynol has been shown to partially inhibit the rise of blood sugar which normally follows stress in rats (Watson and Steinberg, 1958).

This study was undertaken to examine the effects of methylpentynol on the stress reaction of goldfish to capture and handling, as indicated by changes in serum glucose levels.

METHODS AND MATERIALS

On arrival from Ozark Fisheries, Stoutland, Missouri, goldfish (comets; mean standard length 11.1 cm, range 9.3-14.5; mean weight 46.4 g, range 25.0-93.9) were sorted into 18 water-filled 75.5 liter plastic buckets, five fish per bucket. The fish were maintained for approximately 4 months at 14 C (± 2 C), with a 12:12 photoperiod. They were fed chopped frozen shrimp daily until two days before being fin clipped, at which time feeding was terminated until completion of the experiment. Marking the fish allowed comparison of stressed levels to original levels of specific fish. After being marked, the fish were returned to fresh water to which 5 ml of terramycin had been added. Initial blood samples (approx. 1 ml) were taken one week after fin clipping, by cardiac puncture with a #22-gauge needle and heparinized tuberculin syringe. This technique produced 7% mortality. Serum glucose was determined for three surviving individuals per bucket with a Beckman Glucose Analyser ($\pm$ 1 mg/100 ml tolerance), using glucose oxidase.

Seven days following determination of initial levels the 18 containers were divided into three groups of six. We anesthetized the first group of fish (group I) by placing sufficient 98.5% methylpentynol in the water to achieve a final concentration of 4 ml/liter. Fish were left in the solution until they lost equilibrium and swimming activity had ceased, approximately 20-30 minutes. The fish would, however, still respond to deep pressure, corresponding to stage III and between planes 1 and 2 of anesthesia classification of fishes (Klontz, 1965). In the "stressing" procedure the anesthetized fish were netted, held out of water for 20 seconds to standardize transfer times, and returned to fresh water to which 8 liters of non-treated water from their original bucket had been added.

The group II received treatment identical to group I (netting and handling) but were not anesthetized. Group III was used as a control. Control fish were not removed from buckets. Their water was siphoned off until 8 liters remained, then fresh water was added. Thus, for environmental constancy, all buckets had fresh water and 8 liters of original water.

Post-stress sampling of the three groups began 14 hours after stressing and continued daily for the succeeding five days. At each of these times, blood was taken from three fish per group, providing for two serum glucose readings (initial and post-stress) per fish. The time of day and sampling technique were the same for the post-stress sample as for the initial sample. The post-stress sampling produced less than 2% mortality. Both paired and unpaired T tests were used for statistical analysis of data.

RESULTS AND DISCUSSION

Initial serum glucose levels for the 54 fish ranged from 20.3 to 50 mg/100 ml with a mean of 29.7 mg/100 ml (SD $\pm$ 10.5). This compares favorably (N.S. difference, $P > .2$, unpaired T test) with the results of Chavin and Young (1970) who obtained a mean of 28.5 mg/100 ml (SD ± 9.6) for 300 goldfish.

The use of methylpentynol resulted in considerable changes (Table 1) in serum glucose levels of anesthetized fish. The post-stress serum glucose levels of anesthetized fish deviated markedly

TABLE 1: MEAN SERUM GLUCOSE (mg/100 ml) FOR THREE GROUPS OF GOLDFISH BEFORE AND FOR SIX DAYS AFTER STRESSING

	Methylpentynol and Handled	Handled Only	Control
Initial Level (IL)	24.0 (4.6) a	20.7 (1.5)	23.3 (2.2)
Day 1	47.3 (18.5) b	26.0 (8.5)	26.0 (15.7)
IL	35.0 (5.3)	26.0 (17.4)	20.3 (1.2)
Day 2	24.3 (2.9) c	31.3 (12.3)	18.7 (5.5)
IL	26.0 (6.2)	37.7 (22.7)	32.3 (7.8)
Day 3	16.7 (2.9) d	32.0 (17.4)	29.3 (8.0)
IL	22.0 (7.5)	29.3 (4.0)	28.0 (5.6)
Day 4	38.0 (11) e	32.7 (20.3)	29.3 (1.5)
IL	33.3 (10.4)	27.3 (2.3)	34.0 (5.6)
Day 5	30.3 (13.8)	33.3 (15.0)	28.00 (11.1)
IL	24.3 (4.2)	41.0 (10.0)	50.0 (20.4)
Day 6	18.3 (4.2)	33.7 (4.0)	44.0 (17.5)

a - one standard deviation from the mean
b - significantly different ($P < .05$, paired T test) from initial level
c,d,e - different from initial level ($P < .1$, paired T; $P < .05$, unpaired T)

from their initial levels for days 1 through 4 (Table 1). Small sample size is probably responsible for the Day 2-Day 4 figures being below the level of statistical significance. The graphic presentation (Fig. 1) depicts a damped oscillation returning to the norm. This type of

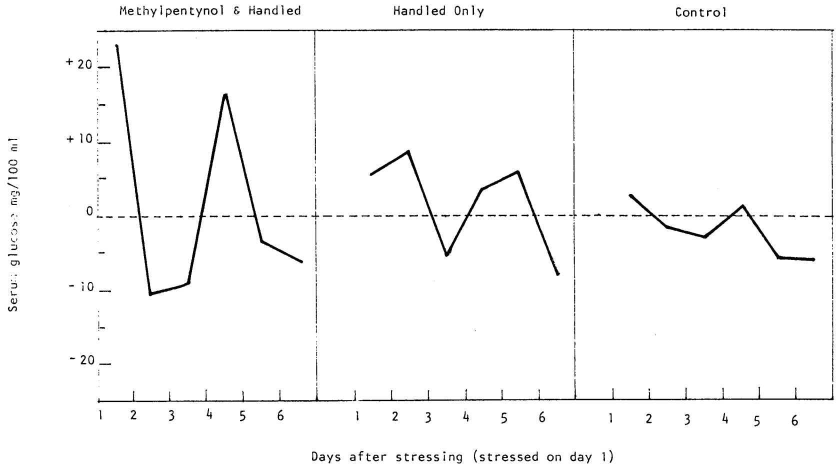

FIGURE 1. A comparison of serum glucose level from anesthetized and handled, and control groups before and after stress. The center line depicts means of three fish per group before stress application. The graph line connects serum glucose levels of the same three fish per group after stressing. Sampling on Day 1 occurred 14 hours after stressing.

oscillation may indicate a typical feedback situation in which physiological processes repeatedly overcorrect in an effort to return some parameter to the norm. Such an overcorrection or "hunting" occurs in man when serum glucose equilibrium is severely disturbed (Tepperman, 1968). The large initial increase in serum glucose may result from a number of factors. Several anesthetics such as ether (Hedner and Rerup, 1962) and MS-222 (Crowley and Berinati, 1972) are known to increase serum glucose levels. Methylpentynol may similarly cause a pharmacological increase in glucose titers apart from external stress stimuli. In contrast, behavioral changes; e.g., pre-anesthesia thrashing and lunging in goldfish (this study) and other species (Howland and Schoettger, 1969) indicate methylpentynol may in itself be a stress stimulus. Finally, there may be an additive or synergistic effect of methylpentynol and stress; i.e., either stress of capture and being held out of water, or the stress of anesthesia induction. Whatever the cause, results indicate that methylpentynol is not a suitable anesthetic or tranquilizer for use in reducing a hyperglycemic reaction in stressed fish. It should not be used by investigators attempting to maintain fish at "normal physiological levels".

We were unable to duplicate Chavin's (1964) and Chavin and Young's (1970) results of significant increases in serum glucose for a period of days after merely transferring fish between identical aquaria. Neither the group which was handled but received no anesthetic (group II) nor control fish (group III) show significant differences between any individual day's serum glucose level and its "norm". These conflicting results are, however, no doubt reconcilable considering the numerous factors which affect serum glucose in fish (Chavin, 1964; Chavin and Young, 1970), a probable answer lying in differing physiological states of the experimental animals, e.g. at differing stages of the life cycle.

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NUTRIENT LIMITATION OF OIL BIODEGRADATION IN LAKES OF VARYING WATER QUALITY IN VILAS COUNTY

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ABSTRACT

The potential for hydrocarbon oxidation was studied for twenty-five Vilas County lakes which varied in nutrient content. Viable counts demonstrated the presence of oil-degrading bacteria, which comprised a small percentage of the heterotrophic bacterial population except in areas near public boat landings where selective enrichment apparently occurred. Despite the presence of these bacteria the rates of hydrocarbon oxidation in all lakes were very low, as compared to rates previously measured for Lake Mendota. The low rates in the Vilas County lakes were probably due to deficiencies of nitrogen and phosphorus, since the addition of available N and P to the lake waters stimulated the rate of hydrocarbon breakdown. Comparisons between hydrocarbon oxidation rates and indigenous nutrient content show better corrrelations and greater dependence on phosphorus than on nitrogen. Although phosphorus is probably actually limiting the process, phosphorus and nitrogen are both rate limiting. Because of nutrient and other environmental limitations, the presence of oil-degrading microorganisms should not be taken as an indication that hydrocarbons will be readily biodegraded in freshwater environments. Management to prevent oil spills is thus more critical in pristine oligotrophic lakes such as those of Vilas County, than it is in the eutrophic lakes of southern Wisconsin.

INTRODUCTION

The microbial decomposition of hydrocarbons has become important as a result of massive oil pollution incidents. Catastrophic oil spills at sea have led to an effort to understand the process of oil biodegradation in seawater (ZoBell, 1969; Floodgate, 1972; Atlas and Bartha, 1973a). The common occurrence of hydrocarbon pollution of freshwaters has not received similar attention. In the navigable waters of the State of Wisconsin, more than fifty spills of at least one hundred gallons of hydrocarbons have occurred since 1969, according to the Wisconsin Department of Natural Resources. Examples include the recent spillage of 273,000 gallons of crude oil near Lake Ripley in Jefferson County because of a ruptured pipeline (Ostrander, 1973), and the spillage of 1,600 gallons of No. 5 lubricating oil into Lake Michigan when a barge went aground on the South Milwaukee Harbor breakwater on 24 February 1975 (personal communication, Captain of the Port Office, U.S. Coast Guard Base, Milwaukee). Additional oil pollution of freshwater occurs from street runoff, watercraft, and refineries (ZoBell), 1964 and Ludzack and Kinkead, 1956).

In earlier studies we examined the dependence of microbial oil biodegradation on environmental conditions (Ward and Brock, 1976). Low temperature, lack of dissolved oxygen and alternative organic compounds were found to inhibit the rate of oil oxidation. Another critical environmental factor is the availability of nitrogen and phosphorus. In the epilimnion of eutrophic Lake Mendota these nutrients become scarce after summer stratification, correlating with a coincident decrease in the rate at which oil is degraded by indigenous oil-degrading microorganisms. Since the addition of nitrogen and phosphorus relieved the rate limitation, the cause is attributed to the low levels of N and P in the lake water. If nutrient limitation of hydrocarbon oxidation is a general phenomenon, lakes with low nutrient levels should not support rapid rates of oil biodegradation. Since many of the lakes in Vilas County are extremely oligotrophic, it seemed likely that their oil biodegradation rates would be considerably lower than those of Lake Mendota. Most of the lakes studied were selected on the basis of recent chemical data (records of the Wisconsin Department of Natural Resources) in order to provide a range of nutrient levels. The objective was to gain understanding of the fate of hydrocarbons in different lakes and thereby to assist in the abatement of oil pollution and the cleanup of oils spilled into freshwaters.

MATERIALS AND METHODS

Except for Pauto, Little Rock, Sparkling and Trout lakes, stations were established by canoe approximately 200 meters off shore towards the lake center from the closest public access. In most cases this was sufficient to establish stations in deep enough water that thermal stratification could be measured and the effects of the littoral zone avoided. Samples from Pauto, Little Rock and Sparkling lakes were collected a few meters off shore at public boat landings. Samples from Trout Lake were collected at the end of the University of Wisconsin Trout Lake Laboratory pier, where gasoline-powered watercraft frequently were operated. Field measurements were made with an oxygen meter and thermistor (Yellow Springs Instrument, Model 51-A), and a pH meter (Orion Research, Model 401).

The rate of hydrocarbon oxidation was measured in two ways — by oxygen uptake and by a radioisotope method. For the oxygen uptake study, samples were collected by immersing sterile acid-cleaned 300 ml BOD bottles over the side of the canoe, and sterile mineral oil (Fisher Paraffin Oil) was added aseptically in the field after sampling. Samples were incubated at 25 C in the dark. Periodic dissolved oxygen readings were made with the oxygen meter and an oxygen electrode (YSI, model 5420). Oxygen demand of the lake water (which was generally low) was subtracted. The rate of $^{14}CO_2$ production during the oxidation of 1-^{14}C-hexadecane by surface water samples was also followed. Forty milliliters of lake water was drawn into a sterile syringe and injected into sterile acid-cleaned 60 ml serum vials which contained 0.1 μ Ci of 1-^{14}C-hexadecane (Amersham/Searle Corp.) diluted with nonradioactive hexadecane to a specific activity of 0.13 mCi/mmole. Nonbiological controls contained 4.2% formaldehyde. Vials were capped in the field and incubated at 25 C in the dark. Periodically duplicate vials and formaldehyde controls were sacrificed for $^{14}CO_2$ determination. Details of these methods have been reported elsewhere (Ward and Brock, 1976). Rates of oxygen uptake and $^{14}CO_2$ production, corrected for controls, were estimated from the linear regions of oxidation time courses. Rates were determined on indigenous lake water samples and also on identical samples to which P and N were added as KH_2PO_4 and KNO_3 to provide final concentrations of 100 μg P/1 and 300 μgN/1.

Samples for nutrient analysis were collected in sterile acid-cleaned one liter Nalgene bottles and were kept frozen until analyzed. Dissolved inorganic phosphate, nitrate, and ammonia were assayed on thawed samples which had been clarified by filtration through pre-rinsed 0.45μm Millipore filters. All glassware used in chemical analyses was acid-cleaned in 3N HC1 and rinsed in only glass redistilled water. Phosphate, nitrate and ammonia were assayed by standard analytical methods (Strickland and Parsons, 1968).

Most-probable-number of mineral oil-oxidizing bacteria and heterotrophic bacterial plate counts were determined as previously described (Ward and Brock, 1975).

TABLE 1. RATES OF HYDROCARBON OXIDATION, CELL COUNTS AND CHEMICAL AND PHYSICAL PROPERTIES OF VILAS COUNTY LAKES STUDIED

Lake	Nutrient Analyses			Cells/ml		Hydrocarbon Oxidation Rate[a]					
						Mineral oil mg O_2/1/h		Hexadecane cpm/h			
	μgPO₄P/1	μgNO₃-N/1	μgNH₃-N/1	hetero-trophic	MPN[c] oil	indigenous	N+P[d]	indigenous	N+P	temp.	pH
Big Crooked	0[b]	0	22.1	365	23	.007	.083	23.9	311.2	24C	8.6
Palmer	9.8	0	27.7	1295	43	.027	.083	111.7	399	26	8.5
Black Oak	0	0	15.1	815	0	.000	.075	13.3	266	24.5	7.6
Lac Vieux Desert	4.2	2.2	5.3	1295	9	.018	.063	98.4	399	25.5	8.6
Big Sand	1.2	0	0	3100	3	.016	.058	26.6	332.5	24.5	8.1
North Twin	2.6	0	11.6	6700	4	.010	.075	45.2	234.1	23.5	8.3
Pickerel	4.6	0	4.0	5850	4	.010	.054	66.5	665	24	8.9
Muskellunge	3.8	0	23.5	12500	15	.029	.083	117.0	532	23.5	7.3
Catfish	5.4	0	14.7	6800	15	.025	.067	111.7	353.8	23.5	7.7
Little St. Germaine	2.4	0.9	5.1	3700	93	.005	.044	29.3	199.5	23.5	8.0
Otto Mielke	0.4	0	0	540	4	.003	.047	45.2	465.5	24	4.5
Manitowish	1.2	0	2.6	1070	20	.009	.081	39.2	266	21	7.2
Pokegama	0	0	0	1065	4	.015	.090	87.8	239.4	23	7.7
Flambeau	0.2	0	0.2	495	4	.011	.075	29.3	199.5	23	7.6
Fence	0.4	0	3.0	315	0	.014	.069	26.6	311.2	22.5	7.7
Johnson	1.8	0	0	640	9	.003	.083	29.3	300.6	23.5	8.1
Arrowhead	3.2	0	42.6	5150	240	.025	.071	77.1	444.2	25.5	6.6
Snake	1.8	0	6.7	1125	15	.005	.108	31.9	465.5	24	7.4
Erickson	1.6	0	12.1	380	23	.006	.100	18.6	266	23	7.1
Big Muskellunge	3.4	0	16.5	235	4	.015	.075	29.3	220.8	24	7.5
Crystal	0	0	9.1	150	15	.006	.081	26.6	433.6	24	5.7
Pauto	0	0	28.6	2235	15000	.009	.081	47.9	292.6	24.5	5.2
Little Rock	0	0	3.5	4100	9300	.011	.088	37.2	284.6	25	5.1
Sparkling	0	0.8	0.5	5206	2300	.008	.083	26.6	266	24	7.4
Trout	5.6	3.0	5.1	690	43	.006	.094	47.9	353.8	24.5	7.8

[a] mgO_2/1/h during mineral oil oxidation; and cpm/h $^{14}CO_2$ produced during 1- ^{14}C-hexadecane oxidation

[b] 0 indicates that concentrations were too low to be detected by the assays used (detection limits were approximately 2.5 μg P/1, 1 μg NO_3-N/1, and 5 μg NH_3-N/1)

[c] MPN=most-probable-number per milliliter of water for bacteria able to grow on mineral oil

[d] 100 μg P/1 and 300 μg N/1 added aseptically

RESULTS

Table 1 summarizes the results obtained for all of the lakes studied. The presence of hydrocarbon-degrading bacteria in the surface waters of these lakes was confirmed by enumeration of such organisms from one milliliter samples. Except for Black Oak and Fence lakes the concentration of oil-degrading bacteria was sufficient for enumeration by the most-probable-number method. The presence of oil-degrading microorganisms is also evidenced by the finite rates of hydrocarbon oxidation for all lakes. The fact that hydrocarbons were oxidized but oil degrading bacteria not detected in samples from Black Oak and Fence lakes demonstrates that our enumeration technique was not sensitive enough to detect extremely low levels of these microorganisms. In all lakes except Pauto, Little Rock and Sparkling lakes oil-degrading bacteria comprised 10% or less of the total heterotrophic bacterial community. In water from Sparkling Lake about 50% of the heterotrophic community were able to grow on mineral oil, and in Lake Pauto and Little Rock Lake the most-probable-number of oil-degrading bacteria exceeded the total heterotrophic plate count. This indicated the possibility of discrepancy between our counting procedures and/or the occurrence of oil-degrading bacteria which could not grow on the nutrient rich medium used for the heterotrophic count. Since these sites were most likely subjected to oil pollution, an enrichment in the population of hydrocarbon-degrading bacteria relative to heterotrophic bacteria may have occurred.

During the study period (24-28 July 1974) water temperatures did not vary among the lakes studied (see Table 1). Thus, temperature was not considered an environmental variable (Ward and Brock, 1975). It was not possible to control other environmental factors such as pH (see Table 1), which varied among the lakes. The typical response to incubation of lake water samples with hydrocarbons is shown in Fig. 1a. The oxidation of mineral oil and hexadecane proceeded more slowly in lake water samples without added nutrients, indicating hydrocarbon oxidation was N and/or P limited. Black Oak Lake is representative of lakes with low indigenous nutrient content. The indigenous hydrocarbon oxidation rates were very low in such lakes and addition of nitrogen and phosphorus stimulated the rate about ten-fold or greater. In lakes with higher levels of dissolved inorganic N and P, exemplified by Muskellunge Lake in Fig. 1b, the indigenous rates of hydrocarbon oxidation were higher, but stimulation by added nutrients was still

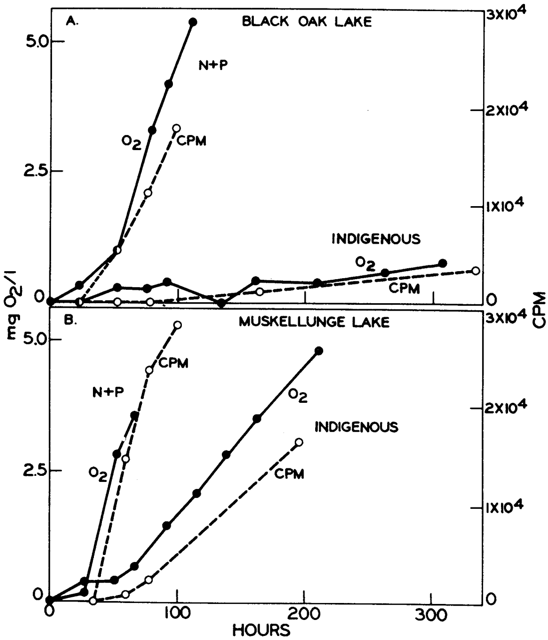

FIGURE 1. Oxygen uptake during mineral oil oxidation (———) and $^{14}CO_2$ produced during 1-^{14}C-hexadecane oxidation (- - -) by natural surface water samples from A) Black Oak Lake and B) Muskellunge Lake, with and without the addition of 100 μg P/1 and 300 μg N/1.

appreciable. Similar results were found for all twenty-five lakes (see Table 1). The degree of stimulation by added nutrient varied from 2.7 to 27.7 times the indigenous rate depending on the magnitude of the indigenous rate.

Rates of hydrocarbon oxidation in natural samples could be correlated to indigenous nitrogen and phosphorus concentrations. The dependence of hexadecane oxidation rate on phosphorus and nitrogen concentrations are graphically represented in Figs. 2 and 3; the regression lines and correlation coefficients are given in each figure. Similar correlations were found for mineral oil oxidation rate and phosphorus or nitrogen levels. When the slopes of the regression lines are computed on an equimolar basis for phosphorus and nitrogen, these empirical observations predict that hexadecane and mineral oil oxidation rates are 17.7 and 11.8 times more dependent on phosphorus than nitrogen, respectively. However, when either nitrogen or phosphorus was added alone during

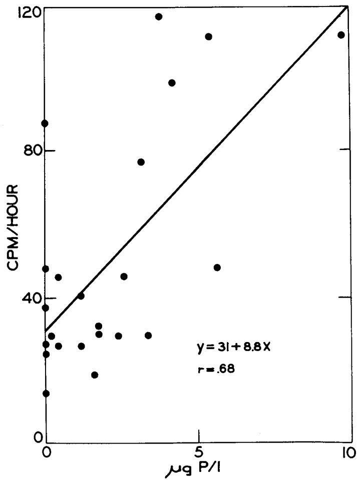

FIGURE 2. Correlation of the rate of $^{14}CO_2$ production during 1-^{14}C-hexadecane oxidation by natural samples from lakes of Vilas County and indigenous concentrations of dissolved inorganic phosphate. The line described by the equation and correlation coefficient represents the linear regression of rate on phosphate concentration.

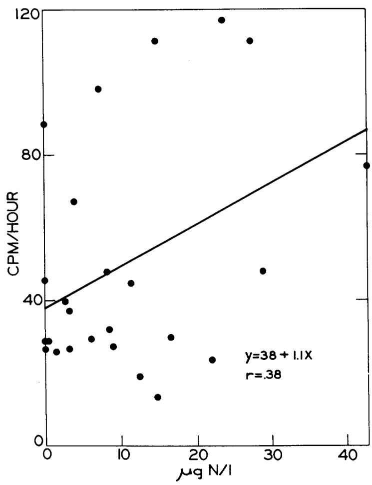

FIGURE 3. Correlation of the rate of $^{14}CO_2$ production during 1-^{14}C-hexadecane oxidation by natural samples from lakes of Vilas County and indigenous concentrations of dissolved inorganic nitrate plus ammonia. The line described by the equation and correlation coefficient represents the linear regression of rate on nitrogen concentration.

mineral oil oxidation time courses, no significant rate stimulation resulted. This indicates that, although at any given time the rates were probably limited by a single nutrient, there was also an insufficient supply of the other nutrient to support higher rates of oil oxidation.

DISCUSSION

The presence of oil-degrading bacteria in pristine lakes of Vilas County, Wisconsin was demonstrated by cultural methods and by the measurement of the activity of such microorganisms in response to additions of hydrocarbons to natural samples. In most lakes studied such bacteria comprised only a small percentage of the total bacterial community. Other workers have found similar relationships except in areas of hydrocarbon pollution where selective enrichment of hydrocarbon-degrading bacteria occurs (Atlas and Bartha, 1973b; Vorosilova and Dionova, cited by Gunkel, 1973). However, in several Vilas County lakes where samples were taken near public boat landings, the numbers of oil-degrading bacteria were greater and, in fact, predominated when compared with the heterotrophic bacterial community. The enrichment of oil-degrading bacteria in these habitats did not result in increased rates of mineral oil and hexadecane oxidation, because severely limited by environmental conditions.

The marked increase in hydrocarbon oxidation when nitrogen and phosphorus were added demonstrated that in all lakes hydrocarbon biodegradation was severely nutrient limited. In fact, the rates could be stimulated from 2.7 to 27.7 times the indigenous rates by such nutrient addition. The rate of hydrocarbon oxidation showed better statistical correlation with phosphorus than with nitrogen concentration and a more than ten-fold greater dependence on phosphorus than nitrogen. These data should be regarded cautiously for several reasons. Because many of the lakes had levels of phosphate, nitrate and ammonia near the lower limit for detection by our assays, the results were less accurate. One must also realize that the data are taken from twenty-five different lakes and that other uncontrolled variables may have affected the hydrocarbon oxidation rates in these natural samples. In reality the rate of hydrocarbon oxidation is probably only limited by the one nutrient that is present in lowest supply relative to demand at any given time. Correlations suggest that the actual limiting nutrient was phosphorus. However, addition of only phosphorus increased the rate only slightly, since nitrogen then became limiting. Thus, to completely relieve nutrient limitation, both nitrogen and phosphorus had to be added. Since additions of nitrogen and phosphorus together markedly stimulated the hydrocarbon oxidation rate, other essential nutrients are probably not limiting in the lakes studied.

Because of the incidence of freshwater oil pollution—well documented for Wisconsin natural waters—it is imperative that the fate of hydrocarbon pollutants be understood. The presence of oil-degrading bacteria in Wisconsin lakes is not in itself sufficient to insure oil biodegradation. Many environmental variables inflict severe limitations on the oil biodegradation process. Temperature, nutrient supply, oxygen availability and organic compounds are factors which may determine how rapidly the microflora of lakes can remove oil pollutants. However, it seems likely that in the Vilas County lakes, the bacterial nutrients nitrogen and phosphorus are the most important factors limiting oil biodegradation during summer, when oil pollution is most likely to occur.

Nutrient limitation has also been studied in eutrophic Lake Mendota (Ward and Brock, 1975). Although Lake Mendota receives large quantities of dissolved inorganic nitrogen and phosphorus, bloom-forming blue green algae apparently deplete concentrations of these nutrients in mid-summer, so that the hydrocarbon-degrading bacteria are severely limited. When the data of a seasonal study on Lake Mendota and Vilas County lakes were combined, the rate of hydrocarbon degradation was related to the indigenous nutrient content by a saturation curve (Ward and Brock, 1975). At high nutrient levels the rate of hydrocarbon degradation is independent of nutrient concentration, but when nutrient levels are low the rate of oil biodegradation is also low. Such nutrient limitation is of critical importance in nutrient-poor oligotrophic lakes and also in eutrophic lakes where other microorganisms may consume nutrients that are available.

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LOCATIONAL CHANGE: AN ANALYSIS OF NORTHWESTERN WISCONSIN'S EMPLOYMENT-MIX, 1950-1970

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INTRODUCTION

Since 1961, when legislation was first enacted under the Kennedy Administration, the federal government of the United States has provided financial and technical assistance to areas (counties, cities, and labor markets) of the country confronted with chronic economic distress (generally defined as high unemployment or low average income levels). "Economically distressed" areas, as defined by federal guidelines, exist in virtually all states in the nation, and Wisconsin is no exception. Measured both by level of unemployment and by average income during the last several decades, economic distress in Wisconsin has been most acute in the northwestern region. Northwestern Wisconsin, as defined for the purposes of this study, comprises a ten-county area (Ashland, Bayfield, Burnett, Douglas, Iron, Price, Rusk, Sawyer, Taylor, and Washburn), bounded on the north by Lake Superior and on the west by Minnesota. These same ten counties have been included in a federally-designated economic development district and a state regional planning commission.

In 1970, Northwestern Wisconsin contained about 155 thousand people, slightly more than 3% of the Wisconsin total. But unlike the state of Wisconsin, which has experienced steady, if not rapid, population growth over the past several decades, Northwestern Wisconsin has experienced persistent population losses. The region's population declined by nearly 17% between 1940, when a census-recorded population maximum of over 186 thousand was attained, and 1970 (U.S. Bureau of the Census, 1952, 1963, 1973). Each census interval between 1940 and 1970 recorded a loss for the region, although the rate of decline (2.1%) in the 1960s was well below the rate of loss in the two previous decades.

Population decline in Northwestern Wisconsin between 1940 and 1970 resulted from substantial net out-migration. In the 1960s, for example, all but one of the region's counties experienced net out-migration, with the net migration rate exceeding -4.4% in half of the counties (State of Wisconsin, 1972). Net out-migration is generally symptomatic of declining or shifting employment opportunities, which often produce difficult problems of economic adjustment. Such has been the case for Northwestern Wisconsin.

In rate of unemployment and average income levels, Northwestern Wisconsin has deviated appreciably from state and national norms in recent years. For example, the average annual rate of unemployment in the region in 1969 and 1970 exceeded 7%, whereas the Wisconsin rate in the same period was below 4% (State of Wisconsin, 1972). The region's median family income in 1969 was less than $7,300, almost 30% below the state average of $10,068 (U.S. Bureau of the Census, 1973).

This paper is intended to provide greater understanding of recent economic change, as measured by employment, in Northwestern Wisconsin. The focus of the paper is on marginal increments of employment change in the periods 1950-60 and 1960-70. It delimits the nature of comparative locational changes between Northwestern Wisconsin and the United States and isolates the relative influence of regional and national change-generating forces.

The method of analysis employed is the "shift and share" technique (Dunn, 1960). It is relatively recent in origin and apparently has not yet been widely used in economic analyses of distressed areas and development districts. Since comprehension of the findings of this paper require an awareness of the analytical structure of the shift and share technique, as well as an appreciation of its technical limitations, the following section is devoted to a brief discussion of the method.

THE SHIFT AND SHARE TECHNIQUE

The technique is essentially a statistical standardization procedure, which allocates regional employment change (or other kinds of regional change, such as income) into three additive components:

(1) that part attributable to change in total national employment (in other words, the national change effect measures the strength of the tendency of a given industry in a region to change in the same manner as all industries in the nation);

(2) that part attributable to the growth of the mix of industries in a region that are greater or less than the rate of growth or decline for all industries in the nation (i.e., the industry-mix effect recognizes that a given region has a distinctive distribution of industries, and that in the nation industries have varying rates and directions of change);

and (3) that part attributable to differences between the rate of growth of specific industries in a region and the rate of growth of the same industries in the nation. This relationship may be expressed symbolically as:

$$d_{ij} = n_{ij} + k_{ij} = c_{ij}$$

Where: n_{ij} = the national change component for industry i in region j

k_{ij} = the industry-mix effect for industry i in region j

c_{ij} = the regional competitive effect for industry i in region j

d_{ij} = the absolute change in employment over a given period for industry i in region j

Letting: r = the national rate of growth for all industries over the period examined

r_i = the national rate of growth for industry i over the period examined

r_{ij} = the rate of growth of industry i in region j over the period examined

With: E_{ij} = employment in industry i in region j in the initial period

E^*_{ij} = employment in industry i in region j in the terminal period

Then: $n_{ij} = E_{ij} \times r$

$k_{ij} = E_{ij} \times (r_{ij} - r)$

$c_{ij} = E_{ij} \times (r_{ji} - r_i)$

$d_{ij} = E^*_{ij} - E_{ij}$

Finally: $d_{ij} = n_{ij} + k_{ij} + c_{ij}$

Technical Limitations

The shift and share technique is subject to several potential sources of bias. One of these may originate from the level of industrial classification. Dunn (1960) has pointed out that at any level of classification where the data could still be disaggregated into two or more logical and realistic subdivisions, the competitive effect contains within itself an element of subsector industry-mix effect. In other words, the finest level of industrial classification obtainable is generally desirable. The data for this study were taken from the U. S. Bureau of the Census and represent the finest level of disaggregation available for the counties under investigation. Unfortunately, however, the Census Bureau did not maintain complete uniformity of industrial classification in the three census years examined; as a result, several sectors had to be combined. Moreover, the 1950 and 1960 censuses included the category "industry not reported", whereas no such category was included in the 1970 census. This presents problems of comparison between the 1960 and 1970 censuses. But the distortion is likely to produce only minor net shifts in employment, and our attention is focused primarily on broader patterns of change.

A second limitation of the technique results from the necessity to select a discrete time interval over which to measure employment change. This produces a bias in the industry-mix effect similar to the index number problem. Essentially, the longer the time period, the greater the industry-mix distortion. For relatively short periods, such as those used in this study, distortion in the industry-mix effect is unlikely to be very significant (Dunn, 1960).

A third source of bias can emerge if there are variations in the level of unemployment among the base years (Choquill and Cohen, 1966). The unemployment rate in the United States varied only slightly (by less than 1%) in the three census years examined. Variation in the level of unemployment in Northwestern Wisconsin was somewhat greater (about 2%), although the region's unemployment rate was consistently well above the national level over the period examined.

STUDY FINDINGS

As indicated above, the shift and share technique apportions regional employment change into three components, the analytical implications of which are distinctly different. These differences can be examined by working through and analyzing the changes in any one of the industrial sectors shown for Northwestern Wisconsin in Tables 1 and 2.

Consider, for example, the transport equipment industry.

Between 1950 and 1960:

$$r = 0.1454;\ r_i = 0.3540;\ r_{ij} = 1.3493$$

With: $E_{ij} = 229;\quad E^*_{ij} = 538$

Then:
$$n_{ij} = E_{ij} \times r = 33$$
$$k_{ij} = E_{ij} \times (r_{ij} - r) = 48$$
$$c_{ij} = E_{ij} \times (r_{ij} - r_i) = 228$$
$$d_{ij} = E^*_{ij} - E_{ij} = 309$$

Finally:
$$d_{ij} = n_{ij} + k_{ij} + c_{ij}$$
$$309 = 33 + 48 + 228$$

Sectors:

1 = Agriculture, Forestry, Fisheries
2 = Mining
3 = Construction
*4 = Furniture, Lumber, Wood Products
5 = Metal Industries
6 = Non-electrical Machinery
7 = Electrical Machinery
8 = Transport Equipment
9 = Other Durable Goods
10 = Food, Kindred Products
11 = Textiles, Apparel
12 = Printing, Publishing
13 = Chemicals, Allied Products
14 = Other Non-durable Goods
15 = Railroads, Railway Services
16 = Trucking Services
17 = Other Transportation
18 = Communications
19 = Utilities, Sanitary Services
20 = Wholesale Trade
21 = Food, Dairy Products Stores
22 = Eating, Drinking Places
23 = Other Retail Stores
24 = Finance, Insurance, Real Estate
25 = Business, Repair Services
26 = Private Households
27 = Other Personal Services
28 = Entertainment, Recreation Services
29 = Educational Services
30 = Health, Welfare, Other Professional Services
31 = Public Administration
32 = Industry Not Reported

*Sectors 4-14 are manufacturing industries.

In summary, the transport equipment industry of Northwestern Wisconsin would have expanded by 33 employees between 1950 and 1960 had it grown at the national rate for all industries combined. That it grew by 309 employees during this period can be attributed to the positive effect of both industry-mix and regional competitiveness. Nationally, the transport equipment sector was growing relative to all industries in the 1950-60 period, and the region gained 48 employees by virtue of this favorable industry-mix. Furthermore, the region gained an additional 228 employees in the transport equipment industry because this sector grew more rapidly in the region than in the nation. Relative to other regions in the nation, Northwestern Wisconsin had apparently improved its access to inputs such as raw materials and labor, to markets, or both.

The entries in the column of Tables 1 and 2 entitled "Net Relative Change" were obtained by summing the totals for "Industry-Mix" and "Regional Competitiveness". They indicate the region's net change or deviation from the overall national performance standard in a particular industry.

TABLE 1. EMPLOYMENT SHIFTS IN NORTHWESTERN WISCONSIN, 1950-60

Sector	Employment 1950	Employment 1960	Change	Changes Related to: National Growth	Industry-Mix	Regional Competitiveness	Net Relative Change
1	19,074	10,786	-8,288	2,773	-10,052	-1,009	-11,061
2	858	881	23	125	-380	278	-102
3	2,694	2,525	-169	392	-113	-448	-561
4	3,098	2,661	-437	450	-784	-103	-887
5	474	529	55	69	44	-58	-14
6	212	405	193	31	22	140	162
7	74	160	86	11	43	32	75
8	229	538	309	33	48	228	276
9	200	406	206	29	25	152	177
10	1,314	1,474	160	191	112	-143	-31
11	332	326	-6	48	-74	20	-54
12	515	752	237	75	91	71	162
13	252	217	-35	37	53	-125	-72
14	858	1,092	234	125	-74	183	109
15	4,251	2,524	-1,727	618	-1,993	-352	-2,345
16	523	819	296	76	84	136	220
17	1,476	1,059	-417	215	-176	-456	-632
18	382	485	103	56	3	44	47
19	712	664	-48	104	-1	-151	-152
20	1,530	1,232	-298	222	-29	-491	-520
21	1,675	1,338	-337	244	-220	-361	-581
22	2,510	2,397	-113	365	-201	-277	-478
23	4,162	4,505	343	605	120	-382	-262
24	805	1,048	243	117	208	-82	126
25	1,419	865	-554	206	123	-883	-760
26	801	977	176	116	42	18	60
27	1,805	1,495	-310	262	-187	-385	-572
28	474	275	-199	69	-60	-208	-268
29	2,364	3,019	665	344	1,152	-841	311
30	1,962	2,668	706	285	740	-319	421
31	1,931	2,230	299	281	248	-230	18
32	950	1,311	361	138	1,850	-1,627	223
TOTAL	59,916	51,663	-8,253	8,712	-9,336	-7,629	-16,965

TABLE 2. EMPLOYMENT SHIFTS IN NORTHWESTERN WISCONSIN, 1960-70

Sector	Employment 1960	Employment 1970	Change	National Growth	Changes Related to: Industry-Mix	Changes Related to: Regional Competitiveness	Net Relative Change
1	10,786	5,663	-5,123	1,988	-5,730	-1,381	-7,111
2	881	400	-481	162	-193	-450	-643
3	2,525	3,036	511	465	35	11	46
4	2,661	2,962	301	490	-712	523	-189
5	529	675	146	97	-64	113	49
6	405	1,156	751	75	35	641	676
7	160	196	36	29	16	-9	7
8	538	482	-56	99	-4	-151	-155
9	406	872	466	75	127	264	391
10	1,474	848	-626	272	-621	-277	-898
11	326	461	135	60	-49	124	75
12	752	514	-238	138	-105	-271	-376
13	217	234	17	40	-9	-14	-23
14	1,092	1,466	374	201	174	-1	173
15	2.524	1,687	-837	465	-1,282	-20	-1,302
16	819	628	-191	151	3	-345	-342
17	1,059	1,024	-35	195	70	-300	-230
18	485	503	18	89	61	-132	-71
19	664	932	268	122	163	-17	146
20	1,232	1,365	133	227	285	-379	94
21	1,338	1,524	186	247	-70	9	-61
22	2,397	2,568	171	442	220	-491	-271
23	4,505	5,053	548	830	605	-887	-282
24	1,048	1,168	120	193	252	-325	-73
25	865	819	-46	159	262	-467	-205
26	977	688	-289	180	-583	114	-469
27	1,495	1,473	-22	275	86	-383	-297
28	275	243	-32	51	19	-102	-83
29	3,019	4,754	1,735	556	1,893	-714	1,179
30	2,668	4,960	2,292	492	1,536	264	1,800
31	2,230	2,508	278	411	284	-417	-133
32	1,311	n.a.	-1,311	n.a.	n.a.	n.a.	n.a.
TOTAL	51,663	50,862	-801	9,276	-3,296	-5,470	-8,766

n.a. = Not Applicable

An examination of the column totals (the algebraic sums of the corresponding entries for the separate industries) in Tables 1 and 2 reveals information about the overall performance of Northwestern Wisconsin relative to the nation in employment change between 1950 and 1960 and between 1960 and 1970. Basically, the region fared poorly. On an aggregate basis, the region fell short of the national growth standard by 16,965 employees between 1950 and 1960. The expected overall employment growth for the region in this period, based on the national norm, was 8,712, whereas actual employment declined by 8,253. The deficit of nearly 17 thousand employees resulted more from an adverse industry-mix than a deteriorating competitive position, although both factors were important contributors.

Between 1960 and 1970, Northwestern Wisconsin's overall employment growth deficit, relative to the national standard, was 10,322 (this figure is higher by 245 employees than the column totals in Table 2 reflect, because of the absence of a national growth total for sector #32). In contrast to the previous decade, the region's employment deficit in the 1960s was attributable more to a declining competitive position than to an adverse industry-mix.

In 1950 and, to a lesser extent, in 1960, Northwestern Wisconsin had a high concentration of employees in industries that were declining, either absolutely or relatively, in national employment. This is reflected in the large negative industry-mix totals in both periods for such sectors as agriculture, forestry, and fisheries; railroads and railways, and furniture, lumber, and wood products. The agriculture, forestry, and fisheries sector, alone, had a negative industry-mix total exceeding the aggregate figure for all industries in the region in both the 1950-60 and 1960-70 periods.

Positive employment changes in Northwestern Wisconsin attributed to industry-mix effects were distributed among 18 of the 32 sectors between 1950 and 1960 and 19 of the 31 sectors between 1960 and 1970. In both periods, however, increments were small for most of these sectors. Eleven sectors experienced growth attributable to a positive industry-mix in both periods, with the most impressive absolute gains concentrated in the trade and service industries.

Twenty-one sectors contributed to Northwestern Wisconsin's total downward shift of more than seven thousand employees between 1950 and 1960 associated with the effects of regional competition; this figure increased to 22 sectors between 1960 and 1970, notwithstanding a diminished total downward employment shift. In both periods, the relatively small total positive change due to regional competition was concentrated largely in the manufacturing sectors: 63.4% of the gain between 1950 and 1960 originiated in the manufacturing industries, a figure that increased to 80.7% between 1960 and 1970.

Further insight into Northwestern Wisconsin's declining competitive position relative to the nation in the 1950-60 and 1960-70 periods can be obtained by isolating the various components of the regional competitive effect. As noted above, the competitive effect consists of two main components: industries which made either comparative gains or comparative losses relative to the United States. Each of these components may be further disaggregated into three parts. A comparative gain may occur in three ways: an industry may have a larger than expected gain, a smaller than expected loss, or a gain rather than an expected loss. The term "expected" refers to the anticipated employment shift in a given industry in a region based on the rate and direction of change for the same industry in the nation. A comparative loss can occur if an industry has a larger than expected loss, a smaller than expected gain, or a loss rather than an expected gain.

Comparative gains and comparative losses of Northwestern Wisconsin's industries in the periods 1950-60 and 1960-70 are summarized by sector and component parts in Table 3. As the

TABLE 3. NORTHWESTERN WISCONSIN INDUSTRIES WITH COMPARATIVE GAINS OR COMPARATIVE LOSSES, 1950-1970

Comparative Gains	*Sectors**		*Employment Shift*	
	1950-60	1960-70	1950-60	1960-70
Larger than Expected Gain	6, 7, 8, 9, 12, 14, 16, 18, 26	3, 5, 6, 9 11, 21, 30	1,004	1,464
Smaller than Expected Loss	11	26	20	114
Gain Rather than Expected Loss	2	4	278	523
Total Shift			1,302	2,063
Comparative Losses				
Larger than Expected Loss	1, 4, 15	1, 2, 10, 15	-1,464	-2,128
Smaller than Expected Gain	5, 10, 23, 24, 29, 30, 31, 32	7, 13, 14, 18, 19, 20, 22, 23, 24, 29, 31	-3,682	-3,386
Loss Rather than Expected Gain	3, 13, 17, 19, 20, 21, 22, 25, 27, 28	8, 12, 16, 17, 25, 27, 28	-3,785	-2,019
Total Shift			-8,931	-7,533

*** Sectors are coded by name preceding TABLE 1.**

table shows, both gains and losses were distributed among each of the component parts in each period, although a rather substantial movement of industries from one category to another was evident between the periods. For example, only three of the 11 industries with comparative gains between 1950 and 1960 also experienced gains between 1960 and 1970. Two of these were manufacturing sectors (non-electrical machinery and other durable goods) and the third a service sector (private households). Five sectors—agriculture, forestry, and fisheries; educational services; business and repair services; other retail stores; and wholesale trade—headed the list of 15 sectors experiencing comparative losses in both periods. In the 1950-60 period, these five sectors accounted for just over 40% of total comparative losses, a figure that increased to about 51% in the 1960-70 period.

SUMMARY AND CONCLUSIONS

This paper has attempted to isolate and analyze the components of employment change in Northwestern Wisconsin in the 1950-60 and 1960-70 periods. During each of these intervals, employment in the nation increased substantially. In contrast, employment in the region dropped sharply between 1950 and 1960 and declined slightly between 1960 and 1970. The region's negative employment shift in each period can be attributed both to a large negative industry-mix effect and to a large negative competitive effect. The region's adverse industry-mix resulted largely from a relatively high concentration of employment in both 1950 and 1960 in several industries (*viz.*, agriculture, forestry, and fisheries; and railroads and railway services) that were in serious decline in the nation. The negative competitive effect in both periods was spread more evenly among the approximately 70% of the region's sectors that experienced comparative employment losses relative to the same sectors in the nation.

Although this analysis suggests that, in the aggregate, Northwestern Wisconsin fared extremely poorly relative to the nation in employment growth between 1950 and 1970, there were some encouraging developments. First, the relatively high overall rate of employment decline in the 1950s was reduced dramatically in the 1960s. In large part, this can be ascribed to diminished, although still considerable, employment losses in natural resource-oriented sectors that experienced even larger absolute declines in the 1950s. As these sectors are rapidly approaching equity with the nation in their contribution to regional employment, continued improvement in Northwestern Wisconsin's distinctly adverse industry-mix may be expected in forthcoming decades. Second, a number of the region's manufacturing industries made impressive comparative gains relative to the same industries in the nation during the decade of the 1960s. An attempt to explore the reasons for these gains is beyond the scope of this paper. But such research should surely be given a high priority in economic analyses of the region, for such knowledge may comprise a key component of a planning strategy designed to stimulate the region's economy.

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PRELIMINARY ASSESSMENT OF THE IMPACT OF A CLIMATIC CHANGE UPON THE GROWING SEASON IN WISCONSIN

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ABSTRACT

This report is an initial investigation of the response of length of growing season across the State of Wisconsin to a cooling trend in northern hemispheric temperature. Contrary to expectations, from 1950-74 the growing season apparently lengthened over significant portions of the state. It is suspected, however, that more sophisticated statistical analyses are required in order to confirm, modify or reject this conclusion.

INTRODUCTION

Much concern is expressed over the potential impact of the present cooling trend in northern hemispheric air upon the world's dwindling food reserves. The average annual hemispheric air temperature has been slowly dropping since the mid-1940s (Fig. 1). This cooling followed a 50-year period of warmth and climatic stability that was unprecedented in the past 300 years (Bryson, 1974). It was during this period of generally favorable weather that world food production soared and human population doubled. Agricultural policies and practices adapted to this abnormal climatic regime and the assumption of climatic constancy (NCAR, 1974) but now appear unsuited for the hostile climates that may be imminent.

Already some investigators are attributing recent monsoon failures and attendant drought and famine in Africa and Asia to changes in atmospheric circulation patterns accompanying the cooling trend (Bryson, 1973). In England the growing season now averages two weeks shorter than in the favorable decades prior to 1950 (Lamb, 1969). Some agronomists such as Thompson (1975) predict that if the cooling trend continues, a shortening of the growing season will eventually prove limiting for agriculture in

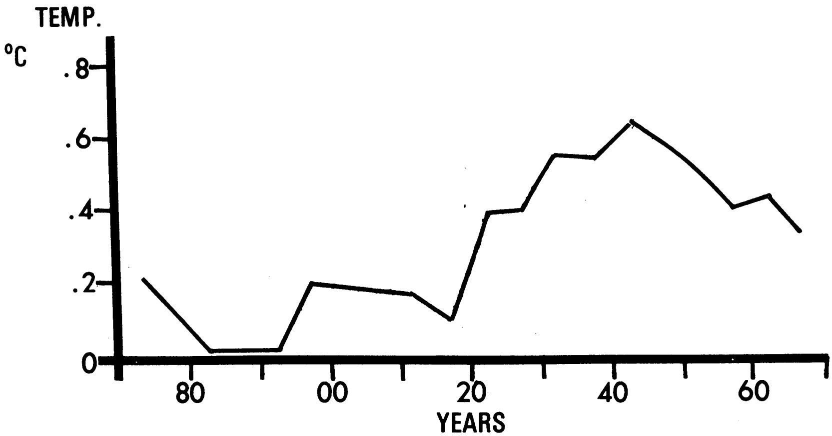

FIGURE 1. The change in average annual northern hemispheric air temperature. 1870s through 1960s. Values are five-year means expressed as deviations from the 1880-1884 mean. After Kalnicky, 1974, p. 102.

high latitudes, while in mid-latitudes there may be a gradual southward shift of crop zones. The impact of such changes upon agricultural systems, both primitive and modern, would be disruptive.

Whether the cooling trend will continue through the remainder of this century or abruptly end or reverse in a few years, cannot be determined. In any event, the magnitude of hemispheric cooling, at first glance, is not very impressive: Thus far, the temperature drop has amounted to only a few tenths of a degree Celsius per decade. A continuation of cooling at the same rate, even for another 100 years, would yield a further temperature reduction of *only a few* degrees. However, such a temperature drop could result in a return to a climate comparable to that which prevailed during the early nineteenth century—the latter part of a harsh period known as the Little Ice-Age. It was during the Little Ice-Age that colder weather triggered significant displacement of biotic zones, dramatic glacial advance, and marked expansion of Arctic pack ice.

How can a seemingly minor change in hemispheric temperature bring about such drastic effects? The problem stems from the fact that the average annual hemispheric temperature is computed from temperature measurements at hundreds of weather stations. This mass of data has the effect of concealing dramatic changes that occur locally. In fact, minor changes in temperature at the hemispheric scale may translate into considerably greater changes at a smaller scale. The local change may even involve a reversal in the direction or sign of the hemispheric trend. Thus, Kalnicky (1974) demonstrated that both the magnitude and direction of the post-1950 temperature change in the United States has been non-uniform: The greatest cooling thus far has taken place in the Southeast, while for the same period, significant warming has occurred in portions of the Far West.

A review of climatic records of the past reveals another observation that may warrant concern as hemispheric temperatures continue to fall: It appears that weather tends to be more unstable during times of relatively low hemispheric temperature. Thus, in addition to geographically non-uniform climatic changes, dramatic oscillations in weather extremes may be anticipated if the cooling trend continues. Hence, there may be more frequent establishment of record high and low temperatures and more frequent midsummer frosts in northern latitudes. Such instability was characteristic of weather regimes of the early nineteenth century and quite unlike the generally balmy and stable weather of the first half of the twentieth century. For example, Rosendal (1970) reports that during the 1830s and 1840s in Wisconsin there was an unusually high frequency of record coldest and warmest months.

Temperature changes and an increased likelihood of extreme weather conditions are likely to have the most immediate impact upon food production in regions that are already climatically marginal for agriculture. Evaluation of the climatic changes (if any) that are occurring in such ecotonal areas appears, then, to be a high priority objective. It is expected that this will allow for the design and implementation of alternative agricultural practices that would be conducive to food production under more adverse climatic conditions. An example is the development and substitution of crop varieties that are more frost resistant (Newman and Pickett, 1974).

STUDY OBJECTIVE

This study is a preliminary analysis of the impact of the hemispheric cooling trend upon the length of the growing season across the State of Wisconsin. Such an assessment is of particular concern in view of the fact that in the northern sections of the state production of major cash crops, such as soybeans and corn for grain, is already limited by a short growing season. From Kalnicky's study

(1974) it is apparent that the temperature trend across the entire state is following the hemispheric trend. Hence,. the immediate outlook for agriculture in northern Wisconsin appears bleak, especially if we accept the notion that cooling is correlated with a shortening of growing season. But, prior to discussing the analysis of data, it is well to review the growing season concept and its limitations.

THE GROWING SEASON

Although the length of time during the year when air temperatures remain sufficiently mild to permit plant growth is a critical determinant of agricultural productivity, the growing season is a complex and ill-defined concept (Huschke, 1959; Wilsie, 1962). Usually the growing season is described as the period between dates of occurrence of the last killing frost in spring and the first killing frost in fall. However, whether a frost kills a plant depends upon the plant species and its life stage (Ventskevich, 1958), as well as the time of year, duration of freezing temperatures, and the rate of freezing (Rosenburg, 1974). Traditionally, the period most commonly used to designate the growing season is the freeze-free period, *i.e.*, the time between the last day of a recorded shelter temperature of 32°F (0°C) in the spring and the first date of 32°F (0°C) in the autumn. To avoid differences in microclimate resulting from variations in topography and soil type, the period between the last spring day and the first autumn day on which a temperature of 28°F (-2.2°C) occurs can also be used. Utilization of the 28°F-free period provides greater assurance that no localized areas escape a killing frost (Wilsie, 1962). The use of 28°F-free period and 32°F-free period is facilitated by the reporting of both for weather stations in the *Annual Climatic Summaries* published for each state by the National Oceanic Atmospheric Administration.

An additional complication in defining the growing season arises from the fact that although near-freezing temperatures may not kill a plant, growth is usually quite slow at these temperatures. For example, Duncan and Hesketh (1968) found that both growth and photosynthesis of corn practically cease at temperatures below 50°F (10°C). In general, most temperate plants do not grow at temperatures below 41°F (5°C) (Greulach, 1973). Thus another measure called the vegetative period or vegetative season has been defined as the summer period between dates of last and first occurrence of 42°F or 40°F (Huschke, 1959; Wilsie, 1962).

Because of complexities involved in plant-atmosphere interactions, available measures of growing season are, at best, merely first approximations. For convenience the indices of growing season used in this study are the lengths of freeze-free period and 28°F-free period as reported in the *Annual Summary of Climatological Data for Wisconsin.*

PROCEDURE

Climatic records of reporting stations in Wisconsin were initially examined for continuity. Those stations which had relocated during the study period, and those stations whose records were discontinuous were omitted from analysis. In order to insure an adequate spatial distribution of stations, it was necessary to begin the study with 1950 data. Even so, only 43 stations provided a continuous and reliable record of length of growing season through 1974.

For each station the growing season record was analyzed for the presence of any systematic change during the twenty-five year study period. Mean lengths of freeze-free and 28°F-free periods were compared for the 1950-59 and 1965-74 decades. Further, the data were checked for trends by computation of running means of varying lengths (11-, 9-, 7-, and 5-year). Additionally, in order to assess the relative roles of spring and autumn climatic events in the changing length of growing season, dates of the last spring and first autumn occurrence of 28°F and 32°F were tabulated. The mean dates were then calculated and compared for the decades 1950-59 and 1965-74. For these data, also, running means were determined to detect trends.

RESULTS

During the 25-year period, 1950-74, the freeze-free period lengthened across the major portion of Wisconsin (Fig. 2). The direction of this change is surprising in view of Kalnicky's finding (1974) that in the 1960s summer (July through August) temperature departures from normal (1931-60 mean) were negative across the entire state. There is, however, considerable variance in the magnitude of lengthening of the freeze-free period. For example, at Janesville and River Falls the freeze-free period increased by 0.2 and 1.0 days, respectively (Table 1). In contrast, at Coddington the increase was 18.4 days, and at Sturgeon Bay it was 17.3 days. Farther north in Vilas and Oneida counties, Willow

TABLE 1. COMPARISON OF MEAN LENGTH OF 28°F-FREE PERIOD AND MEAN LENGTH OF FREEZE-FREE PERIOD FOR THE DECADES 1950-59 AND 1965-74. (STATIONS ARE ARRANGED BY CLIMATIC DIVISION.)

Station	28°F-Free Period 1950-59	28°F-Free Period 1965-74	Change in Length	32°F-Free Period 1950-59	32°F-Free Period 1965-74	Change in Length
Northwest						
Ashland EX F	132.8	136.6	+3.8	*	*	*
Cumberland	169.5	169.5	0.0	143.5	143.2	-0.3
Holcombe	157.8	157.2	-0.6	*	*	*
Ladysmith	138.4	154.1	+15.7	115.3	123.8	+8.5
Solon Springs	133.2	138.3	+5.1	*	*	*
Winter	125.1	132.4	+7.3	*	*	*
North Central						
Long Lake Dam	110.4	121.4	+11.0	78.5	88.8	+10.3
Owen	*	*	*	115.2	123.1	+7.9
Rainbow Res	130.9	136.2	+5.3	108.7	109.3	+0.6
Rest Lake	*	*	*	106.3	120.5	+14.2
Rhinelander	154.3	155.3	+1.0	127.9	124.5	-3.4
Tomahawk	142.7	148.8	+6.1	116.0	120.4	+4.4
Wausau AP	168.3	165.6	-2.7	138.1	142.9	+4.8
Willow Res	*	*	*	97.1	113.3	+16.2
Northeast						
Brule Island	120.8	133.4	+12.6	93.5	94.0	+0.5
Marinette	182.1	178.1	-4.0	142.1	144.9	+2.8
West Central						
Blair	*	*	*	131.0	120.4	-10.6
Eau Claire AP	159.3	156.6	-2.7	138.7	132.8	-5.9
La Crosse AP	191.1	181.6	-9.5	171.5	155.5	-16.4
River Falls	167.5	161.2	-6.3	140.6	141.7	+1.1
Central						
Coddington	122.4	131.3	+8.9	82.0	100.4	+18.4
Hancock EX F	153.0	145.8	-7.2	132.4	132.0	-0.4
Marshfield EX F	150.5	140.1	-10.4	126.5	123.1	-3.4
New London	161.0	157.5	-3.5	*	*	*
Pittsville	149.5	144.4	-5.1	123.4	123.0	-0.4
Stevens Point	159.5	162.1	+2.6	127.3	139.3	+12.0
Wis. Rapids	148.6	147.0	-1.6	125.3	126.7	+1.4
East Central						
Appleton	193.8	193.7	-0.1	165.3	164.9	-0.4
Chilton	*	*	*	139.7	142.0	+2.3
Green Bay AP	172.4	163.7	-8.7	133.4	141.5	+8.1
Sturgeon Bay	177.4	169.6	-7.8	132.9	150.2	+17.3
Southwest						
Baraboo	158.6	155.9	-2.7	139.2	129.5	-9.7
Lone Rock AP	154.9	154.8	-0.1	138.8	136.3	-2.5
Lynxville Dam	196.9	197.3	+0.4	175.3	173.4	-1.9
Prairie Du Sac	198.5	186.9	-11.6	171.9	159.6	-12.3
Richland Ctr	169.1	164.1	-5.0	142.0	141.4	-0.6
South Central						
Janesville	189.2	192.8	+3.6	165.4	165.6	+0.2
Madison AP	176.8	159.5	-17.3	151.6	134.9	-16.7
Watertown	183.9	176.9	-7.0	156.1	152.3	-3.8
Wis. Dells	169.6	167.2	-2.4	142.1	144.0	+1.9
Southeast						
Lake Geneva	191.1	177.3	-13.8	164.1	156.3	-7.8
Milwaukee AP	197.4	185.0	-12.4	175.6	163.2	-12.4
Waukesha	186.3	195.3	+9.0	156.4	166.2	+9.8

+ Longer - Shorter *Missing Data

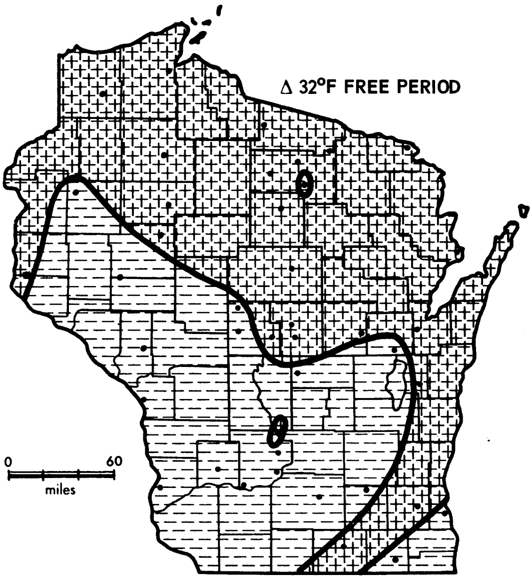

FIGURE 2. Change in length of freeze-free period 1950-59 to 1965-74; (+) longer, (-) shorter; (. stations).

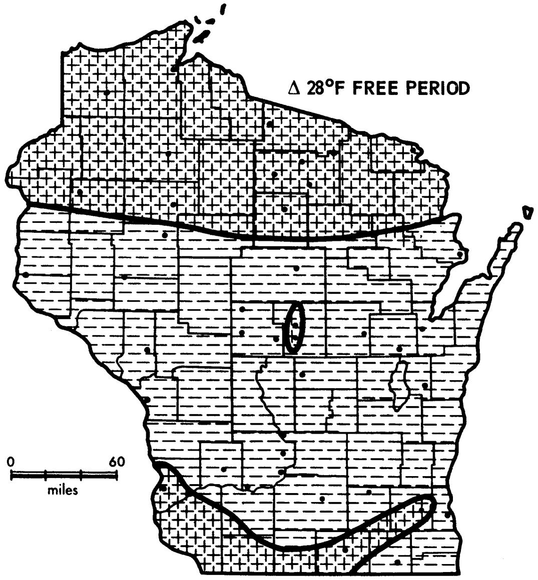

FIGURE 3. Change in length of 28°F-free period 1950-59 to 1965-74; (+) longer, (-) shorter; (. stations).

Reservoir's freeze-free period increased by 16.2 days, Rest Lake by 14.2 days, and Long Lake Dam by 10.3 days.

There is, however, a significant portion of the western and southern sectors of the state that experienced a shortening of the freeze-free period (Fig. 2). As in the case of stations with lengthened freeze-free periods, there is considerable variance in magnitude. On the northern boundary between areas of increased freeze-free season and decreased freeze-free season, Cumberland experienced a decrease of only 0.3 days, and at Appleton, Hancock and Pittsville the decrease was 0.4 days (Table 1). However, at both Madison and La Crosse the freeze-free period was reduced by more than two weeks—16.7 and 16.4 days respectively.

The pattern of change in length of 28°F-free period differs somewhat from that of the freeze-free period. The direction of change for both indices is the same in the northern and west-central portions of the state (Fig. 3), but in the east and extreme south, signs are reversed for the two measures of growing season. Thus, the area of Wisconsin that experienced a reduction in length of the 28°F-free period is somewhat larger than the region where the freeze-free period shortened.

The magnitude of change in the 28°F-free period was as variable as that of the freeze-free period. In the north, the increase ranges from 6.0 days at Rhinelander to 15.7 days at Ladysmith and 12.6 days at Brule Island (Table 1). Unfortunately, complete records are not available for the 28°F-free period for stations at Rest Lake and Willow Reservoir, which experienced a more than two week lengthening of the freeze-free period. The small pocket in the southern-most portion of the state which also showed an increase in the 28°F-free period is demarked by only three stations: Lynxville Dam, 0.4 days; Janesville, 3.6 days; and Waukesha, 9.0 days. Both Janesville and Waukesha also showed an increase in the freeze-free period. For the area that experienced a reduction in 28°F-free period, the decrease ranges from 0.1 days at Lone Rock and Appleton to 13.8 days at Lake Geneva and 17.3 days at Madison.

Another point of concern in assessing the changing length of growing season is the relative significance of spring and fall climatic events (Figs. 4 through 7). Consider those fourteen stations in the southern and western sectors of the state where the growing season is shorter for both the 32°F and 28°F indices. For all but one of these stations the average date of last occurrence of 32°F in spring was later, while at one station there was no change. Also, the last spring occurrence of 28°F was later for thirteen of the fourteen

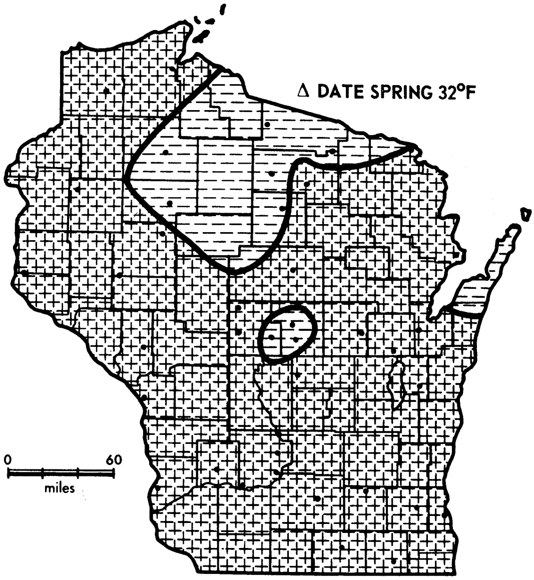

FIGURE 4. Change in date of last 32°F in spring 1950-59 to 1965-74; (+) later, (-) earlier; (. stations).

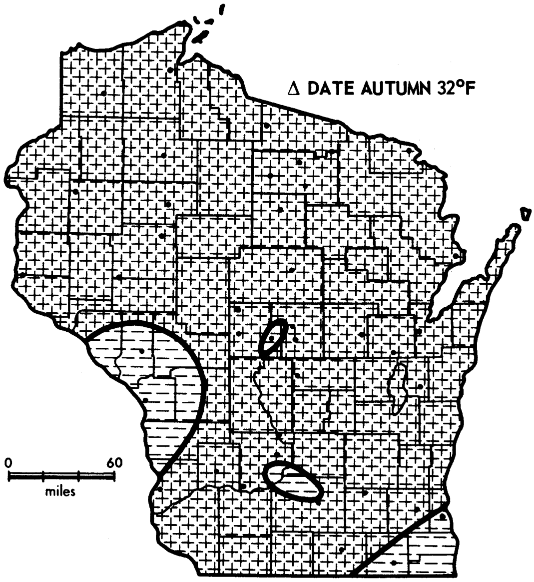

FIGURE 5. Change in date of first 32°F in autumn 1950-59 to 1965-74; (+) later, (-) earlier; (. stations).

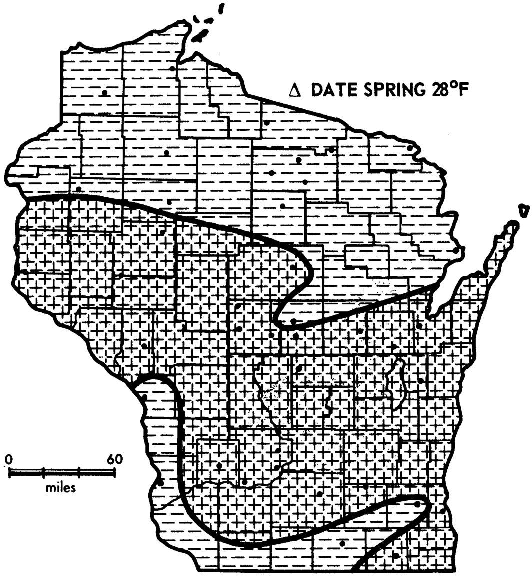

FIGURE 6. Change in date of last 28°F in spring 1950-59 to 1965-74; (+) later, (-) earlier; (. stations).

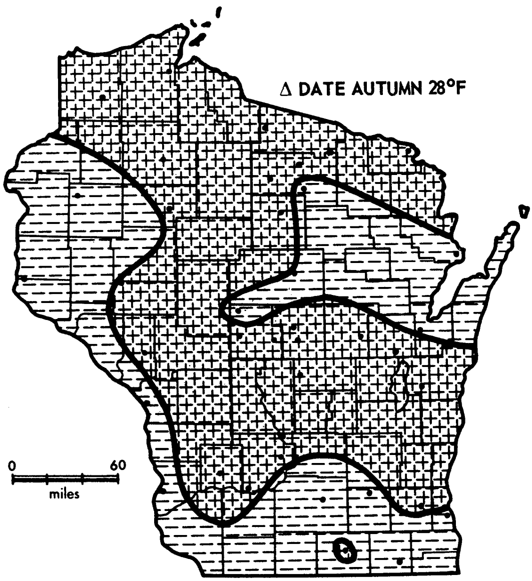

FIGURE 7. Change in date of first 28°F in autumn 1950-59 to 1965-74; (+) later, (-) earlier; (. stations).

stations. For autumn, the data are less definitive. The first freeze was later for seven of the fourteen stations, showed no change for three, and was earlier for four stations. A similarly nondescript pattern is evident for the first autumn occurrence of 28°F with half of the stations having later dates and half earlier. Thus, in regions where the growing season clearly shortened, it appears primarily to be the result of later cold outbreaks in spring.

For those nine stations where the growing season lengthened (as measured by both 28°F and 32°F indices), there appears to be a different pattern. For five of these stations, the average date of last occurrence of 32°F in spring was earlier, three stations showed no change, while at one station the date was later. The last spring occurrence of 28°F was earlier for seven of the nine stations. In autumn all nine stations reported later occurrences of the first 28°F

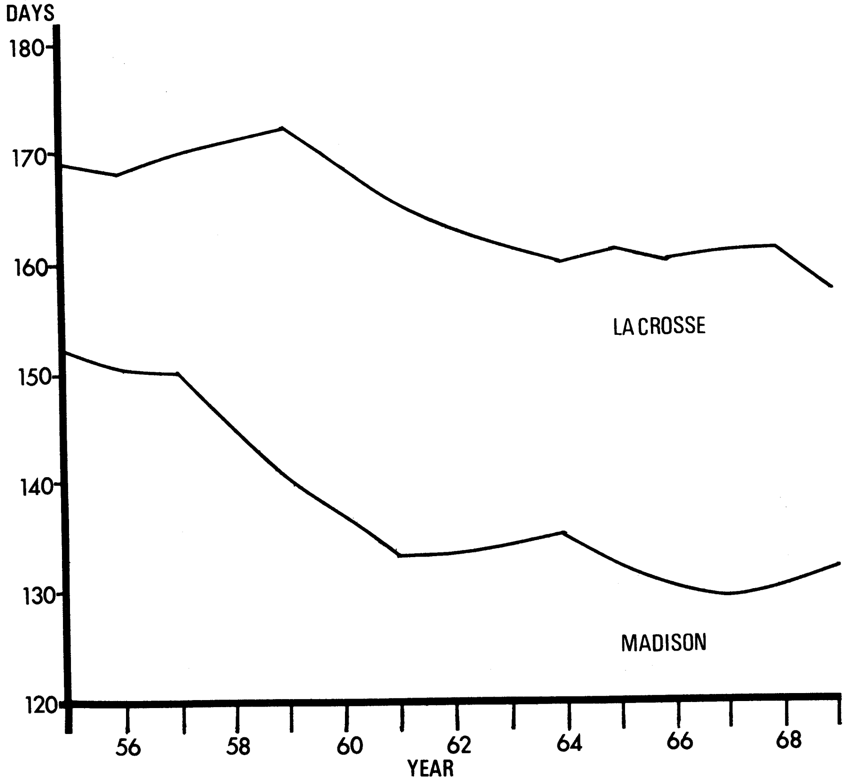

FIGURE 8. Eleven-year running mean of length of freeze-period (in days) for La Crosse and for Madison from 1950 through 1974.

date, and for seven stations the first freeze occurred later, while two stations experienced no change in average date. Hence, it may well be that changes in both spring and autumn climatic events are contributing to the extended growing season in certain locales in Wisconsin.

Results reported to this point are based upon differences obtained between average values calculated for the two decades that bracket the study period. More significant insight into the character of the change in length of growing season (if any) is gained by computation of running means. As expected, 11-year running means yield the maximum smoothing of data and permit identification of long-term trends. In Fig. 8 are plotted the 11-year running means of the length of freeze-free period for La Crosse and for Madison (localities which experienced the most significant shortening), and in Fig. 9 the same analysis is presented for Stevens Point and Sturgeon Bay data (stations where the freeze-free period increased in length). In both sets of plots, inter-station variability is evident. For example, while the trend showed an initial upturn at La Crosse, for the same time interval at Madison the trend was downward. However, the plots in both Fig. 8 and Fig. 9 indicate that major changes in the length of the freeze-period occurred during the late 1950s. Since that time

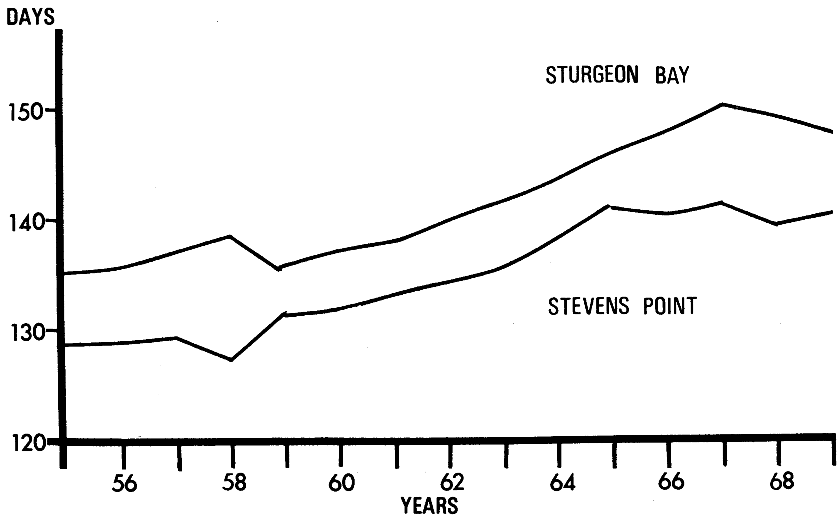

FIGURE 9. Eleven-year running mean of length of freeze-free period (in days) for Sturgeon Bay and for Stevens Point from 1950 through 1974.

TABLE 2. STANDARD DEVIATIONS OF LAST SPRING AND FIRST AUTUMN OCCURRENCE OF 28°F AND LENGTH OF 28°F-FREE PERIOD FOR THE DECADES 1950-59 AND 1965-74. (STATIONS ARE ARRANGED BY CLIMATIC DIVISION.)

Station	Spring Date 1950-59	Spring Date 1965-74	Autumn Date 1950-59	Autumn Date 1965-74	Length 1950-59	Length 1965-74
Northwest						
Ashland EX F	9.0	11.8	8.2	10.0	13.8	16.8
Cumberland	11.7	6.7	8.4	12.9	13.9	14.9
Holcombe	12.7	7.9	15.4	9.1	19.3	14.8
Ladysmith	9.0	5.2	8.8	10.8	15.4	12.4
Solon Springs	7.4	9.6	7.9	8.3	14.4	14.5
Winter	7.3	9.4	7.4	12.1	9.8	15.5
North Central						
Long Lake Dam	8.4	10.8	8.7	11.1	12.1	18.5
Owen	*	*	14.9	14.1	*	*
Rainbow Res	4.9	11.4	8.7	8.2	8.9	13.8
Rest Lake	*	*	7.7	8.8	*	*
Rhinelander	12.0	5.2	12.0	8.8	16.0	10.6
Tomahawk	10.3	8.7	9.3	8.8	16.3	14.6
Wausau AP	10.2	8.4	12.5	12.8	16.7	19.4
Willow Res	*	*	*	*	*	*
Northeast						
Brule Island	5.8	11.5	12.6	13.2	12.2	16.9
Marinette	11.9	11.1	14.6	12.0	15.9	20.2
West Central						
Blair	*	*	10.0	9.1	*	*
Eau Claire AP	11.3	5.2	11.4	12.3	12.9	12.2
La Crosse AP	9.0	12.3	6.2	11.6	9.4	16.5
River Falls	11.7	7.3	8.4	14.4	13.6	16.6
Central						
Coddington	11.2	10.0	12.7	10.0	18.5	12.1
Hancock EX F	12.7	10.5	11.0	11.8	13.0	17.7
Marshfield EX F	13.2	9.2	9.3	9.6	16.1	16.4
New London	10.4	10.0	7.8	12.6	12.9	16.3
Pittsville	11.0	9.2	14.4	8.0	17.1	13.0
Stevens Point	12.3	8.3	10.1	11.0	17.0	17.2
Wisconsin Rapids	9.6	9.8	9.3	8.7	12.8	16.1
East Central						
Appleton	10.3	11.2	9.3	7.9	11.5	15.2
Chilton	*	*	12.4	14.5	*	*
Green Bay AP	12.7	8.4	12.8	13.3	19.9	20.3
Sturgeon Bay	13.0	8.0	11.4	13.3	16.0	17.7
Southwest						
Baraboo	11.3	9.2	12.8	11.4	12.8	16.2
Lone Rock AP	10.5	8.9	9.3	7.0	10.9	10.3
Lynxville Dam	9.4	7.8	9.9	11.0	9.5	17.0
Prairie Du Sac	9.2	7.3	9.2	11.9	10.3	13.0
Richland Center	9.0	8.5	10.9	11.9	14.7	13.7
South Central						
Janesville	8.6	12.8	10.4	14.2	11.0	17.1
Madison AP	14.2	9.8	15.0	9.9	18.3	17.9
Watertown	10.5	13.1	11.4	12.8	16.4	21.6
Wisconsin Dells	12.5	6.3	11.2	12.6	16.6	12.8
Southeast						
Lake Geneva	10.6	10.9	10.3	16.1	15.6	16.5
Milwaukee AP	9.7	12.0	10.4	15.0	14.6	21.7
Waukesha	9.9	11.5	12.8	12.7	8.5	19.5

* Missing Data

TABLE 3. STANDARD DEVIATIONS OF LAST SPRING AND FIRST AUTUMN OCCURRENCE OF 32°F-FREE PERIOD FOR THE DECADES 1950-59 AND 1965-74. (STATIONS ARE ARRANGED BY CLIMATIC DIVISION.)

Station	Spring Date 1950-59	Spring Date 1965-74	Autumn Date 1950-59	Autumn Date 1965-74	Length 1950-59	Length 1965-74
Northwest						
Ashland EX F	8.5	11.5	*	*	*	*
Cumberland	6.7	8.8	7.8	7.7	10.8	13.7
Holcombe	5.9	10.2	*	*	*	*
Ladysmith	10.2	9.7	12.3	11.0	19.8	14.5
Solon Springs	*	*	*	*	*	
Winter	*	*	12.4	13.2	*	*
North Central						
Long Lake Dam	9.3	12.2	17.5	29.0	20.3	29.0
Owen	8.3	10.2	11.1	14.1	14.5	18.4
Rainbow Res	11.5	9.4	7.1	9.7	27.6	15.8
Rest Lake	9.7	10.5	11.4	10.6	9.5	12.9
Rhinelander	3.6	8.7	8.3	10.9	9.3	15.5
Tomahawk	10.0	7.9	7.2	14.6	12.2	17.9
Wausau AP	10.5	9.4	5.5	8.1	14.2	15.2
Willow Res	7.9	8.3	13.0	12.3	19.3	18.1
Northeast						
Brule Island	7.5	11.0	9.7	25.4	14.1	32.4
Marinette	6.8	7.3	9.2	12.5	11.6	14.9
West Central						
Blair	8.2	9.5	7.7	8.2	8.4	7.6
Eau Claire AP	7.2	10.1	7.9	9.6	12.9	15.1
La Crosse AP	10.2	13.6	10.0	11.4	12.2	19.2
River Falls	6.4	10.2	7.8	11.0	10.4	15.7
Central						
Coddington	9.3	10.2	15.0	14.8	18.6	15.4
Hancock EX F	12.9	8.5	7.5	5.6	11.1	9.7
Marshfield EX F	5.2	9.9	7.7	8.1	7.0	12.8
New London	*	*	6.6	8.0	*	*
Pittsville	6.1	7.7	6.9	9.1	7.6	9.2
Stevens Point	5.0	8.0	6.1	8.2	8.6	13.0
Wisconsin Rapids	6.2	10.7	5.1	12.5	8.3	19.3
East Central						
Appleton	12.9	8.4	9.9	13.3	18.5	19.7
Chilton	10.3	7.9	7.6	12.3	17.0	13.0
Green Bay AP	10.7	8.3	7.2	9.0	12.7	13.4
Sturgeon Bay	9.2	9.5	10.1	14.0	12.6	9.4
Southwest						
Baraboo	14.0	9.2	7.4	8.3	12.0	14.1
Lone Rock AP	13.6	7.8	8.0	10.0	12.4	12.1
Lynxville Dam	8.6	7.8	12.0	11.5	13.8	12.5
Prairie Du Sac	11.2	5.8	11.9	10.1	15.7	13.0
Richland Center	12.5	7.8	8.2	7.3	8.6	9.9
South Central						
Janesville	8.0	7.7	9.0	11.1	14.5	17.5
Madison AP	14.5	12.0	10.9	6.9	15.5	16.3
Watertown	12.7	13.4	8.9	8.9	17.1	17.0
Wisconsin Dells	10.9	8.6	8.0	7.9	11.2	11.8
Southeast						
Lake Geneva	12.0	5.7	11.8	14.9	16.1	14.3
Milwaukee AP	9.0	5.0	14.7	12.6	18.1	15.7
Waukesha	10.9	7.8	10.4	12.4	15.4	18.4

* Missing Data

there appears to be some stabilization in the length of the growing season.

CONCLUSION

Preliminary results of this study indicate that the response of length of growing season to hemispheric cooling is non-uniform in both sign and magnitude across the State of Wisconsin. However, there is reason to suspect the validity of this conclusion. The standard deviations of indices of length of growing season within decades (Tables 2 and 3) are of the same order of magnitude as the change measured between decadal means. This suggests that variations in local conditions (*e.g.*, exposure, urbanization) may be obscuring the long-term regional climatic trend. Hence, the simplistic statistical approach taken here may well be inadequate to separate the climatic signal from the considerable noise introduced by local difference in response to the march of weather episodes. Resort must be made to more sophisticated analyses in order to confidently confirm, modify or reject the conclusions presented here. Such approaches may also serve to identify the nature of the changes in controlling circulation patterns accompanying hemispheric cooling. It is suggested that this effort involve:

1. Analysis of distribution of daily temperature minima for months that bracket the growing season.
2. Air mass frequency analysis utilizing both trajectory and partial collective approaches (Bryson, 1966).
3. A detailed assessment of the notion that temperature and length of growing season are positively correlated.
4. An investigation of alternative means of describing the length of growing season and an assessment of change.

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AMPHIBIANS AND REPTILES OF THE PIGEON LAKE REGION

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Pigeon Lake is located at 46° 21′ N, in Drummond Township of Bayfield County, Wisconsin. It is about 30 miles north of Hayward and is surrounded by the Chequamegon National Forest.

A field station, currently run by a consortium representing nine campuses of the University of Wisconsin, has been in operation at Pigeon Lake since 1960. As a result of class work in the field during this period, information has accumulated on the amphibians and reptiles of the area, and a general discussion of their status in the area will hopefully be of use to future students and researchers.

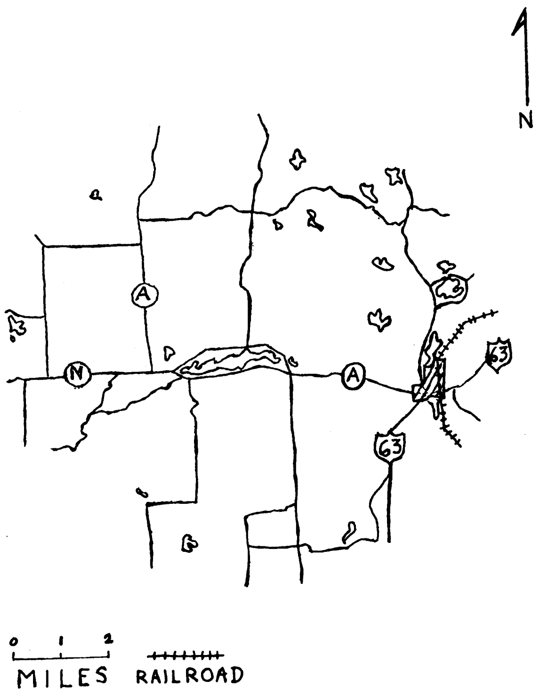

FIGURE 1. Study Area. Pigeon Lake is in the center; the hatched area at the right is the town of Drummond.

The study area for this report (Fig. 1) is defined as a 5 mile radius from the field station. This is mixed hardwood-conifer, area mainly second growth, with interspersed tilled areas, pasture and abandoned fields. There are a number of streams and numerous small ponds and lakes; the latter generally oligotrophic or mesotrophic. In addition there are many bog areas, some of which are lake-edge, with a few cat-tail (*Typha*) communities. It is a lightly-settled area, with approximately 7 people per square mile.

The elevation in the study area varies from 1200 to 1400 feet. Average annual temperature for January is 12.4 F, and for July is 67.1 F. Precipitation averages about 27" per year. Frost penetration in exposed areas may reach 48"; there is an average of 116 frost-free days per year. The soils are silty loams and sandy loams ranging in pH from 5.5 to 6.5

CLASS AMPHIBIA

Family Ambystomatidae

Blue-spotted Salamander (*Ambystoma laterale*)—Uncommon. Woodland areas, under logs. (Briggs, 1974). Specimens deposited in collections at U. W.-Superior (UWS) and Milwaukee Public Museum (MPM)

Tremblay's Salamander (*Ambystoma tremblayi*)—Rare. A triploid species very similar to *A. laterale*. One specimen collected near Lake Owen, 1974. (MPM)

Spotted Salamander (*Ambystoma maculatum*)—Uncommon. Temporary woodland ponds. Egg masses found on May 20, 1974, probably deposited in late April or early May. (UWS and MPM)

Family Salamandridae

Central Newt (*Notopthalmus viridescens*)—Common. Adults breeding in ponds mid-May to June. Efts in and under logs and stumps in wooded areas. (UWS and MPM)

Family Plethodontidae

Four-toed Salamander (*Hemidactylium scutatum*)—Uncommon. Locally abundant under logs. (MPM)

Red-backed Salamander (*Plethodon cinereus*)—Common. Often under logs in moist woods. Both red and gray phases are found. Gravid females were collected in late May, 1974. (UWS and MPM)

Family Bufonidae

American Toad (*Bufo americanus*)—Common. Larvae had tail buds by late May, 1974, and adults had stopped calling. (UWS and MPM)

Family Hylidae

Chorus Frog (*Pseudacris triseriata*)—Common. Produces the first loud choruses in Spring. (MPM)

Spring Peeper (*Hyla crucifer*)—Common. Breeds in late May and early June. (UWS and MPM)

Southern Gray Tree Frog (*Hyla chrysoscelis*)—Uncommon. In pond on County Trunk A, 3-4 miles north of County Hwy. N. (MPM)

Gray Tree Frog (*Hyla versicolor*)—Common. Breeds in late May and early June. (UWS and MPM)

Family Ranidae

Green Frog (*Rana clamitans*)— Common. Starts calling first week of June. (UWS and MPM)

Mink Frog (*Rana septentrionalis*)—Uncommon, but abundant at Bearsdale Springs. (UWS and MPM)

Northern Leopard Frog (*Rana pipiens*)—Common. Starts calling first week of June. (UWS and MPM)

Wood Frog (*Rana sylvatica*)—Common. Begins laying eggs as soon as open water available. (UWS and MPM)

CLASS REPTILIA

Family Chelydridae

Snapping Turtle (*Chlydra serpentina*)—Common. Begins egg-laying in May. (UWS and MPM)

Family Testudinata

Painted Turtle (*Chrysemys picta*)—Common. Jacobson and Walz (1966) found 45 individuals (22% adults) in Pigeon Lake. Their weight averaged 1.16 lbs. (UWS and MPM)

Wood Turtle (*Clemmys insculpta*)—Rare. (MPM)

Family Scincidae

Prairie Skink (*Eumeces septentrionalis*)—Rare. Occurs on southern shore of Pigeon Lake. (UWS)

Five-lined Skink (*Eumeces fasciatus*)—Rare.

Family Colubridae

Ringneck Snake (*Diadophis punctatus*)—Common.

Hognose Snake (*Heterodon platyrhinos*)—Rare.

Smooth Green Snake (*Opheodrys vernalis*)—Fairly common in old fields near Pigeon Lake. (UWS and MPM)

Fox Snake (*Elaphe vulpina*)—Uncommon.

Eastern Garter Snake (*Thamnophis sirtalis*)—Common. (UWS and MPM)

Red-bellied Snake (*Storeria occipitomaculata*)—Common.

The following is a list of animals whose range includes the study area but were never observed (Conant, 1975).

Mudpuppy (*Necturus maculosus*)

Bullfrog (*Rana catesbeiana*)

Pickerel Frog (*Rana palustris*)

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