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TRANSACTIONS

of the Wisconsin Academy of Sciences, Arts and Letters

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Transactions welcomes articles that explore features of the State of Wisconsin and its people. Articles written by Wisconsin authors on topics other than Wisconsin sciences, arts and letters are occasionally published. Manuscripts and queries should be addressed to the editor.

Submission requirements: Submit three copies of the manuscript, double-spaced, to the editor. Abstracts are suggested for science/technical articles. The style of the text and references may follow that of scholarly writing in the author's field. Please prepare figures with reduction in mind.

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From the Editor

You know you're from Wisconsin if. . .

. . . you define summer as three months of bad sledding.
. . . you have experienced frostbite and sunburn on the same weekend.
. . . you have more miles on your snowblower than your car.
. . . your Fourth of July picnic was moved indoors due to frost.
. . . you define swimming season as Labor Day weekend.
. . . you design Halloween costumes to fit over snowsuits.
. . . you decided to have a picnic this summer because it fell on a weekend.

Sound familiar? While this group of one-liners was forwarded to me by a friend in Texas, Wisconsinites are used to sharing similar sentiments with each other about Wisconsin weather, especially its frequent long hard winters. Let's face it: the weather in Wisconsin is a source of endless fascination (and, at times, frustration) to residents and visitors alike.

There are, of course, many positive sides to the Wisconsin weather story. From my own weather experiences over just this past year I can bring to mind scintillating star shows in the unobstructed winter skies above Door County; a frost-swathed mid-March morning in Oshkosh when every tree and bush sparkled and tinkled like a swaying crystal chandelier in the dawning sunlight; balmy evenings in late spring and early summer when the scent of lilacs graced my walks around our neighborhood; a cool, drizzly day that turned a hike along the Wisconsin River at the Dells into a sort of walk through an Impressionist painting; hot, hot days in mid-July that called out a profusion of wildflowers, especially the roadside chicory and fields of Queen-Anne's-lace, purple knotweed (a.k.a. knapweed or star thistle), and coneflowers; sunny days at the Cedarburg Bog in Saukville and at the Whitefish Dunes State Park along Lake Michigan; and a picture-postcard summer day at the beginning of August when white clouds flung carelessly across a deep blue sky seemed to gently chide the carefully patterned green and gold farm fields of southwestern Wisconsin between Platteville and Madison. *You know you're from Wisconsin if. . . you've ever enjoyed days like these.*

I was reminded of what a special place Wisconsin is by the fourteen school teachers from twelve other states (from as nearby as Illinois and Michigan and as far away as Hawaii, North Carolina, and Massachusetts) who spent a month studying with me on the University of Wisconsin Oshkosh campus from mid-June to mid-July. While they enjoyed engaging in intellectual pursuits during our National Endowment for the Humanities seminar, they literally reveled in our trips together around some of the eastern parts of the state. Their visits to beautiful Crescent Beach at Algoma; Summer Fest in Milwaukee; an evening pops concert at Buttermilk Park in Fond du Lac; State Street, the Wisconsin State Capitol, and the University of Wisconsin campus in Madison; the International Crane Foundation, with its marvelous restored prairie, in Baraboo; and various places around Green Lake, the Fox Cities, and Oshkosh, invariably resulted in praises for the people, places, flora and fauna, geology, and—yes!—even the weather of Wisconsin. *You know you've visited Wisconsin if . . . you have memories to treasure like these.*

This issue of *Transactions* features articles we have grouped into two sections, each of which showcases Wisconsin and its natural and human environments.

The three featured contributions to the opening section of *Transactions* pay tribute to one of Wisconsin's (and the nation's) pioneer conservationists, Aldo Leopold. Many have observed 1999 as a sort of Leopold Year, marking as it does the fiftieth anniversary of the publication of Leopold's classic, *A Sand County Almanac.* The Wisconsin Academy has joined wholeheartedly in the commemoration. The Academy's 129th Annual Conference at Stevens Point in April featured a day-long plenary session on "Aldo Leopold and Conservation on Private Lands." In October the Academy sponsored a national conference in Madison dedicated to "Building on Leopold's Legacy: Conservation for a New Century." Honorary cochairs for this conference were Nina Leopold Bradley of the Aldo Leopold Foundation and Gaylord Nelson, former U.S. Senator and now counselor for the Wilderness Society, which Leopold helped found in 1935. An entire issue of our sister publication, *The Wisconsin Academy Review,* also was devoted to Leopold and his legacy.

The three articles on Leopold are revised versions of lectures originally presented as part of an extended Aldo Leopold Lecture Series sponsored by the University of Wisconsin Arboretum in Madison last year. Andrew Hipp deserves special thanks for his efforts in helping make these lectures available to *Transactions.* We are especially delighted that Nina Leopold Bradley consented to let us include her homage to her father, including her reminiscences of life at the now famous Leopold family "Shack." Also of great interest are the contributions of J. Baird Callicott and Susan Flader. The former presents an incisive analysis of the important speech Leopold delivered at the dedication of the Wisconsin Arboretum and Wildlife Refuge and the extensively revised version he subsequently published in *Parks and Recreation* magazine. The latter offers us valuable insights into the meanings and implications of environmental citizenship, as suggested by Leopold's work and writings. *You know you're from Wisconsin (certainly in spirit!) if . . . you share some way in the wilderness vision of Aldo Leopold.*

In the second section of articles, Ellen Argyros takes a fresh look from an ecofeminist perspective at *Come and Get It,* a novel by one of Wisconsin's most celebrated writers, Edna Ferber. Other articles in this section concentrate on

Wisconsin's natural resources. Craig Annen and Jonathan Lyon present a study of the Curtis Prairie restoration project at the University of Wisconsin Arboretum, while Thomas Eddy documents the vascular flora of Mitchell Glen in Green Lake County. Terry Balding takes readers to another part of Wisconsin with his study of red-shouldered hawk detections along the lower Chippewa River. Waterways of Wisconsin and its neighbors provide the focus for the other three studies presented in this section: Ed Avery's research on brown trout in Emmons Creek in central Wisconsin; the analyses by Joan Jass and Jeanette Glenn of museum specimens of a freshwater bivalve mollusk abundant throughout Wisconsin; and Jeffrey Ripp's historical review of the evolution of the Great Lakes Fisheries Commission.

I hope all readers of this issue of *Transactions* will find the contents both challenging and enlightening. Dare we forecast a "warm and sunny" reading experience? Ah, but as my son will remind me when next he ventures a mid-winter visit from Atlanta to Oshkosh:

You know you're from Wisconsin if . . .

. . . the snow on your roof in September weighs more than you do.

. . . you've taken your kids trick-or-treating in a blizzard.

. . . driving is better in the winter because the potholes get filled with snow.

Bill Urbrock

The Wisconsin Academy of Sciences, Arts and Letters was chartered by the State Legislature on March 16, 1870, as a membership organization serving the people of Wisconsin. Its mission is to encourage investigation in the sciences, arts and letters and to disseminate information and share knowledge.

Nina Leopold Bradley

A Sense of Place

Today I speak to you of my own experience, my own deep attachment to a particular place. This attachment happened over time, with my family, on a sand farm along the Wisconsin River—land that was neither grand nor dramatic, but mundane, humbled, and degraded. It seems to have happened by slow accrual, like the growth of a coral reef. I dwell in this place and am finally a part of this place.

Recently I came across a splendid little book by Deborah Tall, who inspired me with the following statement: "How does land evoke our love? Surely not just driving through *scenery* or *landscape,* treating nature as a prop."

This makes me think of a quip in *The New Yorker* not long ago, recording two secretaries in conversation after their drive-through vacations. It went something like this:

> "But you get so tired with nothing but scenery all the time."
> "Yes, but you get even more tired and bored without any scenery."
> "Well, I guess. But I like it better when there's mostly landscape and not so much scenery."
> "Well, I guess. But then most of the scenery was gone when we were there. There were just mountains and things."

It seems all too often we hurry through "scenery," without any attempt to engage the land. This may be the price we pay for our mobility and rootlessness.

On our sand farm along the Wisconsin River I was able to get inside the scenery and the landscape. I became a living part of a living place. As we worked with family, friends, and neighbors to restore health to the abused land, we were experiencing the slow sensitizing of people to land. We learned how to look, how to dwell, and how to think about land. This was *sick land* but *rich country* for the growth of perception.

No one knew better than my father, Aldo Leopold, the joy of wild, unspoiled land. His love of wilderness was passionate and enduring. He had spent immense energy in protecting wilderness and trying to understand its dramatic complexity. He realized that wilderness was important in part so that we might retain the capacity to compare unspoiled land with lands more intensively altered by human economic activity. My father's rationale for wilderness protection was not just recreational or scenic, but scientific, biological, political, economic, and deeply aesthetic. He wrote, "... the raw wilderness gives definition and meaning to the human enterprise . . . the ability to see the cultural value of wilderness boils down, in the last analysis, to a question of intellectual humility."

In the 1930s Aldo visited the Rio Gavilan in northern Mexico. This river still ran clear between mossy, tree-lined banks. Fires burned periodically without any apparent damage, and deer thrived in the midst of their natural predators, wolves and mountain lions. "It is here," Leopold reflected years later, "I first realized . . . that all my life I had seen only sick land . . . here was a biota still in perfect aboriginal health." In *Song of the Gavilan* he wrote:

> This song of the waters is audible to every ear, but there is other music in these hills, by no means audible to all. To hear even a few notes of it you must first live here for a long time, and you must know the speech of hills and rivers. Then on a still night, when the campfire is low and the Pleiades have climbed over rimrocks, sit quietly and listen for a wolf to howl, and think hard of everything you have seen and tried to understand. Then you may hear it—a vast pulsing harmony—its score inscribed on a thousand hills, its notes the lives and deaths of plants and animals, its rhythms spanning the second and the centuries.

Here, the vital new idea for my father was the concept of biotic health. In this essay Aldo grasped the idea of the land community and the need for a deeper understanding of the functioning of land as an interrelated, indivisible whole. Through his intellectual struggle to better understand the system as a whole, there evolved within him a continuing love and respect for land—a deepening spirituality. He would now inspire others along the same route.

The ecological integrity of the Gavilan was put into perspective when my father visited the slick, clean forests of Germany in 1935—spruce trees in straight lines, the forest floor devoid of vegetation. Litter piled up on the forest floor as a dry, sterile blanket which smothered all natural undergrowth, even moss.

Leopold came to realize that what was lacking in the German forests was *wildness*—not wilderness per se—but a lack of *biodiversity*. He wrote of Germany,

> The forest landscape is deprived of a certain exuberance which arises from a rich variety of plants fighting with each other for a place in the sun. It is almost as if the geological clock had been set back to those dim ages when there were only pines and ferns. I never realized before that the *melodies* of nature are music only when played against the undertones of evolutionary history. In the German forest one now hears only a dismal fugue!

My father's experience in the German landscape deepened his appreciation of ecological integrity—his conviction of a relationship between ecological diversity and the stability of the land organism.

And so it was an extraordinary event when Aldo Leopold purchased his Wisconsin farm. Here, the frontier story had come full circle from *wilderness* to *farm land* to *waste*. Here was the perfect metaphor for "sick land."

In *A Sand County Almanac* he wrote, "My own farm was selected for its lack of goodness and its lack of highway; indeed my whole neighborhood lies in a backwash of the River Progress."

Gross understatement! The sandy soils, outwash from the glacier, had produced one or two crops of corn—perhaps a crop of buckwheat or rye before the soils were exhausted. Any timber had been cut. The corned out fields were coming up in sand burrs and quack grass. Sand burrs in our socks were effective reminders.

There was little left to support a farm family. The previous owner had finally given up and moved to California, the farm house having burned to the ground. The only remaining structure was an old chicken coop, waist deep in chicken and cow manure.

What could be more of a challenge for a bunch of teenagers than repairing the chicken coop. Weekend after weekend, the Leopold family worked to make the chicken coop more habitable—cleaning out manure, constructing a fireplace, attaching a bunk house, a new roof, drilling a small sand-point well, and many other items contributing to comfort.

The "Shack" became a family enterprise to which each member contributed: cutting and splitting wood, building bird houses for martins, screech owls, and bluebirds.

In my father's quiet way we finally were led to understand his direction: what *did* this land look like before white man took it away from the Indians. Reconstruction of the native landscape became our aim. We now realize this was one of the earliest attempts at ecological restoration.

From April to October scarcely a weekend went by that someone did not plant or transplant something—butterfly weed, tamarack, wahoo and oak, penstemon and puccoon. Spring vacation became the principal planting season. Each year we planted some 3,000 native pines on the land. We planted them with shovels so sharp they sang and hummed in our wrists as they sliced the earth. We planted a mosaic of conifers, hardwoods, and prairie to restore health and beauty to the community.

In winter we banded resident birds. We recorded daily, weekly, seasonal events on the land—tracks of animals in the snow, arrival of migratory geese, courtship of woodcock, etc. Here in reality Father's statement rang true—"Keeping records enhances the pleasure of the search, and the chance of finding order and meaning in these events."

It was our mother whose enthusiasm sustained the project. Mother worked as hard as anyone, planting, weeding, whatever the enterprise. She was "chief sawyer" as the gang cut good oak to cook our grub and warm our Shack.

With Mother's Spanish background she taught us Spanish songs, and each evening the guitar concert filled the old shack until weariness forced us to our bunks.

In years of drought, our struggling plantings did not survive. We learned that "sun, wind and rain" and the thrust of life would truly determine the outcome of all our investment in the place.

Here in the sand counties, Aldo Leopold initiated a *different relationship* with the land, at once more personal and more universal. From his own direct participation in the restoration of the land he was to come to a deeper appreciation of the ecological, ethical, and aesthetic understanding of land. He gained a new sense of belonging to something greater than himself, a continuity with all life through time. At the same time he was finding new dimensions to his sense of place—so, too, did his family members, colleagues in this venture.

What happened involved the senses, the memory, the history of family. It came from working on the land in all weathers, suffering from catastrophes, enjoying its mornings or evenings or hot noons, valuing it for the very investment of labor and feelings.

By his own actions my father instilled in his children a love and respect for the land community and its ecological functioning.

I now read with new perspective my father's statement: "There are two things that interest me—the relationship of people to each other and the relationship of people to land."

Family weekends at our sand county farm turned out to be a place where my father put these two concepts into practice—the relationship of our family members to each other and their relationship to this piece of land. These two interests became more a way of life than simply interests. New values were developing somewhere within us.

At the Shack, we all became participants in the drama of the land's inner workings. In the very process of restoration—of planting, of successes and failures, of animals and birds responding to changes—we grew increasingly to appreciate and admire the *interconnectedness* of living systems.

As we transformed the land, it transformed us. This must be how a *sense of place* is nurtured. My father once wrote that restoration can be a ritual of self renewal. And so it was. As we worked together, there came love and respect for each other and for the land community.

One of the principal achievements of *A Sand County Almanac* is the recasting of our notion of natural beauty, away from the conventionally "scenic" to the more subtle sense that comes with ecological and evolutionary awareness.

Through my father, my family, and this experience I have learned to love this land. This place has taught me how to look and how to live, and so at last to sing its poetry.

Nina Leopold Bradley *lives on the Leopold Memorial Reserve and is a director of the Aldo Leopold Foundation. She is a plant ecologist presently working on prairie restoration and continuing the study of phenology started by her father in the 1930s.* ***Address:*** *Aldo Leopold Foundation, Inc., E12919 Levee Road, Baraboo, WI 53913.*

J. Baird Callicott

"The Arboretum and the University": The Speech and The Essay

The dedication ceremony of the University of Wisconsin Arboretum and Wildlife Refuge occurred on June 17, 1934. Aldo Leopold had joined the faculty the previous year as the nation's first professor of game management, and had been involved, as such, in the conception and design of the Arboretum (Meine 1988). He was among those who spoke on this occasion.

According to William R. Jordan III (personal communication), long a member of the Arboretum staff and founding editor of *Restoration and Management Notes,* in his speech Leopold was the first person to clearly articulate the concept of ecological restoration and provide a rationale for it. Once more, Leopold earns the metonyms of pioneer and prophet that so frequently accompany his name. Apparently, he is the seminal figure in ecological restoration as he is in ecosystem-management forestry, conservation biology, and environmental ethics.

Here is the key passage: "Our idea in a nutshell is to reconstruct, primarily for the use of the University, a sample of original Wisconsin—a sample of what Dane County looked like when our ancestors first arrived here during the 1840s." Before this central and summary statement, Leopold characterized what most arboretums were about as "a collection of trees" of one sort or another, some organized taxonomically, others—those that were "more advanced"—organized "ecologically" as "natural associations." The restoration project at the University of Wisconsin Arboretum was then unique and (perhaps now as well as then) represented the most advanced concept of what an arboretum might be.

Leopold followed this clear articulation of ecological restoration with a lyrical description of "what our state was like before we took it away from the Indians" and how different the Lake-Wingra environs were then from what his audience beheld in 1934. His description was organized hydrologically. He first described the "oak-openings" on the uplands; next the tamarack forest on the Wingra marsh, "undergrown with sphagnum moss and orchids"; then the "wild rice bed" on the lakeshore; and finally the lake itself, once a haven for waterfowl, but by 1934 spoiled as a habitat for its erstwhile avifauna and native fishes by, in all probability, the introduction of carp. This could all be ascertained from the "embalmed" pollen grains preserved in the marsh peat, he noted.

Next Leopold turned to the question "why dig up these ecological graves?" And answered that the ecological changes befalling the area, while the concomitants of the laudable utilitarian conversion of aboriginal Wisconsin to fair farms and productive forests, portended disutilities for the future: "the erosion of topsoil which followed too much wheat and too many cattle"; fires which "burned up the peat beds in our drained marshes"; exotic insect pests, such as white-pine blister rust and white-oak June-beetles "from the four corners of the earth"—all will at a minimum "reduce our standard of living" and may even "threaten the actual physical existence of . . . the present social structure." To us Leopold may seem to have been not only a prophet, but, more particularly, a Jeremiah, predicting a plague of locusts and thistles, a prophesy that has not come true—not yet anyway. The little island of ecological healing represented by the Arboretum notwithstanding, the ecological changes Leopold reviews and laments have, if anything, accelerated by many orders of magnitude since 1934. Yet here we are today enjoying, for the moment at least, an unprecedented standard of living and a social structure that remains more or less intact. But remember, this was 1934. Dust Bowl. Depression. Bolshevism entrenched in Russia. Fascism gathering force in Germany. The future did not look at all either certain or bright.

Just as he had reduced the concept of ecological restoration to a "nutshell," so he reduced the rationale for it to a nutshell at the end of his remarks. He said: "This, in a nutshell, is the function of the Arboretum: a reconstructed sample of old Wisconsin to serve as a bench mark, a starting point, in the long and laborious job of building a permanent and mutually beneficial relationship between civilized men and a civilized landscape."

There are two distinct lobes of meat in this nutshell. Examine the latter first: "a mutually beneficial relationship between civilized men and a civilized landscape." This is one of several formulations that Leopold struck to crystallize his novel philosophy of conservation.

At the turn of the century two philosophies of conservation had taken shape (Hays 1959, Fox 1981). The more venerable, going back to Ralph Waldo Emerson and Henry David Thoreau, came to be called "preservation." Its most forceful and influential champion was John Muir. Its standard or norm and its sanctum sanctorum was wilderness, "in contrast with those areas where man and his own works dominate the landscape . . . an area where the earth and its community of life are untrammeled by man, where man is a visitor who does not remain"—to quote the eventual Wilderness Act of 1964 (Anonymous 1998: 121). The other philosophy—call it conservation proper—was summed up, at the turn of the century, as the "wise use" of "natural resources." Its most forceful and influential champion was Gifford Pinchot, the first Chief of the United States Department of Agriculture Forest Service, by which Leopold was first employed. Pinchot's (1947: 325–26) conservation motto was straightforwardly utilitarian and anthropocentric: "the greatest good of the greatest number [of people, it went without saying] for the longest time."

Leopold and another maverick ranger, Arthur Carhart, had first proposed a system of wilderness preserves under the auspices of the Service on the national forests (Meine 1988). Thus we tend to think of Leopold as having begun his career in forestry firmly in the Pinchot camp. Then, gradually he became enlightened by his study of ecology and his experience on the ground in the arid Southwest, especially in regard to range management (Leopold 1924). The interconnection among "natural resources," Leopold slowly but steadily came to realize, frustrates their separate utilitarian exploitation and management for maximum sustained yield. Ultimately, therefore, he left the ecologically unenlightened Pinchot conservationist camp and came over to the Muir preservationist camp. His resignation from the Forest Service in 1928 formalized and finalized this conversion.

But that's not the correct interpretation of what happened. Leopold's push for wilderness preservation in the mid-1920s was expressed in terms of Pinchovian wise use, not Muirian Transcendentalism (Leopold 1925). The principal use of wilderness was recreation, which of course for Leopold mainly meant big game hunting. And for some regions of the country—too rugged to log, too remote to graze, too arid or too nutrient-poor to plow—wilderness recreation was their highest use. Leopold did reject species-by-species, commodity-oriented resource management, but not in the context of his wilderness advocacy. In any case, by the time he had become a university professor he had evolved a new paradigm of conservation that lay between the Pinchovian and Muirian extremes. Leopold's new idea of conservation was a human harmony with nature, as he expressed it with characteristic grace and simplicity in the *Almanac* (Leopold 1949). Not hands-off Muirian nature preservation. Not efficient Pinchovian resource exploitation. Not a compromise between the two: islands of wilderness—the bigger and more numerous the better—surrounded by intensively, albeit efficiently, exploited but ecologically degraded tree plantations, grain plantations, cattle pasture and feedlots, suburban and urban sprawl. Rather a mutually beneficial relation between people and land; a symbiosis; a mixture of beauty and utility *in the same place* (Leopold 1939, 1991*a,* 1999*a*).

Now examine the other lobe of meat in the nutshell rationale for ecological restoration, the function of the Arboretum. It will be a reconstructed sample of old Wisconsin, to serve as a bench mark, a starting point, in the long and laborious job of building a permanent and mutually beneficial relationship between civilized men and a civilized landscape. After having come to his novel philosophy of conservation, incidentally, Leopold was justifying wilderness preservation in exactly the same terms. "A science of land health," he wrote, "needs, first of all, a base datum of normality, a picture of how healthy land maintains itself as an organism. . . . The most perfect norm is wilderness" (Leopold 1941: 3). Less perfect, perhaps, but just as important is an ecologically restored landscape. Doubtless there is intrinsic value in a reconstructed sample of old Wisconsin as there is in a big Western wilderness preserve. In Leopold's rapturous description of the presettlement environs of Lake Wingra, there is a palpable nostalgia and affection. But that is not the only rationale for the Arboretum restoration project, nor is it the rationale that Leopold explicitly states. Rather, if we are to forge our own symbiosis with the land upon which we now live, we need a bench mark of land health. We found the land in a state of good health. We have ecologically transformed it and thereby compromised its health. We cannot and will not everywhere try to take it back to what it was, try to restore it to a previous state. "Americans shall look forward not backward," Leopold says expressly. Americans are civilized and their landscape shall be civilized. But can it not also be healthy? Can there not also be a mutually beneficial relationship between civilized men and a civilized landscape? At the conclusion of this article I return to Leopold's concept of land health and, more particularly, its ecological and ethical foundations.

Implicit in the possibility of a future symbiosis between civilized European-Americans and the civilized landscape upon which it is erected is the conviction that the previous tenants of the Upper Midwest had established their own mutually beneficial relationship with the place that would later be called Wisconsin. If *they* could do it, maybe *we* could do it. In *The Story of My Boyhood and Youth,* John Muir (1913: 32) exclaims "Oh that glorious Wisconsin wilderness!" To the contrary, Leopold knew that Wisconsin was not in a wilderness condition in 1849 when Muir first beheld it, for Leopold acknowledges that "we took it away from the Indians." Moreover, though not mentioned in Leopold's talk, present at the dedication, dressed in full ceremonial regalia, and giving a speech of his own, was a Winnebago Chief, Yellow Thunder, a living reminder that old Wisconsin was not a place where, until the 1840s, man was a visitor who did not remain (Meine 1988).

Four months later, Leopold's address at the dedication ceremony of the University of Wisconsin Arboretum and Wildlife Refuge was published in the October issue of *Parks and Recreation.* Or was it? Leopold had so thoroughly revised the text of his speech that only a few phrases remained from the original to indicate that the published essay had evolved from it—and in so short a period of time, given manuscript preparation, typesetting, proofreading, and the other time-consuming steps from the pencil, with which Leopold composed, to the printing press. One memorable fragment stands out: In the speech Leopold wrote: "This task [preserving an environment fit to support citizens] is of a complexity far beyond what I can here take time to explain. I will ask you to accept my word that it is a long and difficult job. To perform it, a University must have, for the daily use of its faculty and students, a living exhibit of what Wisconsin was, what it is, and what it expects to become." In the essay we read, "If civilization consists of coöperation with plants, animals, soil, and men, then a university which attempts to define that coöperation must have, for the use of its faculty and students, places that show what the land was, what it is, and what it ought to be." Hard on the heels of this remark is a disparaging mention of what an arboretum normally is, "a 'collection' of imported trees," which also echoes the speech. Finally, in the next and last paragraph of the essay, the whole of which is shorter than the speech, Leopold condensed his invidious comparison of the present ecological condition with that prevailing in the past, emphasizing the corrosive combination of wetland draining and burning. But his eye to the past remains, in the essay as in the speech, in service of his eye on the future. "At what stage in the retrogression from forest to meadow is the marsh of greatest use to the animal community? How is that desirable stage to be attained and maintained? What is the role of drainage? These questions are of national importance. They determine the future habitability of the earth, materially and spiritually. . . . The scientist does not know the answer—he has been too busy inventing machines. The time has come for science to busy itself with the earth itself. The first step is to reconstruct a sample of what we had to start with. That, in a nutshell, is the Arboretum."

So here is a mystery: Why didn't Leopold just mail the text of his speech to *Parks and Recreation* for publication? Why did he so thoroughly rework it? Adding to the mystery is the fact that the essay purports to be the text of a speech. In it he writes "This Arboretum . . . " as if he were actually standing in it as he spoke. A line or two afterward he writes "I am here to say . . ." a locution more appropriate to a speech than to an essay. Most unambiguously misleading he writes "Take the grass marsh here under our view . . . ." Let me hasten to say that I do not accuse Leopold of dishonesty. Rather, it is a most revealing example of his artistry. By way of comparison, I am convinced that "Thinking Like a Mountain," *Sand County*'s second most famous and oft-quoted essay, is fictional. Neither Susan Flader (1974) nor Curt Meine (1988), Leopold's biographers, could find a record of such a signal event as it purportedly recalls in Leopold's correspondence or journals. "Thinking Like a Mountain" was written in response to a criticism by Albert Hochbaum, who was reading and critiquing drafts of the book that was to become the *Almanac* (Ribbens 1987). Hochbaum had complained that Leopold came off as elitist and superior and reminded him that he had once been as ecologically blind as those he criticized (Ribbens 1987). In support of that observation Hochbaum pointed out that Leopold had had a hand in the extirpation of wolves from the Southwestern game fields (Ribbens 1987). Leopold might enable his readers more to identify with the author, Hochbaum suggested, if the author found his lessons in his own mistakes (Ribbens 1987). Leopold responded with "Thinking Like a Mountain," an environmental transmogrification, as it seems to me, of the story of Saint Paul's conversion on the road to Damascus. The old she-wolf, silently asks, in effect, why persecutest thou me?, with that bewitching green fire in her dying eyes. That in all probability the event did not actually happen does not in the least diminish the truth of the essay. It fits like the keystone in one of the twentieth century's greatest works of literature and one of the greatest works of literary natural history of all time.

So part of the solution to our present mystery is the author's need to transform his text from an oral to a written work of art. The speech is far less aggressive. At one point in the speech Leopold almost apologetically issues a disclaimer. "Now this is not a tirade against careless farming, lumbering, or transportation," he says to his audience that might well include farmers, lumbermen, teamsters, and engineers. But in the essay he openly admits to being "indignant about something." The artist also seems to have felt a need to scale up from the municipal, regional, and state level to the continental and even global level for a national publication; hence the Wisconsin landscape is less the central subject, than an example used to illustrate the more general plight of land and the current human maladaptation to the earth.

The most startling change Leopold made in transforming the Arboretum speech into the Arboretum essay is not in voice or in adaptation to audience, but in substance. He added a philosophical, one might even say, eco-metaphysical theme that is completely absent in the speech—and he put it at the very beginning. Leopold wished his national readership to imagine that this is how he opened his address to the company assembled at the dedication of the University of Wisconsin Arboretum and Wild Life Refuge:

> For twenty centuries and longer, all civilized thought has rested upon one basic premise: that it is the destiny of man to exploit and enslave the earth.
>
> The biblical injunction to "go forth and multiply" is but one of many dogmas which imply this attitude of philosophical imperialism.
>
> During the past few decades, however, a new science called ecology has been unobtrusively spreading a film of doubt over this heretofore unchallenged "world view." Ecology tells us that no animal—not even man—can be regarded as independent of his environment. Plants, animals, men, and soil are a community of interdependent parts, an organism. No organism can survive the decadence of a member. Mr. Babbitt is no more a separate entity than is his left arm, or a single cell of his biceps. Neither are those aggregations of men and earth which we call Madison, or Wisconsin, or America. It may flatter our ego to be called the sons of man, but it would be nearer the truth to call ourselves the brothers of our fields and forests.
>
> The incredible engines wherewith we now hasten our world-conquest have, of course, not heard of these ecological quibblings; neither perhaps have the incredible engineers. These engines are double-edged swords. They can be used for ecological coöperation. They are being used for ecological destruction on a scale almost geological in magnitude. . . .

Pretty strong stuff. And bold. The only mention of ecology in the Arboretum speech is adjectival, first used to characterize the way the more "advanced institutions arrange their tree collection," viz., as "ecological groupings," and then to characterize the Arboretum project as digging up "ecological graves." In the Arboretum essay ecology is characterized as more than just a new science. It is a new world view pregnant with ethical import.

But what ecology? Evidently the ecology of Frederic Clements, the dean of that emerging new science in the early twentieth century, who boldly represented plant formations as superorganisms. The Clementsian paradigm in ecology cast doubt not just on the Judeo-Christian view of nature as created for man's use, it also cast doubt on the prevailing mechanistic world view of classical physics, which informed engineering. The Judeo-Christian dogma that it is man's God-given right to have dominion over and subdue the earth and "the mechanistic conception of the earth" in Newtonian physics combined to create the "iron-heel" mentality that Leopold twice goes on to condemn in the Arboretum essay. A decade earlier (in an essay that he never got around to publishing in his lifetime, but that was finally published more than fifty years after it was written), Leopold (1979) had more fully contrasted the organismic ecological world view with the biblical and mechanical world views, allied in their "anthropomorphism" as he called it.

Now back to the theme with which I began: Leopold's articulation of the nature of and a rationale for ecological restoration in his Arboretum speech. Supplementing the speech with the essay it is evident that the prophet and pioneer of ecological restoration was informed by the Clementsian paradigm in ecology, with one major and crucial difference, as I shall explain directly.

According to Clements (1905, 1916), each region of the world, which he called a "biome," had a characteristic plant "formation" that he called the "climax" because it was determined by the climate—which he supposed to be stable and unchanging. Climate consists of two principal gradients, moisture and temperature. In North America, for example, the moisture gradient runs, low to high, from the Sierra rain shadow eastward to the Atlantic; in the dry Southwest, a formation dominated by saguaro cactus is the climax; a little farther east the climax is short-grass steppe; still farther east, it's long-grass prairie; from the Mississippi valley on eastward, it's forests. Similarly the temperature gradient determines forest types from southern oak-hickory hardwoods to northern spruce-fir softwoods. Elevation complicates this picture, and it does demonstrably in the Southwest where Leopold first worked. Going upslope is like going north, and, in the U.S., like going east: the micro-climate is cooler and wetter at higher elevations.

In any case, from time to time the climax formation in a biome experiences catastrophic external disturbances—volcanic eruption, wild fire, flood, wind storm. There follows a series of plant formations until the climax formation is reestablished. Clements called this process "succession."

Moreover, he viewed this process as a kind of organismic development, an ontogeny. It was the climax "sere" (successional stage) that he believed to be a highly integrated superorganism. Ecology is the study of its anatomy, physiology, and metabolism.

Clements' study area was the Nebraska prairie just at the time it was being settled by European-American agriculturists. To him they represented an alien and external disturbance that not only destroyed the climax formation but that also disrupted and forestalled the process of succession back to climax.

It is just here, I think, that Leopold parts company with Clements. Human beings too, in Leopold's view, are members of ecological superorganisms. Sinclair Lewis's Babbitt, no less than Yellow Thunder, is but one cell of the superorganism in which he lives, moves, and has his being. Human beings and human ecological impacts are not metaphysically set apart from nature, as our biblical Western philosophical traditions often interpret them to be. Nor is *Homo sapiens* a physically alien species, invading Earth from another planet. Hence the ecological effects of human activities are not by definition sullying. Just like the activities of other species, human activities can be ecologically benign as well as malignant, functional as well as dysfunctional, harmonious as well as disruptive. Our "engines . . . can be used for ecological coöperation," Leopold writes, even though at present "they are being used for ecological destruction on a scale that is almost geological in magnitude."

Ecological restoration, as we have come to know it, I submit, rests, implicitly, on the orthodox Clementsian paradigm in ecology, not the Leopoldian alternative (Jordan et al. 1987). The putatively "objective" norm for conventional ecological restoration is the humanly undisturbed climax formation for a given biome. Supposedly, that was the condition it was in just prior to human "settlement" by the "white man," i.e., by *Homo sapiens* of European descent and cultural habits. Granted, the Indians were here already, but they were too few and their cultures were too primitive to have much ecological effect. Or so restorationist orthodoxy would have us think. In addition to destroying the climax and disrupting the process of succession, the white man brought with him a range of "exotic" species; that is, species that had evolved, naturally or artificially, elsewhere. Some of these—for example, wheat, cattle and sheep—were his domesticated cultivars. Others—such as carp and Johnson grass—were neither domesticated, that is, artificially selected, nor cultivated, but were, nevertheless, deliberately introduced. Still others—such as the Norway rat—were inadvertently introduced. Hence, in addition to "pre-settlement" ecological conditions, native species also became a norm for ecological restoration and exotic species a target for eradication.

Contemporary biogeography, ecology, and anthropology have rendered these straightforward norms for ecological restoration problematic (Pickett and Ostfeld 1995):

- The climate has not been stable during the Holocene; hence forests, grasslands, and deserts have slowly wandered around (Davis 1986).
- Local disturbance has been frequent, and not exceptional, and once a patch within a biome has been disturbed, succession does not follow a lock-step order through a series of intermediate formations back to the original climax (Pickett and White 1985).
- Further, the reductive "individualistic" paradigm in ecology, first advocated by Henry Gleason (1926), has eclipsed Clementsian holism; plant formations are not now regarded as highly integrated superorganisms, or even as typological biotic communities that come and go as units, but as stochastic aggregates of species populations that are adapted to similar climatic and edaphic gradients (Simberloff 1980).
- Because species are constantly dispersing to new areas and disappearing from their former haunts, mixing and matching, hit or miss, catch as catch can, the sharp distinction between native and exotic species is blurred (Peretti 1998).
- And, lastly, the impact of *Homo sapiens* has been significant and ubiquitous throughout the Holocene. Geographers and anthropologists now estimate the indigenous population of the Western Hemisphere on the eve of European discovery to be ten to twenty times as great as the geographers and anthropologists contemporary with Clements estimated it to be (Denevan 1992). In 1492 the biomes of North and South America were as much an artifact as those in Europe at the same time—just a different kind of artifact. The oak openings which Leopold eulogizes were created and maintained by Indian-set fires, as John Curtis (1959)—he of the Arboretum's Curtis Prairie—notes in his wonderful book, *The Vegetation of Wisconsin.* In 1492 the only sizable land mass in a "pristine" condition was Antarctica. Then, one of the largest cities in the world, Kahokia, lay only some 600 kilometers and change east of the area in which Clements did his research at the turn of the last century, and only some 500 kilometers south of Lake Wingra (Doolittle 1992). Between the European "discovery" of America and "settlement" Old World diseases reduced the Indian population by ninety or ninty-five per cent—a demographic debacle of unprecedented proportions (Denevan 1992). So it was easy for twentieth-century ecologists to ignore the impact of the indigenes of the Western Hemisphere, as Clements did. But to their credit Leopold and Curtis did not, at least not in Wisconsin.

As a target for restoration, the condition of a given patch when the white man first laid eyes on it is therefore but a snapshot in the ever-changing, ubiquitously human-impacted biogeography of an area. Ecological restoration may learn to live with that, in which case it might be compared to architectural and automotive restoration. Some people have a quaint fondness for structures built in an architectural style at some arbitrarily selected particular time in the past—the Victorian era, for example—and are willing to spend considerable time and energy restoring them. Other people have a quaint fondness for particular old cars—1957 Chevrolets, for example—and are willing to spend considerable time and energy restoring them. Likewise, we environmentalists have a quaint fondness for "pre-settlement" oak savannas and long-grass prairies and are willing to spend considerable time and effort restoring them. I think that Aldo Leopold would confess to being something of an ecological antiquarian himself—without apology. Just as some people buy an old Victorian house and restore it to its former condition as a hobby, Leopold bought an old worn-out farm and attempted to restore the land to its condition prior to its being farmed. (The analogy is not perfect, but it's close enough.)

Such a concession, however, would rob ecological restoration of its moral high ground. We environmentalists believe that the time and energy of ecological restorationists should be subsidized by the general public—in the case of the Arboretum restoration project, through the agency of the University—because it is both the right and the necessary thing to do. Ecological restoration is more than a matter of personal taste, we feel, it is also a matter of impersonal environmental ethics. But why? Leopold may not be as scientifically up-to-date as we are now, nearly sixty-five years later. Even prophets do not always see unerringly into the future, especially into the twists and turns of a science so fickle as ecology. But he is unfailingly wise.

Remember, his rationale for ecological restoration is not stated in terms of the superior value of the previous ecological condition over the present one because the former is "pristine" or "virgin" and the latter is anthropogenic, as Thoreau and Muir before him had done. As noted, contrary to Clements as well as to Muir, he viewed human beings—Lewis's Babbitt as well as Yellow Thunder—as a part of nature. His own antiquarian affections aside, the objective value of the past ecological condition is as a point of reference, a bench mark, for a once and future condition of what Leopold (1991*a*, 1991*b*, 1999*a*, 1999*b*) elsewhere called "land health." Ecological restoration, *sensu stricto*, the restoration of a past ecological condition, is a point of reference for a more general program that we might call ecological *rehabilitation* (Callicott et al. 1999). What was good and right about the Wisconsin that the Indians lived in, took their living from, and actively managed? It was neither pristine nor virgin; the Indians were members of the same species, *Homo sapiens*, as their European-American successors; they lived on the land; and not without significant ecological impact. The difference was that under the aegis of the Indians, old Wisconsin was ecologically functional. Prior to European settlement, the Wisconsin biota recruited, retained, and recycled nutrients from the parent materials. It stabilized the top soil that it had built up. It percolated and modulated the flow of surface waters. It was composed of a diverse assemblage of plants, which provided habitat for a diverse community of animals, related in tangled food webs, woven of lengthy food chains, topped off by long-lived, large-bodied carnivores (Leopold 1991*a*, 1991*b*, 1999*a*, 1999*b*). What Leopold envisioned, indeed what he conceived the task of conservation to be, is the creation of a similar ecological condition in the future, but one that would necessarily involve different species of plants and animals than that which the Indians had adapted to their economy—just as it would involve a different stock of *Homo sapiens.* He characterized it as a civilized landscape for civilized men. The bench mark, the reference point would be the ecological status quo ante as it was when we took it away from the Indians. And the Arboretum was to restore that condition for that purpose. In a nutshell, the principal objective reason for undertaking ecological *restoration* at the Arboretum and elsewhere, from Leopold's point of view, was its service of the more general, more important, and more difficult goal of ecological *rehabilitation* everywhere.

Appendix A: The Speech[1]

What Is the University of Wisconsin Arboretum, Wild Life Refuge, and Forest Experiment Preserve?

What Is an Arboretum? An arboretum is ordinarily a place where the serious-minded citizen can learn, by looking at them, the difference between a white and a black spruce, or see in person a Russian olive, a tamarisk, or an Arizona cypress. That is, it is a collection of trees.

Sometimes an arboretum also serves as an outdoor library of horticultural varieties, i.e., a place where one can compare all the apples, all the lilacs, all the roses.

Some advanced institutions arrange their tree-collection as natural associations, rather than as taxonomic groups. They present, for example, a sample of the Douglas fir forest of the Northwest, showing the hemlocks, larches, and balsams which grow in association with Douglas fir, and also the ferns, salmonberries, yews, and shrubs which grow under it, and if possible the mosses and herbs which grow under the shrubs. Such exhibits are called "ecological groupings" and represent "advanced thought" in arboretum management.

The Wisconsin Arboretum. We want to have all these things, but they by no means represent the main idea which we are trying to express here. It is something new and different. Perhaps we should not call the place an arboretum at all. Whether our idea is a worthy one, I will have to leave you to judge.

Our idea, in a nutshell, is to reconstruct, primarily for the use of the University, a sample of original Wisconsin—a sample of what Dane County looked like when our ancestors arrived here during the 1840s.

Obviously, it will take 50 years to do this thing. Obviously, too, it will be done for research rather than for amusement, and for use by the University, rather than for use by the town.

What I want to try and picture today is why it is important to the future welfare of our state to know what it was like before we took it away from the Indians.

Rebuilding the Wisconsin Landscape. First let me convince you that if you were set down, blindfolded, in Nakoma in 1840, you would not only fail to recognize the place, but you might fail to realize you were in Wisconsin at all.

This hill on which we stand was then an "oak-opening." Our grandparents describe, sometimes with rapture, the beauty of these open orchard-like stands of oaks, interspersed with copses of shrubs, and the profusion of prairie grasses, and flowers which grew between. But just what shrubs, grasses, and flowers were they? We don't know. Why did they remain open, instead of growing up to solid woods? Probably fire, but we're not sure. What oaks? Largely burr-oak, but we are not sure. We do know this, that the bluegrass which now covers half of our

[1]Given by Aldo Leopold at the dedication of the University of Wisconsin Arboretum on June 17, 1934. Printed by permission of the Aldo Leopold Foundation.

county was not present—it came with the white man—while the native grasses which then grew here are now rare or even possibly extinct. The pheasants and possibly even the quail which now inhabit Nakoma were absent; instead the oak-openings were populated with sharptailed grouse, then appropriately called "burr-oak grouse," and now found only a hundred miles to the north. The wild turkey apparently did not occur. The copses contained the ordinary partridge or ruffed grouse. There were elk and deer—elk horns have been pulled out of our local marshes, and of deer we have ample records.

The Wingra Marsh, which we boast of as largely "unspoiled," we would not have recognized in 1840. Those waving meadows of grass, rushes, and dogwood were then largely a tamarack forest, undergrown with sphagnum moss and orchids. We know this because tamarack logs were encountered in draining the golf course. The tamarack forest has been gradually converted into grassland by repeated burning, cutting, grazing, and mowing—a process still plainly visible in any of the tamarack relicts of the eastern half of the county.

The deep layers of peat which comprise this marsh are merely the closely packed remains of sphagnum plants which could not decay because of the acid water in which they were "pickled" through innumerable generations. Professor Fassett of the Botany Department takes his students there to exhume samples of this peat from various depths, and in these samples he finds embalmed the very pollen grains which fell or were blown into the marsh from the plants then growing in and around it. So perfectly are these pollens preserved that their shape and structure tell the kinds of plants which grew, while the relative abundance of the various kinds tells which plants were then most common. The bog is, in short, a vast historical library telling the story of the arboretum back to the Glacial Epoch, 10,000 years ago. Its volumes are still largely untranslated, but it is easy to see why they constitute a valuable educational and scientific asset.

Lake Wingra itself wears so different an aspect that the early settler would not know it now. Much of the shore was then a wild rice bed. The water level fluctuated more, but averaged higher. It was full of waterfowl, whereas now the ducks show almost an aversion to it. Presumably the introduction of carp contributed heavily to these changes, but we do not know.

Why Study Original Wisconsin? Granted, then, that we have radically changed the aspect of land, what of it? It's still good to look at—why worry? Why try to discover the exact processes by which the Wisconsin of 1840 became the Wisconsin of 1930? Americans shall look forward, not backward, so why dig up these ecological graves?

Because we are just beginning to realize that along with the intentional and necessary changes in the soil and its flora and fauna, we have also induced unintentional and unnecessary changes which threaten to undermine the future capacity of the soil to support our civilization.

In some places these changes will merely reduce our standard of living—physical, in the sense of a healthy agriculture; spiritual, in the sense of needless spoliation of natural beauty. In other places, these changes threaten the actual physical existence of even the present social structure. In some cases, the damage is temporary, in others permanent.

For example, the erosion of topsoil which followed too much wheat and too many cattle is carrying the best parts of southwestern Wisconsin to the Gulf of

Mexico. It will take time, geological time, to repair this loss.

The fires which followed lumbering have probably cut by half, for at least a generation or two, the capacity of northern Wisconsin to support a self-sustaining population. Everybody knows this, but few know that the same fires have burned up many of the peat beds in our drained marshes, and thus threaten to turn land once too wet into a future sand-dune. Three marshes in Dane County have been burning all summer. When some old rattletrap of a building catches fire we all rush to the rescue, but when the compound interest of 10,000 years of plants catches fire, our officials sit by with folded hands while the average citizen's depth of understanding is reflected by the observation that he dislikes the smell of peat smoke.

The new insects which modern transportation continuously imports from the four corners of the earth are a standing threat to future agriculture. Our white pine—the very backbone of our original economic structure—now threatens to go down before the blister rust, an imported disease. In the offing stands the threat of June-beetles (white grubs) making it imperative to cut down all the white oaks in our pastures. Granted we could shade our cows under tin roofs—who would want to live in a Wisconsin of oakless pastures?

Now this is not a tirade against careless farming, lumbering, or transportation. It is rather an admission that the tools wherewith we are building our civilization are so powerful, and their use has such complex and unexpected consequences, that we are tearing down about as fast as we are building up. It is an admission that science does not yet know enough, or is not yet sufficiently listened to, to anticipate and prevent this process of wreckage which attends our supposedly advancing footsteps.

Research. The business of a University has heretofore been conceived to be the preparation of citizens to cope with their environment. The University must now take on the additional function of preserving an environment fit to support citizens. This task is of a complexity far beyond what I can here take time to explain. I will ask you to accept my word for the fact that it is a long and difficult job. To perform it, a University must have, for the daily use of its faculty and students, a living exhibit of what Wisconsin was, what it is, and what it expects to become. Examples of what it is lie on every hand. What it expects to become may be exemplified on public forests, refuges, farms, and parks. What it was is to be exemplified on the Arboretum, and I hope on numerous areas created for the purpose.

This, in a nutshell, is the function of the Arboretum: a reconstructed sample of old Wisconsin, to serve as a bench mark, a starting point, in the long and laborious job of building a permanent and mutually beneficial relationship between civilized men and a civilized landscape.

Appendix B: The Essay[2]

The Arboretum and the University (1934)

For twenty centuries and longer, all civilized thought has rested upon one basic premise: that it is the destiny of man to exploit and enslave the earth.

The biblical injunction to "go forth and multiply" is merely one of many dogmas which imply this attitude of philosophical imperialism.

During the past few decades, however, a new science called ecology has been unobtrusively spreading a film of doubt over this heretofore unchallenged "world view." Ecology tells us that no animal—not even man—can be regarded as independent of his environment. Plants, animals, men, and soil are a community of interdependent parts, an organism. No organism can survive the decadence of a member. Mr. Babbitt is no more a separate entity than is his left arm, or a single cell of his biceps. Neither are those aggregations of men and earth which we call Madison, or Wisconsin, or America. It may flatter our ego to be called the sons of man, but it would be nearer the truth to call ourselves the brothers of our fields and forests.

The incredible engines wherewith we now hasten our world-conquest have, of course, not heard of these ecological quibblings; neither, perhaps, have the incredible engineers. These engines are double-edged swords. They can be used for ecological coöperation. They are being used for ecological destruction on a scale almost geological in magnitude. In Wisconsin, for example, the northern half of the state has been rendered partially uninhabitable for the next two generations by man-made fire, while the southwestern quarter has been deteriorated for the next century by man-made erosion. In central Wisconsin a single fire in 1930 burned the soil off the better part of two counties.

It can be stated as a sober fact that the iron-heel attitude has already reduced by half the ability of Wisconsin to support a coöperative community of men, animals, and plants during the next century. Moreover, it has saddled us with a repair bill, the magnitude of which we are just beginning to appreciate.

If some foreign invader attempted such loot, the whole nation would resist to the last man and the last dollar. But as long as we loot ourselves, we charge the indignity to "rugged individualism," and try to forget it. But we cannot quite. There is a feeble minority called conservationists, who are indignant about something. They are just beginning to realize that their task involved the reorganization of society, rather than the passage of some fish and game laws.

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[2]From Susan L. Flader and J. Baird Callicott, *The River of the Mother of God and Other Essays by Aldo Leopold.* Madison: The University of Wisconsin Press. Copyright 1991. Reprinted by permission of the University of Wisconsin Press and the Aldo Leopold Foundation. The essay first appeared in *Parks and Recreation,* Vol. 18, No. 2, October 1934.

What has all this to do with the Arboretum? Simply this: If civilization consists of coöperation with plants, animals, soil, and men, then a university which attempts to define that coöperation must have, for the use of its faculty and students, places which show what the land was, what it is, and what it ought to be. This Arboretum may be regarded as a place where, in the course of time, we will build up an exhibit of what was, as well as an exhibit of what ought to be. It is with this dim vision of its future destiny that we have dedicated the greater part of the Arboretum to a reconstruction of original Wisconsin, rather than to a "collection" of imported trees.

The iron-heel mentality is, of course, indifferent to what Wisconsin was. This is exactly the reason why the University cannot be. I am here to say that the invention of a harmonious relationship between men and land is a more exacting task than the invention of machines, and that its accomplishment is impossible without a visual knowledge of the land's history. Take the grass marsh here under our view: From the recession of the glacier until the days of the fur trade, it was a tamarack bog—stems and stumps are still imbedded there. In its successive layers of peat are embalmed both the pollens which record the vegetation of the bog and the surrounding countryside, and also the bones of its animals. During some drouth, man-caused fires burned off the tamarack, which gave place first to grass and brush, and then, under continual burning and grazing, to straight grass. This is the history and status of a thousand other marshes. What will happen if the decomposed surface peat is all burned off? At what stage of the retrogression from forest to meadow is the marsh of greatest use to the animal community? How is that desirable stage to be attained and maintained? What is the role of drainage? These questions are of national importance. They determine the future habitability of the earth, materially and spiritually. They are just as important as whether to join the League of Nations—it is only our iron-heel inheritance which makes the comparison ludicrous. The scientist does not know the answer—he has been too busy inventing machines. The time has come for science to busy itself with the earth itself. The first step is to reconstruct a sample of what we had to start with. That, in a nutshell, is the Arboretum.

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Susan Flader

Aldo Leopold and Environmental Citizenship

In the outpouring of books and articles in recent years on the meaning of citizenship, many of them lamenting the weakening of civic bonds in America, there has been scant attention to the role of citizenship with respect to the environment.[1] Even among environmentalists, who realize that citizen action has been a hallmark of the "new environmental movement" from the time of the first Earth Day (1970), there is little appreciation of the extent to which our citizenry has played a vital role in the shaping of American environmental policy ever since the origins of the nation.[2]

As we seek the historical roots of our quest for environmental quality and the means for sustaining it, it is worth pondering the roles and responsibilities of citizens and the relationship between the citizenry and the state—in short, how American democracy works. In this exploration, we may seek insights from Aldo Leopold, who was profoundly conscious of the American democratic tradition within which he was working and who thought hard throughout his career about the meanings and implications of environmental citizenship.

We have had in the United States a tradition of a limited or weak state. It may not seem that way today when people complain of a bloated federal bureaucracy, but relative to the strong central states in the democracies of Western Europe and certainly to authoritarian regimes, our government is decidedly limited and our citizens have always had a healthy skepticism about most everything that government tries to do. In this weak state we have traditionally had rather low legal expectations of our citizens. Citizens are expected to obey the law and pay taxes; even voting is optional. Yet we have had in America a concomitantly vibrant tradition of voluntary citizen action.

The foremost interpreter of the era of the American Revolution, Gordon Wood, has termed the phenomenon of revolutionary citizen action "the people out of doors."[3] He was likely not thinking environmentally, but rather portraying "people out of doors" as citizens acting voluntarily outside of the formal channels of government to shape the kind of community they wanted. When we look back at the controversies of the era, however, we see citizens acting often on environmental issues. Local groups organized, with some success, to prevent new dams from blocking the passage of salmon upstream, for example, seeking to protect their community's customary right to fish against interference by new industrial mills.[4]

When we think of the origins of the nation, we tend to think of citizens struggling for liberty, for the right of the individual to pursue his own self-interest. This is a concept of American history that became cemented in our imaginations especially during the Cold War, when we were fighting the menace of international Communism and trying to picture America as everything that the Soviet Union was not. Yet, historians returning to the original documents of the revolutionary era several decades ago began to see in them some ideas that were at first startling, because they were so at odds with the usual interpretation. What they found were people who thought of themselves as citizens of a republic in which the greatest virtue was civic consciousness, a willingness to subordinate one's own self-interest to the good of the community. "Civic virtue," they called it, or "civic republicanism," referring to the participatory civic values of a republic like that of ancient Athens.[5] We tend to celebrate America as a country grounded in individual rights, like the freedoms of speech and of the press and of assembly enshrined in the first article of the Bill of Rights. But a case can be made that these rights pertain to communities as well as to individuals; they protect the opportunity for ordinary citizens to organize and communicate with each other outside of the formal channels of government to shape the environment of their communities or the policies of their governments.[6]

The complex of republican values so pervasive in revolutionary America was largely overwhelmed, scholars are agreed, by democratic egalitarianism, liberal individualism, and capitalist development in the early nineteenth century, ushering in the liberal democratic state we celebrate today. But the tradition of civic organizing has persisted in American history. It has not been mandated by law; it has been voluntary. The tendency of Americans to form voluntary groups—"associations," Alexis de Tocqueville called them[7]—could be used to sustain traditional community values; it could also be used to protect economic self-interest. This tradition of citizen action, especially in its "civic republican" strain, is the tradition out of which much of our American conservation movement grew. But it may also be the tradition from which several strands of what we may think of today as anti-environmentalism emerged—groups devoted to "wise use," property rights, and county supremacy.[8] Citizens organize for a variety of purposes.

It must be noted that not everyone regards voluntary citizen action as key to the shaping of society or environmental policy. Many would argue that ours is a *representative* democracy and that the shaping and administration of policy is the responsibility of elected representatives and executive agencies. Indeed, much of the administrative capacity of the modern American state was developed in the Progressive Era at the turn of the twentieth century, in large part in response to environmental concerns. The U.S. Forest Service, in which Aldo Leopold began his career, has been regarded by scholars as the quintessential example of a progressive agency.[9] Gifford Pinchot, the first chief of the Forest Service, sought to place technically trained experts—professional foresters like Leopold—in government and let them establish specific policies and manage the resources. This was a model of governance that elevated the values of order, efficiency, and control—values that may be quite incompatible with democratic participation. Pinchot once said, "The first duty of the human race is to control the earth it lives upon," and I think Leopold himself once may have believed that.[10] From the perspective of a later day, however, we may note that the progressive model, in elevating the virtues of professionalism and technical expertise, tended to crowd out the citizenry and also their elected representatives, the politicians.

Inasmuch as Aldo Leopold began his career as a professional in the employ of the modern administrative state and is today regarded as something of a prophet of the new environmental consciousness, which elevates the responsibilities of citizenship, we may look to him for insights into the meanings of environmental citizenship—into the role of citizens in the modern state, the tension between the rights of individuals and the claims of the community, and the tension also between professional resource managers and citizen activists. We look first at what Leopold had to say about citizenship in *A Sand County Almanac*, the slender volume of nature sketches and philosophical essays that represents the distillation of his mature thought, and then explore the evolution of his thinking during the course of his career.

As we page through *A Sand County Almanac*, we meet our first citizen in the very first essay, "January Thaw":

> 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.[11]

The mouse is what kind of citizen?—an ordinary citizen who goes about his own business and pursues his own interests. We have many such in our communities.

Skipping perhaps a few citizens, we come to "Pines Above the Snow": "Each species of pine," Leopold tells us, "has its own constitution, which prescribes a term of office for needles appropriate to its way of life." He continues with his analogy between human constitutions and the regimen of various pine trees, the white pine retaining its needles for a year and a half, red and jackpines for two and a half years. "Incoming needles take office in June, and outgoing needles write farewell addresses in October."[12] These pines are going about their own business, but they are also meeting the legal requirements of citizenship, acting according to their constitutions, even taking office in a perfunctory way.

Next we meet the thick-billed parrots of Chihuahua, who "wheel and spiral, loudly debating with each other the question . . . whether this new day which creeps slowly over the canyons is bluer and golder than its predecessors, or less so."[13] They are debating the criteria of the good life, which in Aristotelian thought is an activity of citizenship more fundamental even than that of developing legal constitutions. The vote being a draw, Leopold observes, they head to the high mesas for breakfast.

In "Clandeboye," the great prairie marsh of Manitoba, we find the grebe, a species of ancient evolutionary lineage impelled, Leopold believes, by "pride of continuity."

His is the call that dominates and unifies the marshland chorus: "Perhaps, by some immemorial authority, he wields the baton for the whole biota."[14] Here is the grebe as ethical citizen, as a leader directing the chorus of the marsh for the longterm betterment of the whole community.

Not until the more philosophical essays in the last section of the book do we meet *human* citizens. In "Conservation Esthetic" Leopold discusses the various components of the recreational process, beginning with the most basic motivation of trophy seeking, common to hunters with both shotgun and field glass as well as to most conservationists and even professionals. He goes on to discuss other more highly evolved components of the recreational process, such as a feeling of isolation in nature or the perception of natural processes, and then reaches what to him is the ultimate component, a sense of husbandry. This component, he tells us, "is unknown to the outdoorsman who works for conservation with his vote rather than with his hands. It is realized only when some art of management is applied to land by some person of perception."[15] So, to Leopold, husbandry is the highest form of citizenship: actually working with one's hands, participating actively to build or maintain the land community.

Leopold expresses his concept of environmental citizenship most memorably in "The Land Ethic":

> In short, a land ethic changes the role of Homo sapiens from conqueror of the land-community to plain member and citizen of it. It implies respect for his fellow-members, and also respect for the community as such.[16]

Here Leopold offers us a concept of citizenship in a community larger even than humankind; we are plain member and citizen of a community that embraces the land and all the plants and animals that are a part of it. The usual formula for conservation, "Obey the law, vote right, join some organizations, and practice what conservation is profitable on your own land; the government will do the rest," he tells us is too easy. "It defines no right and wrong, assigns no obligation."[17] Leopold's formula implies personal responsibility to participate actively as an ordinary citizen in maintaining or restoring the health of the biotic community.

This review of *A Sand County Almanac* suggests that Leopold's mature concept of environmental citizenship, with its emphasis on obligation to the community, is similar in some respects to the concept of civic virtue in the republican ideology of the American Revolution, though he conceives the community much more broadly. But one would not necessarily expect to find these ideas early in his career, when he was working for the U. S. Forest Service, modeled on a different conception of the relationship between citizens and the state.

Aldo Leopold throughout his career was a consummate professional, extremely efficiency-oriented during his years in the Forest Service and fascinated by the intricacies of administrative procedures and standards.[18] And yet we get a sense from one of his earliest publications that he was not wholly satisfied with the Forest Service model of governmental administration. Shortly after he had become supervisor of the Carson National Forest in New Mexico at age 25, he was stricken with an illness that nearly led to his death and required more than a year of recuperation. During this time he addressed a letter "to the forest officers of the Carson" reflecting on their responsibilities. The problem that concerned him was how to measure success in forest administration. Was success simply a matter of efficiently following prescribed policies and procedures, or was there something else? "My measure," Leopold wrote, "is *the effect on the forest.*" Even at the start of his career he was concerned about the *ends* of administration, what was happening to the land, not only the procedures, or *means.*[19]

It was a preoccupation he would continue to pursue into the early 1920s, when he was chief of operations in charge of roads, trails, fire control, personnel, and finance on twenty million acres of national forests in the Southwest. In order to improve the efficiency of administration while focussing attention on "the effect on the forest," he developed an intricate system of tally sheets for a new system of forest inspection that would enable foresters to diagnose local problems and monitor the effectiveness of management solutions. Leopold regarded this elaborate system of inspection as one of his points of greatest pride during his career in the Southwest. And indeed, his lifelong fascination with tracking the dynamics of change and the efficacy of management for the total biotic system, begun during his inspection forays in the Southwest, would lead him in our own day to be acknowledged as the exemplar of the new philosophy of ecosystem management recently adopted by the Forest Service and other land management agencies.[20]

Clearly, Leopold was enlarging the responsibilities of professional foresters by extending the boundaries of the community of concern to include the entire biota—soils, waters, plants, and animals—as well as trees and the economic interests of the people who used them. But there was scant room for ordinary citizens in Leopold's model of forest administration. Though he recognized the difficulty of determining the *objectives* of management—a problem that bedevils ecosystem management today—he concluded that these decisions should be made by "only the highest authority."[21] Yet the essay in which he dealt most directly with what he called "standards of conservation" tails off in mid-sentence and remained unpublished, suggesting that Leopold may have realized he was caught in an unresolved problem of authority: who decides the objectives and on what basis? A kind of 'super-inspector' would crop up in his writing from time to time over the years, but I am not sure he was ever really comfortable with this type of authority.[22]

Despite Leopold's commitment to professional expertise in forest administration, he saw roles for citizens in related endeavors. Indeed, when his illness prevented him from resuming his post as a forest supervisor, he began developing a new line of activity—game management—in the Forest Service, and in conjunction with this he traveled all across Arizona and New Mexico organizing game protective associations—citizen conservation organizations—in local communities and statewide. These associations of sportsmen, ranchers, and townspeople would work for non-political game wardens, predator control, and refuges. They were grassroots citizen-action groups in a longstanding American tradition.

Leopold addressed the subject of citizenship in a number of lectures early in his career, including one on "Home Gardens and Citizenship" to students at the University of New Mexico in 1917, just after the American entry into World War I. A home garden, he said, was one mark of a useful citizen. Nobility is won by soiling your hands with useful labor, by building something. Leopold was always one for building something. If your job doesn't allow enough play for creativity, he told the students, you can be creative by working the ground, whereupon he went into a soliloquy about how to raise spectacular tomatoes in your Albuquerque backyard. In a world threatened with food shortage, what right have we to hold idle some of the best agricultural lands in our back yards? he asked. Better to turn them into gardens and learn to be good citizens.[23]

A year later he spoke to the women's club on "The Civic Life of Albuquerque." Having left the Forest Service to become secretary of the Albuquerque Chamber of Commerce, Leopold was now asking "What has the 20th-century American city contributed to human progress?" His answer was public spirit. He defined it as "year-round patriotism in action; . . . intelligent unselfishness in practice." He tried to trace the idea historically, contrasting Confucius, whom he saw as more interested in personal virtues and family ties than in obligations to others, with Socrates, who knew that citizens had a moral obligation to support and improve their government. But then he lost the thread, explaining that "it would require a better scholar than I am to even attempt to trace the idea of public spirit through the era of individualism and the political revolutions of the 18th and 19th centuries."[24]

From this we realize that the concept of civic virtue, the republican ideology of the American Revolution, had been lost to consciousness by 1918. Leopold was assuming a revolutionary America dedicated to individualism; he had lost the thread of public spirit, though he sensed it must have been there somewhere. And in fact historians would not rediscover it until the late 1960s, twenty years after his death. But he went on to define the "modern idea"—modern as of 1918—of public spirit: "It means that a democratic community and its citizens have certain reciprocal rights and obligations." Not only rights, but obligations as well. "The man who cheerfully and habitually tries to meet this responsibility," he says, "we call public-spirited."

Leopold went on to offer a critical assessment of the public spirit of Albuquerque, confiding his dream that his own Chamber of Commerce might serve as the "common center" to organize the "democratic welter" of professional societies, women's groups, religious, political, labor, and other voluntary associations of citizens toward accomplishment of common goals for the betterment of Albuquerque. But he also admitted to some frustration—businessmen unwilling to welcome representation in the chamber by labor and craft organizations, for example.

After little more than a year, Leopold left the Chamber of Commerce to rejoin the Forest Service. A few years later, still feeling the effects of his experience in the chamber, he delivered a scathing "Criticism of the Booster Spirit" to an Albuquerque civic society in which he excoriated "the philosophy of boost." Boost was premised on growth by unearned increment, rather than investment in basic resources, especially the soil, he charged. In his quest for fundamental improvement in the resource base, he began looking to enforced responsibility of landowners. In "Pioneers and Gullies," for example, he described numerous valleys of the Southwest torn out by erosion, and he predicted, for the first time in print, that one day proper land use would be a responsibility of citizens: "The day will come when the ownership of land will carry with it the obligation to so use and protect it with respect to erosion that it is not a menace to other landowners and the public."[25]

Leopold left the Southwest in 1924 to accept a job in Madison, Wisconsin, as director of the Forest Products Laboratory. Though the laboratory's focus on industrial products after the tree was cut proved ultimately frustrating for one so committed to the growing forest and he would leave after only four years, he did manage to extract from the experience a lesson for citizens. In an article, "The Home Builder Conserves," he admonished people, before they castigated the "wasteful lumberman," to think about how their own arbitrary demands as consumers and home builders cause waste. The thinking citizen has power not only in his vote but in his daily thoughts and actions, and especially in his habits as a buyer and user of wood. "Good citizenship is the only effective patriotism," he concluded, "and patriotism requires less and less of making the eagle scream, but more and more of making him think." This theme of the responsibility of the citizen as intelligent consumer is one Leopold would return to from time to time, most notably during World War II in "Land Use and Democracy."[26]

Shortly after his move to Wisconsin, Leopold became involved with the state chapter of the Izaak Walton League of America, which was the most vibrant citizen conservation organization in the 1920s. He worked with the league to promote a non-partisan conservation commission and a forestry policy for Wisconsin. Still hewing to his professional orientation as a forester, however, he warned members to eschew the tendency to actually *write* policy: "It is a pretty safe rule to remember that while groups of men can insist on and criticize plans, only individuals can create them."[27] Leopold himself was a professional writer of policies, as he demonstrated both in the Forest Service and after he left in 1928 to conduct game surveys and recommend conservation policies in the midwestern states, when he drafted an "American Game Policy" adopted by the American Game Conference in 1930, and when he helped write a "Twenty-Five Year Conservation Plan" for his home state of Iowa in 1931.

Leopold was tremendously impressed by the citizen commitment to conservation in Iowa and genuinely proud of the plan for integration of all aspects of conservation—parks, forests, wildlife, fish, water quality, soil conservation—that the team of nationally recognized experts wrote. Iowa was clearly a leader among the states in conservation thought and practice in these years. But buried in Leopold's correspondence are intimations of foreboding. He warned his colleagues in Iowa that they needed to make a special effort to educate the public about what was in the plan, lest people buy into it without personally engaging with it. He was concerned especially about the protection-minded women so active in the parks movement who might become upset if they were suddenly to discover that the plan aimed to produce game to shoot. "There is grave danger," he said, "that the conservationists will blow it up before they even understand what it is."[28]

In 1933, shortly after he accepted a newly created chair of game management at the University of Wisconsin, Leopold proposed to the dean of agriculture the development of a conservation plan for Wisconsin farms similar to the Iowa plan. The purpose, as in Iowa, would be to get all the government agencies working together to encourage farmers and other landowners to care for their lands in a more conservative way—or, as he put it, to "integrate economic with esthetic land use." But the means would differ. In Iowa the plan was produced by imported experts who did not participate in its execution, an arrangement that clearly left Leopold uneasy, whereas in Wisconsin he proposed to "evolve" a plan "rather than to *write* one out-of-hand."[29]

Leopold's emphasis on evolving a plan from the grassroots was prophetic—not only of the emerging emphasis on public involvement in resource planning in our own day but of the situation in Iowa at the time. By 1935 the Iowa conservation plan disintegrated, at least in Leopold's view. After Iowa merged all relevant agencies into a single department, as recommended in the twenty-five–year plan, the new Iowa Conservation Commission bypassed the man whom to Leopold was the obvious director, and most of Leopold's friends in fish and game resigned or were fired. The issue apparently had to do with the Iowa commission's insistence on an immediate showing of quick results by government through public works rather than, as Leopold and his colleagues preferred, a long-term emphasis on building a new conservation consciousness in the citizenry, especially among landowners.[30]

In the wake of the Iowa debacle, Leopold commented to a friend that the only state conservation effort to survive was in Michigan, "strangely enough, by a process of internal disharmony. I am tempted to draw the conclusion that complete unanimity within a state [such as in Iowa] is a symptom of approaching dissolution."[31] In other correspondence and articles in the 1930s he addressed the problem of factions within the conservation community, especially the shotgunners versus the field glass hunters, arguing for tolerance, a capacity for self criticism, and an institutional structure within which factions could argue out their conflicts. "It is a question of applying the democratic process to conservation," he concluded.[32]

Leopold's thoughts on democracy and conservation were further stimulated by travel in Germany in 1935, where he observed an elaborate system of law, public administration, ethics, and customs that was "incredibly complete and internally harmonious." Though he could observe no real distinction between the government, acting hierarchically from the top down, and popular acceptance from below, he recognized that the German system, with its strong central governmental authority, was "manifestly a surrender of individualism to the community."[33] While he could admire it in Germany (before he understood the connection with the Nazi movement), he knew that it wouldn't work in America.

Leopold addressed the tension between the claims of the community and the rights of the individual in America in a number of essays in the 1930s in which he dealt with the role of government. How can we get conservation? he often asked. And his answer: we can legislate it, we can buy it, or we can build it. Government's initial efforts at conservation had been through laws prohibiting hunting, fishing, or cutting, a first step but inadequate. The second step, augmented by the open money bags of the New Deal, was to buy land for conservation, but that could be carried only "as far as the tax-string on our leg will reach." The solution had to be found on private land.[34]

By the time he wrote "Land Pathology" under the menacing clouds of the dust bowl in 1935, he saw only two possible forces that could effect change in private land use. One was the development of institutional mechanisms for protecting the public interest in private land—a quest he had been on for over a decade, especially after his new chair of game management was lodged in the University of Wisconsin's famed Department of Agricultural Economics with its institutional bent. The other was his new preoccupation with "the revival of land esthetics in rural culture." Out of these forces he hoped might eventually emerge what he was even then beginning to term a "land ethic."[35] After his friend Jay "Ding" Darling cautioned him that his search for institutional controls could lead to socialization of property,[36] Leopold seemed increasingly to emphasize development of a personal sense of obligation to the land community, a sense of husbandry.

During these years of the depression Leopold experimented with a form of citizen organization he hoped would encourage a sense of husbandry. With farmers, sportsmen, and his own wildlife students he established a series of cooperative ventures intended to apply conservation to land and improve habitat for game. One of them, the Coon Valley Erosion Project near LaCrosse, Wisconsin, involved cooperation of local landowners with government agencies in a pathbreaking demonstration of erosion control and integrated land use on a watershed scale. But others functioned entirely outside the formal channels of government, including the Riley Cooperative and the Faville Grove Area within an easy drive of Madison. Leopold described these experiments in community conservation as *vertical* rather than horizontal planning, focusing a battery of minds simultaneously on one spot. "It may take a long time to cover the country spot by spot," he admitted, "but that is preferable to a smear."[37]

As war clouds darkened the horizon and called into question his earlier admiration for Germany's tightly regimented system of resource administration, Leopold lectured to his wildlife ecology students about "Ecology and Politics," presenting the case for an evolutionary mandate for individualism. Individual deviations from societal norms in land management, like individual evolutionary variations, he suggested, might enable certain individuals to survive catastrophe even when most members of a species were eliminated.[38] This was an individualism not of economic self-interest but of creative experimentation, in the sense of solutions generated from the bottom up by individual citizens or communities rather than mandated by government on all alike. It was in this spirit that Leopold looked to the evolution of a land ethic.

American entry into World War II further defined the issue: "We must prove that democracy can use its land decently," Leopold argued in a seminal essay, "Land Use and Democracy." Here he called for conservation from the bottom up instead of from the top down. It had to begin with "that combination of solicitude, foresight, and skill which we call husbandry," practiced by landowners on their own land. But nonlandowning citizens had responsibilities in their roles as consumers as well. They could refuse to buy "exploitation milk" from cows pastured on steep slopes and insist on "honest boards" from properly managed forests. There was an indispensable role for government as "tester of fact vs. fiction" or guardian of standards, Leopold acknowledged, but farmers could scrutinize their own practices through courageous use of their self-governing Soil Conservation Districts, and there were opportunities also for self-scrutiny by industrial or citizen groups.[39] More than half a century later, the Forest Stewardship Council's independent third-party certification of forest products and other examples of the movement for green production and consumption standards would attest to the validity of Leopold's visionary argument.

Aldo Leopold's ideas about the roles of government and citizens in the shaping of environmental policy were tested in the last decade of his life as never before by his involvement in the traumatic deer debates of the 1940s in Wisconsin. After being nearly hunted to extirpation in the early decades of the century, the state's deer herd had increased to such an extent that by the early 1940s it needed to be reduced for the good of both deer and forest, and Leopold sought to work with the Conservation Department to build a case for an "any-deer" season, for killing does as well as bucks. But the call for reduction stirred disbelief and resentment among both hunters and the general public, to whom conservation of deer was a good thing. In response, the Conservation Commission organized a Citizens' Deer Committee, appointing Aldo Leopold as chairman.[40]

Leopold's committee had a cross-section of citizens, mostly from northern Wisconsin, most of them distrustful of the policy he was urging on the department. For the first meeting he prepared maps and charts to provide an historical review of deer irruptions nationwide. But he was upstaged by another member of the committee, Joyce Larkin, editor of the *Vilas County News Review.* She didn't think there were too many deer, and she arrived at the meeting armed with a printed booklet of history and local opinion about the deer situation in Vilas County. We don't know how Leopold reacted to Larkin that day, but we do know that he decided to take the committee and several newspaper reporters on a three-day tour of deer yards, to let them discuss what they were actually seeing on the ground. Joyce Larkin, among others, was impressed. She went back to Vilas, got the county board to accept Leopold's challenge to bring clashing interests together to look at the problems locally, and came to a subsequent meeting of the committee with a new report in favor of an any-deer season.[41]

However successful Leopold proved at changing attitudes among the members of his Citizens' Deer Committee by letting them argue out their views with respect to conditions in particular locales, the deer problem proved too widespread and public attitudes too entrenched for him to make much headway in the state as a whole. A new newspaper, *Save Wisconsin's Deer,* ridiculed and castigated him in virtually every issue and offered fuel to those who opposed his reasoning. Yet he never gave up on his effort to educate the citizenry, individually and collectively. It is likely that the unremitting stress of dealing with the deer issue in the public arena during the 1940s helped send Leopold to an early grave. But he had been appointed to a six-year term on the Wisconsin Conservation Commission, and he believed it was his responsibility as a citizen to serve.[42]

During those years he took solace in the exercise of another type of citizenship that he had advocated since the days of his backyard garden in Albuquerque: he practiced husbandry as plain member and citizen of the land community at the sand farm his family called "the shack." He expressed this form of citizenship—citizenship as creative individualism—perhaps most poignantly in his essay, "Axe-in-Hand," which includes a definition of a conservationist that could as easily be read as his definition of a citizen:

> I have read many definitions of what is a conservationist [citizen], and written not a few myself, but I suspect that the best one is written not with a pen, but with an axe. It is a matter of what a man thinks about while chopping, or while deciding what to chop. A conservationist [citizen] is one who is humbly aware that with each stroke he is writing his signature on the face of his land. Signatures of course differ, whether written with axe or pen, and this is as it should be.[43]

Endnotes

[1]See *A Nation of Spectators: How Civic Disengagement Weakens America and What We Can Do About It* (Final Report of the National Commission on Civic Renewal, 1998); and Robert D. Putnam, "Bowling Alone: America's

Declining Social Capital," *Journal of Democracy* 6:1 (January 1995), 65–78. Much of the recent attention to citizenship in the United States has been stimulated by scholarly writing concerning the forging of civil society in new democracies around the world, especially since the fall of the Iron Curtain. See, for example, Andrew Arato, "Interpreting 1989," *Social Research* 60:3 (Fall 1993), 609–46; Michael Bernhard, "Civil Society after the First Transition: Dilemmas of Post-Communist Democratization in Poland and Beyond," *Communist and Post-Communist Studies* 29 (1996): 309-30; Shu-Yun Ma, "The Chinese Discourse on Civil Society," *The China Quarterly* 137 (1994); James Bohman, "Complexity, Pluralism, and the Constitutional State: On Habermas's *Faktizitat und Geltung*," *Law & Society Review*, 28:4 (1994), 897–930; and Nancy Fraser, "Rethinking the Public Sphere: A Contribution to the Critique of Actually Existing Democracy," in *Justice Interruptus: Critical Reflections on the "Postsocialist" Condition* (New York: Routledge, 1997), 69–98.

[2]Susan L. Flader, "Citizenry and the State in the Shaping of Environmental Policy," *Environmental Review* 3:1 (January 1998), 8–24.

[3]Gordon S. Wood, *The Creation of the American Republic, 1776–1787* (New York: W.W. Norton and Co., 1972), 319–28.

[4]See, for example, Gary Kulik, "Dams, Fish, and Farmers: Defence of Public Rights in Eighteenth-Century Rhode Island," in *The Countryside in the Age of Capitalist Transformation*, ed. Steven Hahn and Jonathan Prude (Chapel Hill: University of North Carolina Press, 1985), 25–50.

[5]See Robert E. Shalhope, "Republicanism and Early American Historiography," *William and Mary Quarterly* 39 (1982):334–56; Joyce Appleby, ed., "Special Issue: Republicanism in the History and Historiography of the United States," *American Quarterly* 37 (1985); Gordon S. Wood, *The Radicalism of the American Revolution* (New York: Alfred A. Knopf, 1992).

[6]See Jack N. Rakove, "Parchment Barriers and the Politics of Rights," in *A Culture of Rights: The Bill of Rights in Philosophy, Politics, and Law—1791 and 1991*, ed. Michael J. Lacey and Knud Haakonssen (Cambridge: Cambridge University Press, 1992), 103; and William A. Galston, "Practical Philosophy and the Bill of Rights: Perspectives on Some Contemporary Issues," ibid., 234.

[7]Alexis de Tocqueville, *Democracy in America*, ed. Phillips Bradley (New York: Vintage, 1945), I:ch. 12, II:ch. 5.

[8]See Philip D. Brick and R. McGreggor Cawley, eds., *A Wolf in the Garden: The Land Rights Movement and the New Environmental Debate* (Lanham, Md.: Rowman and Littlefield, 1996).

[9]See Stephen Skowronek, *Building a New American State: The Expansion of National Administrative Capacities, 1877–1920* (New York: Cambridge University Press, 1982); and Samuel P. Hays, *Conservation and the Gospel of Efficiency: The Progressive Conservation Movement, 1890–1920* (Cambridge: Harvard University Press, 1950).

[10]Gifford Pinchot, *The Fight for Conservation* (Garden City, NY, 1910), IV:6. Compare Leopold: "It is no prediction, but merely an assertion that the idea of controlled environment contains colors and brushes wherewith society may some day paint a new and possibly a better picture of itself;" in "The Conservation Ethic," *Journal of Forestry* 31:6 (October 1933), 634–43.

[11]Aldo Leopold, *A Sand County Almanac and Sketches Here and There* (New York: Oxford University Press, 1949), 4.

[12]Ibid., 87.

[13]Ibid., 138.

[14]Ibid., 161.

[15]Ibid., 166–67, 175.

[16]Ibid., 204.

[17]Ibid., 207–8.

[18]For details of Leopold's biography see Curt Meine, *Aldo Leopold: His Life and Work* (Madison: University of Wisconsin Press, 1988), and Susan L. Flader, *Thinking Like a Mountain: Aldo Leopold and the Evolution of an Ecological Attitude toward Deer, Wolves, and Forests* (1974; Madison: University of Wisconsin Press, 1994).

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[20]See Susan Flader, "Aldo Leopold and the Evolution of Ecosystem Management," in *Sustainable Ecological Systems: Implementing an Ecological Approach to Land Management*, ed. W. Wallace Covington and Leonard F. DeBano (USDA Forest Service General Technical Report RM-247, 1994), 15–19.

[21]"Standards of Conservation" (handwritten ms., c. 1922), General Files—Aldo Leopold, Series 9/25/10-6, Box 16, University of Wisconsin Division of Archives [hereafter cited as LP 6B6 (Leopold Papers, Series 6, Box 16)], reprinted in *River*, 82–85.

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[23]"Home Gardens and Citizenship," 23 April 1917, 7pp. tps., LP 8B8.

[24]"The Civic Life of Albuquerque," 27 September 1918, 9pp tps., LP 8B8.

[25]"A Criticism of the Booster Spirit," 6 November 1923, 10pp tps speech to Ten Dons, LP 6B16, reprinted in *River*, 98–105; "Pioneers and Gullies," *Sunset Magazine* 52:5 (May 1924), 15–16 and 91–95, reprinted in *River*, 106–13. Leopold's language on the obligation of landowners was similar to that in a speech he had written in December 1922 for the New Mexico Association for Science, "Erosion as a Menace to the Social and Economic Future of the Southwest." The speech was published many years later in *Journal of Forestry* 44:9 (Sept 1946), 627–33.

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[28]Leopold to Claude V. Campbell, 15 October 1932, LP 3B5, and associated correspondence. See also Jacob L. Crane, Jr., and George Wheeler Olcott, *Report on the Iowa Twenty-five Year Conservation Plan* (Des Moines: Meredith, 1933).

[29]"A Conservation Plan for Wisconsin Farms," 23 October 1933, 6pp tps., LP 6B16.

[30]See Leopold to William Schuenke, 10 July 1935; I.T. Bode to Leopold, n.d. [c. July 1935]; and Leopold to I.T. Bode, 19 July 1935, all in LP 3B5. See also Rebecca Conard, *Places of Quiet Beauty: Parks, Preserves, and Environmentalism* (Iowa City: University of Iowa Press, 1997), 120–36.

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[35]"Land Pathology," 15 April 1935, 8pp tps, LP 6B16, reprinted in *River*, 212–17.

[36]J.N. Darling to Leopold, 20 November 1935, LP 6B16.

[37]"Farmer-Sportsman Set-ups in the North Central Region," *Proceedings North American Wildlife Conference*, February 3–7, 1936 (Senate Committee Print, 74th Cong., 2d sess., 1936), 279–85. See also "Coon Valley: An Adventure in Cooperative Conservation," *American Forests* 41:5 (May 1935), 205-208 [*River*, 218–23]; "Helping Ourselves" (with Reuben Paulson), *Field and Stream* 39:4 (August 1934), 32–33, 56 [*River*, 203–08]; and "History of the Riley Game Cooperative, 1931–1939," *Journal of Wildlife Management* 4:3 (July 1940), 291–302. For recent examples of the burgeoning movement in community conservation, see the special issue of the *Journal of Forestry* 96:3 (March 1998) on community forestry.

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[39]"Land-Use and Democracy," *Audubon Magazine* 44:5 (Sept–Oct 1942), 259–65 [*River*, 295–300].

[40]See Flader, *Thinking Like a Mountain*, 168–260.

[41]Ibid., 183–93.

[42]Ibid., 194.

[43]*A Sand County Almanac*, 68.

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Craig Annen and Jonathan Lyon

Relationships between Herbaceous Vegetation and Environmental Factors along a Restored Prairie-Oak Opening Ecotone

Abstract *We studied a potential ecotone between a wet-mesic prairie and an oak opening in a restored landscape in southern Wisconsin. We described the relationships between herbaceous vegetation and soil variables along the prairie-oak opening transition using twenty-five 1-m^2 plots located on five 75-m transects. We identified a total of 46 herbaceous species and analyzed eight environmental variables: seven soil variables and photosynthetically active radiation (PAR). We observed distinct soil gradients along the ecotone: soil organic matter, total N, pH, P, Mg, and Ca levels all exhibited significant reductions when moving along the ecotone from prairie to oak opening. PAR was weakly correlated with vegetation patterns. Using cluster analysis and ordination techniques, we identified few distinct herbaceous community types along the transition, except for a unique assemblage dominated by reed canary grass* (Phalaris arundinacea *L.*)*. Our canonical correspondence analysis (CCA) results indicated strong correlations between herbaceous vegetation and soil N, pH, Ca, and Mg gradients. Herbaceous species richness and Shannon-Wiener diversity increased moving from the prairie into the oak opening. Overall, our results indicated that (1) distinct soil gradients exist at the site, (2) soil gradients are correlated with herbaceous vegetation patterns in the restored area, and (3) while* P. arundinacea *has a strong influence on the composition of vegetation at the site, non-*Phalaris–*dominated plots exhibited continuous rather than discrete ecotonal properties. The potential importance of soil variables and soil gradients should be considered when studying the characteristics of ecotones in restored habitats.*

Ecotones are transition zones between two or more distinct community types. The role of ecotones (and ecoclines) in describing and explaining spatial and temporal vegetation patterns has received renewed attention in recent years (Naiman and Décamps 1990, Holland et al. 1991, Hansen and di Castri 1992, Gosz 1993, Risser 1995), although interest in the structure and ecological impact of ecotones is by no means new (Clements 1905, Leopold 1933, Weaver and Albertson 1956). Recent ecotone research has been focused on biodiversity (Pulliam 1988, Hansen and Urban 1992, Leach and Givnish 1996), nutrient and material flows between communities (Johnston 1993, McClaran and McPherson 1995), ecotones in landscapes (Boren et al. 1997, Dyer and Baird 1997, Sagers and Lyon 1997), and regulation and response to large-scale climatic change (Nielson 1993, Rusek 1993). Despite the renewed interest in ecotones, characterization of vegetation in and across ecotones remains problematic (Auerbach and Shmida 1993, Jarvis 1995, Stohlgren et al. 1997).

Rates of spatial change in vegetation are scale-dependent, and ecotones can be characterized over a wide range of spatial scales (di Castri 1993, Gosz 1991, Crumley 1993). Assigning boundary classifications can be difficult at larger scales because of the tendency of small-scale differences to average out at larger levels of observation (Allen and Hoekstra 1992). Ecotone studies at the population level encompass the spatial distribution of individuals in a small habitat and facilitates analysis at smaller scales (Fahrig and Merriam 1985, Gosz 1993). In both large and small scale ecotonal landscapes, specific environmental variables can strongly influence the distribution and abundance of vegetation and be correlated with the spatial distribution of ecotones (Gosz and Sharpe 1989, Risser 1990, van der Maarel 1990, Neilson 1993). Grassland and prairie vegetation, in particular, have been shown to be sensitive to changes in soil nutrient status and balance (Wedin and Tilman 1996), and soil gradients have been shown to have a strong influence on the composition of prairie and savanna vegetation (Curtis 1959, Anderson 1968, Jastrow 1987, Zak et al. 1990, Leach 1994).

We studied a suspected ecotone between a restored prairie community and a remnant oak opening. The study was conducted in the Curtis Prairie, a prairie restoration project at the University of Wisconsin-Madison Arboretum. The restoration effort at the Curtis Prairie has been studied from a variety of perspectives, including land use history (Blewett and Cottam 1984), fire (Anderson 1972, Peet et al. 1975), vegetation dynamics (Cottam and Wilson 1966, Blewett 1981), and organic matter incorporation into soils (Nielsen and Hole 1963). However, no studies have assessed potential linkages between underlying soil gradients and composition of vegetation along the restored prairie-oak opening ecotone. Our overall objective was to determine how herbaceous vegetation was distributed in the ecotonal region and if vegetation patterns were correlated with soil variables and/or photosynthetically active radiation (PAR). Specifically, we wanted to determine:

(1) if and how the environmental variables changed across the prairie-oak opening boundary;

(2) if the boundary between the two vegetation zones was discrete or continuous;

(3) if any of the environmental variables were correlated with vegetation composition;

(4) if a plant diversity gradient existed between the adjacent vegetation zones.

Study Site

The 0.45-ha study site was located in the northwestern portion of the Curtis Prairie, a prairie restoration project within the University of Wisconsin-Madison Arboretum. Presettlement vegetation in the area consisted of an oak opening intermixed with patches of tallgrass prairie (Curtis 1959, Sachse 1965, Cottam and Wilson 1966, Blewitt and Cottam 1984). The area was settled and converted into farmland in the 1850s. By the 1920s, the agricultural fields were abandoned, and the area was used as a horse pasture. In 1932 the Arboretum acquired the land, and in 1935 the prairie restoration project at Curtis Prairie was initiated. By 1948 the first prescribed burning was conducted (Curtis and Partch 1948). Current management of the Curtis Prairie includes a two-year cycle of prescribed burning; two-thirds of the prairie are burned one year, and the remaining third is burned the next (Anderson 1972). Occasional brushing and mowing also have been used as management tools. A detailed history of the site is provided by Blewitt and Cottam (1984).

Methods

Herbaceous Vegetation Sampling

Five 75-m transects were established at intervals of 15 m running parallel across the prairie-oak opening border. The transects started at a small drainage channel running southwest to northeast across the site (a topographical low point). Position 1 was in the prairie while position 5 was in the oak opening. All transects were set up at an azimuth of 310°. Sampling plots were located at 15 m intervals along the transect. Herbaceous vegetation was sampled using 1-m^2 quadrat constructed from PVC pipe. Vegetation samples were taken at each 15 m interval along each of the five transects for a total of 25 plots. The quadrat shape and size are appropriate for this type of vegetation (Brummer et al. 1994).

Herbaceous vegetation within each plot was clipped at the base of the plant (plant-soil interface) and separated according to species. Nomenclature follows Gleason and Cronquist (1991). The species samples were then dried by placing them in a drying oven at 65°C for 48 hours or until a constant weight was obtained. Dry weight biomass was determined for each species (g m^{-2}) (Appendix A). Photosynthetically active radiation (PAR) was measured on each plot using a Li-Cor LI-192SA Quantum Sensor (Lincoln, NE). Paired light measurements were taken in full sunlight adjacent to the study area, above the herbaceous canopy (approximately 1.3 m) as a measure of light interception by oak opening burr oaks (*Quercus macrocarpa* Michx.), and at approximately 8 cm above the ground surface beneath the herbaceous canopy.

Soils

A composite soil sample was taken from each plot to a depth of approximately 10 cm from three arbitrary locations within each plot. Leaf litter was removed from the sample area prior to soil collection. Soil samples were stored in plastic bags and kept refrigerated until analysis. Soils were analyzed at the University of Wisconsin-Madison's Soil Testing, Plant Analysis and Feed and Forage Analysis Laboratory in Madison, WI. Soils were analyzed for pH, organic matter, total N, available P, and exchangeable K, Ca, and Mg.

Soil pH was measured using a glass electrode pH meter in a 1:1 w/v aqueous solution following the methods of Corey and Tanner (1961). Calcium was measured as lime ($CaOH_2$) using a glass electrode Ca meter in a 1:1 w/v aqueous solution. Available phosphorous was measured after the methods of Bray and Kurtz (1945). Available potassium was measured according to the methods outlined in Wilde et al. (1979). Percent organic matter (OM) was determined following the methods of Schulte (1980). Total nitrogen was measured using the semi-micro Kjeldahl procedure (Bremner and Mulvaney 1982)

Vegetation Analysis

Classification of herbaceous vegetation was conducted using Cluster Analysis performed by program PC-ORD (McCune and Mefford 1995). To evaluate the variation in herbaceous vegetation and environmental variables along the transects, analysis of variance tests were performed using the general linear model (GLM) procedure in Minitab 8.2 (Minitab 1991). Mean separations across transect position groups were conducted using Fisher's test at $P < 0.05$. Species density was defined at the total number of species found in a sample plot and was used as an estimate for species richness (Magurran 1988). Species diversity was determined using the Shannon-Wiener diversity index, $H' = -\sum pi \ln pi$, where pi is the proportion of importance value of the ith species. These values were based on dry-weight biomass.

To evaluate relationships between vegetation and environmental variables, we performed multivariate analyses, namely detrended correspondence analysis (DCA) and canonical correspondence analysis (CCA) ordinations on herbaceous species-environmental variable matrices. We conducted the ordinations using the programs PC-ORD (McCune and Mefford 1995) and CANOCO 3.10 (ter Braak 1990). Herbaceous species biomass was used in the plant matrix as an indicator of plant abundance. Plant dry weight biomass was used in all the ordination and classification methods described. The DCA procedure used segment detrending, nonlinear rescaling of axes, and rare species downweighting (Hill and Gauch 1980). The CCA procedure involved linear combination of variables for site scores, no transformation of species abundance matrices, and the use of a Monte Carlo permutation to test the significance of the first axis eigenvalue (ter Braak 1990). In all CCA ordinations performed, the Monte Carlo test indicated that the eigenvalues for the first axis were significant ($P < 0.05$). Given the influence of noisy environmental data on CCA (McCune 1997), CCA was used and interpreted in the limited context of describing plant community variation with respect to the limited set of measured environmental variables in the study. Soil and environmental variables were transformed, when necessary, to meet the assumptions of normality. Significance is reported at the alpha = 0.05 level, unless otherwise noted in the text.

Results

A total of 46 herbaceous species were found on the study plots (Appendix A). Standing crop, dry weight biomass on the plots ranged from 69 to 2117 g m^{-2} (mean = 533 g m^{-2}). A distinct biomass gradient was also observed along the prairie-oak opening transition; mean plot biomass was 642 g m^{-2}, 1046 g m^{-2}, 437 g m^{-2}, 307 g m^{-2}, and 231 g m^{-2}, at transect positions 1, 2, 3, 4, and 5, respectively. Herbaceous species density on plots ranged from 2 to 11 species (mean = 5.9). Note that the species density totals do not include a limited number of spring ephemeral species. A summary of the overall fidelity of the herbaceous species encountered in the study indicated that the majority of the species sampled were uncommon; cumulative totals of species fidelity show that

64.6% of the species were found on three or fewer plots, 29.1% were found on from four to eight plots, and the remaining 6.3% were found on nine or more plots.

Soil Chemical Gradients

Table 1 provides a comparison of the means, standard deviations, and ranges of the environmental variables in the study. The relatively wide ranges of environmental variables depicted in Table 1 indicate the existence of soil heterogeneity at the site. Table 2 summarizes the correlations between environmental variables in the study. Moving from prairie towards the oak opening, seven of the eight environmental variables under examination were found to be negatively and significantly correlated with distance along the transects: pH (r = -0.81), organic matter (r = -0.73), N (r = -0.75), P (r = -0.63), Ca (r = -0.82), Mg (r = -0.88), and PAR above the herbaceous canopy (r = -0.53) (Figure 1). Table 2 shows that K was not significantly correlated with distance or any of the environmental variables measured. Furthermore, PAR above the herbaceous canopy was weakly correlated with all other environmental variables, and PAR beneath the herbaceous canopy exhibited even weaker correlations (Table 2). Table 2 also shows that many of the soil nutrient variables were strongly correlated.

Table 1. Means, standard deviations, and ranges (minimum and maximum) of environmental variables along a prairie-oak opening ecotone in the Curtis Prairie.

Variable[a]	*Mean*	*Standard Deviation*	*Range*
pH	6.6	0.7	5.3 - 7.5
Organic matter	5.3	1.2	2.6 - 7.1
N	0.23	0.06	0.11 - 0.34
P	24.6	6.8	13.0 - 35.5
K	0.34	0.07	0.23 - 0.48
Ca	5.5	1.7	2.8 - 7.7
Mg	4.0	1.4	1.9 - 6.2
PAR	76.1	34.5	8.6 - 97.6

[a]Variables shown are in the following units: organic matter (OM) %; Total N %; available P (P) mg/l; exhangeable K (K) cmol+kg^{-1}; exhangeable Ca (Ca) cmol+kg^{-1}; exhangeable Mg (Mg) cmol+kg^{-1}; photosynthetically active radiation (PAR) µmol s^{-1}m^{-2}.

Table 2. Pearson correlation coefficients between variables measured in the study.

Variable[a]	*D*	*pH*	*OM*	*N*	*P*	*K*	*Ca*	*Mg*	*PAR over*	*PAR under*
Distance (D)	-	-.81	-.73	-.75	-.63	.06	-.83	-.88	-.53	-.14
pH		-	.54	.68	.41	.10	.87	.89	.49	.20
OM			-	.92	.80	.19	.76	.76	.43	.14
Total N				-	.74	-.02	.46	.43	.40	.17
P					-	.08	.28	.67	.20	-.05
K						-	-.03	.01	.13	.11
Ca							-	.94	.46	.13
Mg								-	.43	.07

[a]Variables shown are in the following units: distance (D) m; organic matter (OM) %; Total N %; available P (P) mg/l; exhangeable K (K) cmol+kg^{-1}; exhangeable Ca (Ca) cmol+kg^{-1}; exhangeable Mg (Mg) cmol+kg^{-1}; photosynthetically active radiation (PAR) µmol s^{-1}m^{-2}.

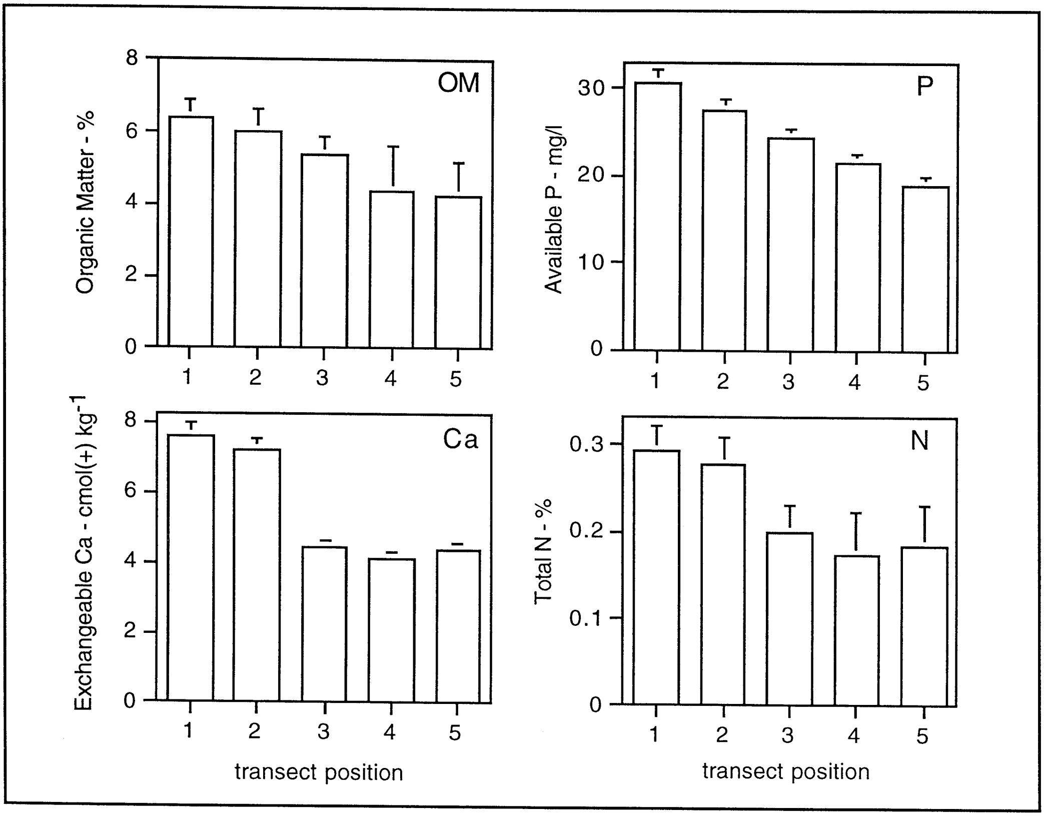

Figure 1. Graphs show relationships between transect position and soil nutrient levels. Transect position 1 corresponds to prairie and 5 corresponds to oak opening in the Curtis Prairie. Bars represent one standard deviation.

Figure 1 is a composite graph of transect position plotted versus measured soil levels of total N, available P, exchangeable Ca, and percent OM. Significant reductions in soil N (P < o.001), Ca (P < 0.001), P (P = 0.030), and OM (P = 0.002) were noted moving from prairie (position 1) to oak opening (position 5). The Mg results (not shown) were highly similar to the Ca results. These results indicate strong underlying soil gradients on the study site moving across the prairie restoration-oak opening transition zone.

Vegetation along the Transition

Cluster analysis identified six weak clusters in the dataset. However, only a single distinct herbaceous assemblage was found in the study area. Reed canary grass (*Phalaris arundinacea* L.) dominated the plant assemblages found in transect positions 1 and 2 along the ecotone. The DCA ordination results (not shown) also indicated this pattern. Figure 2 shows that positions 1 and 2 had significantly lower DCA mean scores than positions 3 to 5 (P < 0.001). No significant differences in mean DCA scores were found between positions 3, 4, and 5. However, the standard deviation was highest for position 3. This latter result indicates the vegetation at position 3 (between the prairie restoration and oak opening) shows a high rate of species change at that location. The five remain-

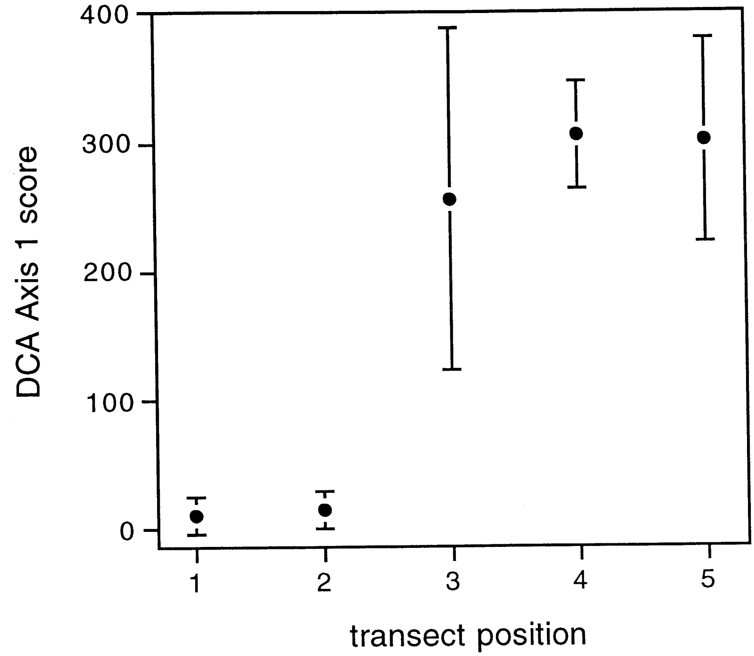

Figure 2. A plot of DCA axis 1 scores (±1 SD) versus plot position along the five study transects.

ing non-Phalaris–dominated clusters were located in plots spread out along the three remaining transect positions. No clear patterns of prairie versus oak opening vegetation were found.

Vegetation-Environmental Relationships

Ordinations were used to detect relationships between vegetation and measured environmental variables. Both DCA and CCA were run, but because the two ordinations produced similar results, only the CCA results are presented in detail. Figure 3 is a summary CCA ordination showing plot ordination on a biplot for the 25 vegetation plots with eight environmental variables. The first three axes of the CCA ordination explained 35.2% of the variation in the species matrix. The three vectors shown in Figure 3 correspond to the environmental variables showing strong correlations with the first CCA axis, namely Ca (r = -0.88), N (r = -0.72), and pH (r = -0.71). Mg also exhibited a strong correlation (r = -0.78) as did OM (r = -0.58); however, a vector for Mg wasn't included in Figure 3 because Mg results were similar to those of Ca. The results in Figure 3 parallel the results presented in Table 2. The CCA correlations also closely paralleled the correlations between environmental variables and the DCA ordination axes. While CCA may be sensitive to noise in environmental data (McCune 1997), the results provide corroboration of the soil gradient analysis and the DCA results.

The distribution of plots in Figure 3 also shows a separation of the plots dominated by *Phalaris*, with all *Phalaris*-dominated plots located exclusively on the left side of the ordination. No clear segregation of plots

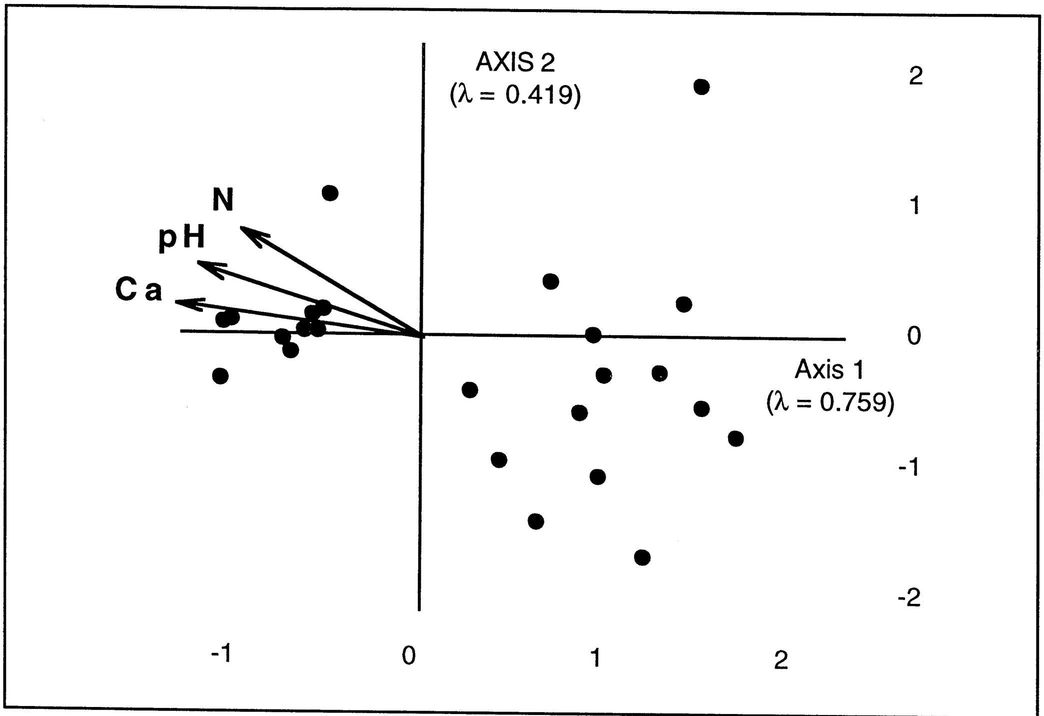

Figure 3. A CCA ordination biplot of 25 plots and 9 environmental variables. The environmental variables with the strongest correlation with the vegetation matrix are shown in the biplot.

was observed on the right half of the CCA biplot, indicating more of a continuous distribution than discrete gradation of herbaceous assemblages in the non-*Phalaris*–dominated plots.

Diversity Gradients

In addition to soil chemical gradients, a herbaceous plant diversity gradient also was found along the prairie-oak opening transition. Plant diversity was calculated for each transect position using both species richness (S) and the Shannon-Weiner Diversity Index (H'). The results in Table 3 show that both species richness and Shannon-Weiner diversity were positively correlated with distance along the transition zone; as prairie graded into oak opening, species richness and diversity increased. Diversity estimates were strongly correlated with Ca (r = -0.90), N (r = -0.84), OM (r = -0.72), and pH (r = -0.67). Interestingly, no significant relationships were found between any of the PAR measurements and species diversity measures.

There was a strong negative correlation between *Phalaris* and species richness (r = -0.75) and diversity (r = -0.78) along the ecotone transition. While the cause-effect relationship between *Phalaris* and plant diversity is beyond the scope of this study, the results suggest that *Phalaris* dominance reduces diversity.

Discussion

The term ecotone was first used by Clements (1905) to describe the "tension zone" between plant communities where the major

Table 3. Correlations between Shannon-Weiner diversity (H'), species density (S), and distance and environmental variables. Values represent Pearson's correlation coefficients (r).

Variable[a]	*S*	*H'*
Distance (D)	.60	.73
pH	-.44	-.67
OM	-.66	-.72
N	-.74	-.84
P	-.82	-.53
K	.12	.13
Ca	-.62	-.90
Mg	-.67	-.80
PAR	-.25	-.46

[a] Variables shown are in the following units: distance (D) m; organic matter (OM) %; Total N %; available P (P) mg/l; exhangeable K (K) cmol+kg^{-1}; exhangeable Ca (Ca) cmol+kg^{-1}; exhangeable Mg (Mg) cmol+kg^{-1}; photosynthetically active radiation (PAR) µmol s^{-1}m^{-2}.

dominant species in adjacent communities overlapped in their distribution. In recent years, the term ecotone has been used interchangeably with the terms "transition zone" and 'landscape boundary' (van der Maarel 1990; Shugart 1990; Holland et al. 1991; Hansen and di Castri 1992). The presence of ecotones and their manifestation are influenced by a host of factors, including edaphic conditions, geomorphology, disturbance, and climate (Risser 1990, van der Maarel 1990, Gosz 1993).

The results of our study indicate distinct ecotonal characteristics in both vegetation and soil variables in the Curtis Prairie. The herbaceous layer exhibited sharp ecotonal boundaries only at the transition between *Phalaris*-dominated communities and prairie-oak opening vegetation. Cluster analysis and CCA ordinations showed little distinct separation between plots on non-*Phalaris*–dominated plots; herbaceous vegetation assemblages were more continuous than discrete across the prairie-oak opening transition. Our results also indicate that there were both soil chemical and diversity gradients along the prairie-oak opening ecotone in the study area. Organic matter, pH, P, Ca, Mg, and total N decreased along the gradient from prairie to oak opening; plant diversity increased from prairie to oak opening. Given the importance of total N and available P to plant nutrition, the role and influence of OM in prairie soil development, and the impacts of Ca and Mg on plant distribution in calcareous and dolomitic soils, our results highlight the importance of soil gradients along the prairie oak opening transition in this study. However, the presence of *Phalaris* at the site may have had a strong influence on altering pre-*Phalaris*–invasion vegetation and soil patterns.

Integrating vegetation analyses with environmental and physiographic variables can provide a more robust basis for classification and characterization than vegetation analyses alone (Rowe 1984, Hix 1988, Palmer 1993). The soil gradient analysis and CCA results indicate that herbaceous species were influenced by soil gradients across the ecotonal landscape. The correlations between the soil variables and herbaceous species diversity indicate that plant diversity may also be influenced by soil chemical gradients. In the oak opening portion of the ecotone, lower nutrient availability may promote greater diversity compared to that of the prairie.

Ecotones may provide pathways for the invasion of exotic plants that can disrupt community dynamics (Risser 1990, Planty-Tabacchi et al. 1996). An important factor influencing the observed diversity patterns in our results was that *Phalaris* had a negative impact on herbaceous species diversity on the study site. *Phalaris* was a dominant species on the wetter soils on the prairie side of the ecotone but was not found in the oak opening or the prairie-oak opening interface. *Phalaris* is an exotic species that grows in dense clumps, outcompetes local flora, and is highly resistant to flooding (Apfelbaum and Sams 1987, Chonchou and Fustec 1988). Seasonal flooding has occurred and continues to occur near and around an overflow ditch within the study area. *Phalaris arundinacea* was most dominant near the overflow ditch, and it follows that the ditch is quite possibly the vector by which seeds of *P. arundinacea* first entered the area.

Current management techniques (i.e., fire and selective brushing) may have influenced the ecotone under study. In addition, light (PAR) may have a long-term impact on the vegetation composition at the site depending on phenology, available wavelengths of light, and variation in herbaceous canopy composition. While the influence of these variables requires more investigation, the results of the present study clearly demonstrate the potential influence of soil factors on the composition and distribution of herbaceous vegetation. We suggest that soil variables and gradients should be considered when studying characteristics of ecotones in restored habitats.

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Appendix A. A summary of all herbaceous species identified in the vegetation sampling.

Species	Total Biomass - g
Agrostis alba L.	21.3
Allium cernuum Roth.	11.7
Andropogon geradii Vitm.	798.5
Arctium minus Bernh.	1.0
Asclepias syriaca L.	0.5
Aster ericoides L.	3.8
Aster laevis L.	5.6
Aster lanceolatus Willd.	9.8
Aster novae-angliae L.	148.9
Aster oolentangiensis Riddell	1.9
Aster pilosus Willd.	21.0
Baptisia leucantha T.&G.	47.9
Blephilia ciliata (L.) Raf.	1.1
Brachelytrum sp.	52.2
Bromus inermis Leyss.	18.2
Carex sp.	17.9
Cirsium discolor (Muhl.) Spreng.	3.3
Cornus racemosa Lam.	182.9
Euphorbia corollata L.	2.1
Galium triflorum Michx.	0.4
Helianthus grosseserratus Martens	602.4
Hypericum perforatum L.	14.7
Lactuca canadensis L.	36.0
Lespedeza capitata Michx.	100.3
Liatris aspera (L.) Willd.	14.0
Lycopus americanus Muhl.	4.2
Monarda fistulosa L.	658.0
Oenothera biennis L.	33.3
Pastinaca sativa L.	26.3
Pedicularis canadensis L.	2.2
Phalaris arundinacea L.	142.6
Poa compressa L.	21.8
Poa pratensis L.	52.2
Polygonum pensylvanicum L.	85.2
Pycanthemum virginianum (L.) Durand & Jackson	6.4
Rosa sp.	3.3
Rubus occidentalis L.	10.4
Rudbeckia hirta L.	0.3
Silphinium terebinthinaceum Jacq.	42.1
Solidago altissima L.	732.7
Solidago gigantea Ait.	14.3
Solidago nemoralis Ait.	856.8
Solidago ulmifolia Muhl.	0.2
Sorghastrum nutans L.	504.8
Toxicodendron radicans (L.) Ktze.	0.6
Unknown	2.4
Viola pedata L.	0.1
Vitis riparia Michx.	0.0

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Ellen Argyros

"Pulp Fiction": Edna Ferber's *Come and Get It* and Ecofeminism

Edna Ferber's novel *Come and Get It* is pulp fiction not so much because of its dealings with sensational subjects or its being printed on low-quality paper as because it is about the making of pulp, the logging industry in Wisconsin in the early half of the twentieth century, the empire-making of Barney Glasgow. Granted, the book does contain some melodramatic elements: the lust of a sugar daddy for a sweet young thing, the sudden *deus ex machina* when that sugar daddy dies in a boating accident, the social-climbing tendencies of that opportunistic young woman once the wealthy Barney Glasgow dies and she can marry his son, heir to his fortune. Still, *Come and Get It* is of interest not because of its melodrama but because what it reveals about the status of women and the status of the environment in Wisconsin around the turn of the century right up until before World War II. It is also is an impressive testimony to the "Wisconsin character," as Ferber defines it. In her novel, Ferber rewards those who are unpretentious, work hard, save their money yet do not become seduced by the trappings of material success into becoming what they are not. She is also extremely aware of the way in which Midwesterners define themselves—sometimes defensively—against standards set in the east.

Given the recent interest in such local environmental issues as what to do about the high concentration of PCBs in the Fox River and in such national gender-political issues as the sexual predation of our own president upon young women like Monica Lewinsky, it would appear to be a timely moment in which to examine the kinds of connections Ferber makes in her novel between the treatment of the environment and the treatment of women.

After giving an overview of Ferber's life, I will provide a brief plot synopsis for those unfamiliar with this relatively obscure novel, address what kind of a feminist she is, and then go on to argue that it is tempting to read Ferber as a kind of proto-ecofeminist in some parts of *Come and Get It,* even though her primary sympathies are not so much with those who share her gender or ideological stance towards the environment as with those who share her values about the salubrious and ethical benefits of hard work.

Edna Ferber's Life

Edna Ferber is described by her biographer, Julie Goldsmith Gilbert (Ferber's great-niece), as a "massive little woman" who may have been physically tiny—she was only 5'2"—but was extremely strong-willed. The Ferber in Gilbert's biography could be fiercely protective of those she loved, while unsparingly savage towards those for whom she felt contempt; there's a kind of masculine swagger in Edna Ferber, according to Gilbert's presentation. Ferber had a great deal of respect for the common worker, enjoyed being in the position of the sharply observant onlooker, gave lavish meals, was given to fits of outrage, had difficulty trusting others, and always wanted to be the one who rejected first. Gilbert writes that Ferber's

> life was antiseptic—absolutely no excesses were allowed. She was a Middle Western maiden lady who took care of her mother, her family, and her typewriter. She recycled herself with every book, and each seemed a testament more to her own health and vigor than to inspiration. With themes like Seattle, Oklahoma, Alaska, New England, the West, Texas—she had no time or penchant for personal probing. There was too much to do. Her ego was as mammoth as her scope, and no man, vice, crisis, or illness was going to deter her. An obsessive in the most productive sense, a spinster in the most resolved sense, a plain woman who kept herself in silk purses, and an angry daughter who determinedly made her mother's life roses. . .one would assume that her bill of mental health was immaculate. A presumption. Her complete devotion to her mother Julia bordered on the incestuous. Her hatred of her sister Fannie was at times close to being pathological. Her need and ability to 'play God' was despotism at its worst. There were chinks in her armor. Many. (Gilbert, 13)

Edna Ferber was born on August 15, 1885, in Kalamazoo, Michigan, of Jewish parents. According to Gilbert, Edna's mother had wanted a boy, whom she would have named Edward. Instead, she had a second girl, and she named her Edna. Edna's father, Jacob, was a Hungarian; her mother, Julia, was born in Milwaukee. Her father was the owner of a general merchandise store, first in Iowa, then in Appleton (on College Avenue). Her older sister, Fanny, and Edna had frictive relations for much of their lives, perhaps because Fanny was the more beautiful of the two, but there may have been other reasons as well.

At 17, Ferber graduated from the Ryan High School in Appleton. For her graduating essay she wrote an account of the life of the women workers in a local mill. The local editor of the *Appleton Daily Crescent* saw it, recognized that it was good reporting, and gave her a job in 1903 as a local reporter at $3.00 a week—a huge salary for a young woman in a small town. She then was graduated from the Appleton paper to Milwaukee, where she was also a reporter. While she was earning a living as a reporter, she wrote *Dawn O'Hara,* her first novel. It sold well. While it was in the press and selling during 1911 and 1912, Ferber began publishing the story of Emma McChesney, a travelling saleswoman. The character appealed to the public, and Ferber's success began to grow. In 1913, the stories were collected under the title *Roast Beef Medium,* and that book also sold well. This was followed by *Buttered Side Down,* another collection of short stories, and more novels, *Fanny Herself* (1917), *Cheerful by Request* (1918), *The Girls* (1922), *Show Boat* (1926), *Giant* (1952), *Ice Palace* (1958), and others. She was a prolific writer, with a total of twelve novels—including *So Big,* for which she won a Pulitzer Prize in 1924—twelve short story collections, two autobiographies, nine plays. Twenty five of her properties sold to the films, although "only" ten of her works were actually made into motion pictures. She never married, and she died in 1968 at the age of 83.

Come and Get It : Plot Synopsis

Come and Get It was published in 1935, just before World War II struck in Europe and Asia and at a time of labor strikes in the United States. *Porgy and Bess* was opening in New York at this time; the following year *Gone with the Wind* was a best-seller, and Charlie Chaplin's *Modern Times* was released.

In *Come and Get It,* Edna Ferber chronicles the rags to riches tale of the handsome Barney Glasgow, who marries the boss's homely daughter in order to consolidate his wealth and become one of the leading lumber barons in the state; after Barney's death about two thirds through the novel, she goes on to describe his son's inheritance and augmentation of the Glasgow fortune.

Barney Glasgow is orphaned at the age of 14 and taken under the wing of Swan Bostrum. The young Barney proves a quick study in how to fell a tree and how to make himself indispensable to his boss. He discovers the various illicit but technically legal ways of acquiring land with lumber on it. Through clever bits of legal fraud, Barney wins his way into his boss' heart and business. He secures his career when he opportunistically marries the boss's "thin-lipped, hook-nosed, bony" daughter, Emma Louise, who is several years older than the dashing Barney. Barney is not attracted to his wife, nor does he like his calculating son Bernard, although he is fond of his daughter Evelyn. Evelyn, following in her father's footsteps, is in the process of marrying a person she does not love simply because he is the son of another lumber baron, and because she feels that this is what she is expected to do. The marriage is even more of a travesty because she really loves and is loved by a handsome Italian worker, whose love she sacrifices in order to maintain her social standing. Prior to his marriage to Emma Louise, Barney and Swan both had been attracted to a pretty young prostitute, Lotta Morgan. Barney loves her, but Swan does the right thing and marries her. Lotta remains married to Swan for ten years and then, after giving birth to a little girl Karie, dies.

Then the plot skips ahead 35 years, and we meet Karie's daughter, Lotta Lindbeck (Lotta II). At age 18, Lotta II is now a "ravishing beauty." Barney never actually forces himself sexually upon her, but he is infatuated with her, showers her with gifts, and regards her as his possession. He wishes to marry her and feels that with all the millions he has, it's a shame that he remains married to a homely woman whom he does not love. He is therefore incensed to discover Lotta and his son Bernie kissing at a party and to learn of Bernie's intention to marry her. The two men fight and nearly kill one another. Barney threatens to disown his son, whom his wife hides. Then, when everyone in the family but the son Bernie decide to go out on a boat, the boat explodes. Bernie becomes heir to the Glasgow fortune and marries Lotta.

The rest of the novel follows the career of Lotta Glasgow, who is shunned by the wealthy women of Butte des Morts; in frustration she becomes an expatriate, travelling in Europe and repudiating the life she once lived in Butte des Morts. But her grandfather Swan, the moral authority in the novel, returns to Iron Ridge to resume his humble life among the pine trees. Lotta's mother Karie, although she stays with her daughter and helps her care for her grandchildren, remains as down to earth, unpretentious, and seemingly uncorrupted by wealth as she ever was. Lotta, of course, becomes a complete social-climber and snob, flaunting her newfound wealth. Against her will, her European-born children become intrigued by their American origins. When their father loses millions during the Great Depression and has a nervous collapse, his wife reluctantly returns home with their grown children—who are excited about the paper mills but who also want to travel across America and learn about their native land.

The novel ends with Lotta and Karie and the grandchildren helping to celebrate Swan's 85th birthday up in his tiny cabin up north. The old man can still heft an axe, and he cuts down a 100 year old pine tree while his daughter Karie yells "Come and get it!" to the gaping crowd.

Public Reception of the Novel and Brief Critical Evaluation

The public's initial response to *Come and Get It* was anger. Specifically, Ferber's treatment of Polish-American workers was perceived as pejorative, discriminatory. Gilbert defends Ferber: "Ferber, always true to authentic ethnicity, had used the term 'dumb Polack girls' in the context of the story. No doubt, in her research of the territory, she had heard it mentioned. To Polish-Americans, it was unmentionable" (Gilbert 329). Gilbert even received a letter of protest from a congressman. Others complained that Ferber had conducted her research for the novel in a way that violated the etiquette of the time. Gilbert writes:

> When she went to Wisconsin to do research for *Come and Get It,* she enlisted the help of an executive of a large paper mill in Neenah . . . . The executive gave her all she needed to know. What he didn't know was that he unwittingly gave her himself to use as the main character in her book . . . . What stung him was not so much her portrayal of him, but the fact that she never, after their long sessions together, even wrote him a thank-you note. And, as is often the case in tight-knit societies, everyone knew about her rude conduct. The whole town tsked. (330)

In my opinion, *Come and Get It* is not Ferber's best work. The characters seem a bit two-dimensional: the dashing robber baron, the dowager wife, the blond bombshell. The plot plods along somewhat tediously until Barney's lust for the young Lotta develops; then it suddenly erupts into melodrama, only to have Barney's family (with the exception of his heir, Bernard) die in a rather improbable plot contrivance.

Ferber herself recognized that this was not a perfect novel. In her autobiography *A Peculiar Treasure,* she writes about how "in the writing of the novel Come and Get It, [sic] I was guilty of. . . [a] . . . stupid blunder. I killed Barney Glasgow in the middle of that book because he was dominating the story. The book gave a gasp right there, and the murder was doubled." (223)[1] Ferber further confesses that "Plot is something that doesn't interest me. Character I find absorbing. My novels usually are character-strong and plot-weak. I'd be sorry to have it the other way round" (224). There is, of course, a rather transparent and somewhat defensive false dilemma implicit her assumption that a writer will inevitably make mistakes in one area, either in developing characters or in developing plotlines.

Ecofemism Defined

Its failings notwithstanding, when I first read this novel and in subsequent readings of it, I was struck by the sorts of connections Ferber invites us to make between Barney's ravaging of the land—with no intentions of replenishing the lumber supply once it has been depleted—and his desire to ravage his best friend's granddaughter, again, with little thought about what the consequences of this action would be on his friendship with Swan, on his relationship with his children, or on his relationships with the people of his community. Vaguely remembering that ecofeminists also draw connections between the treatment of the land and the treatment of women, I did some research into ecofeminism and then re-read the novel through the lens provided by that ideological perspective.

Ecofeminism, I found, is a relatively recently coined term used to link the domination of both land and women without regard for the feelings or desires of the women or for the future productiveness of the land. Literary ecofeminists explore the manifold ways in which the exploitative treatment of women reflects a similarly exploitative and opportunistic treatment of the environment. Marie Mies and Vandana Shiva in *Ecofeminism* describe the origins of ecofeminism, "which grew out of various social movements of the late 1970s and early 1980s . . . The meltdown at Three Mile Island prompted large numbers of women in the USA to come together in the first ecofeminist conference—'Women and Life on Earth: A Conference on Eco-Feminism [*sic*] in the Eighties'—in March 1980, at Amherst. At this conference the connections between feminism, militarization, healing and ecology were explored" (Mies and Shiva 13-14).

Gretchen Legler discusses what an ecofeminist literary criticism might look like: "Ecofeminist literary criticism is a hybrid criticism . . . that gives literary and cultural critics a special lens through which they can investigate the ways nature is represented in literature and the ways representations of nature are linked with representations of gender, race, class, and sexuality" (quoted in Warren 227). According to Legler, "many canonical authors still place nature 'out there' as an 'other.' Many canonical authors refine and entrench the notion of nature as a sacred place where only solitary, single, and chaste men go to cleanse their spirits and be one with God" (quoted in Warren 229). Legler suggests that "critiquing canonical works through an ecofeminist lens might include investigating the ways in which gender, race, and class are represented in and inform the writings of these 'fathers' of American nature writing"; she goes on to suggest that ecofeminists might well study the texts of such contemporary women writers as Annie Dillard, Gretel Ehrlich, Linda Hasselstrom, Sue Hubbell, Alice Walker, Leslie Silko, Diane Ackerman, and others in order to study how their "postmodern pastoral" is a vision "informed by ecological and feminist theories, and . . . that images human/nature relationships as 'conversations' between knowing subjects" (quoted in Warren 229).

Putting it bluntly, Legler suggests that ecofeminists today might take one of two tacks: bashing the likes of Melville and Hawthorne as perpetuators of a colonialist approach to nature or marveling at the subversive strategies of Silko and Dillard. Her assumption seems to be that the nineteenth-century male writers will inevitably "get it wrong" in their representation of nature as a feminine category to be transcended, while the late twentieth-century female writers will "get it right." My approach is to ignore these polarized positions and stake out a third possibility in examining the work of a woman writer for whom gender alone is not, as we have seen, an easy means of identification with others—for whom a hard work ethic was a more important means of identification—in order to see where she fits into the vast gulf between Melville and Dillard, in order to investigate how her novel might be read as a precursor to ecofeminist paradigms.

An Ecofeminist Reading of *Come and Get It*

Let us return to Ferber's novel. That Barney Glasgow has a nakedly exploitative relationship to the land and to women is evident in the very title of the novel *Come and Get It,* the title of which may be read as a double entendre, conflating the desires for (lumberjack) food, (cheap) land, and (extramarital) sex. In fact, at one point, Katie warns the lovely Lotta to be suspicious about the extent of Mr. Glasgow's attentions to her. Her exact words to Lotta—"A girl looks the way you do men just think they can come along and help themselves" (177)—underscore this connection between appetite for food and appetite for sex. Barney's lust to wring profit from the land and his lust to consummate his relationship with the lovely granddaughter of his best friend are clearly equated: he feels he is entitled to both, and his sense of self-restraint towards Lotta is slowly weakening at the point when he is suddenly killed off in the narrative.

Moreover, although his son recognizes the importance of replanting new trees for future generations to harvest, Barney—in his infinite stubbornness and shortsightedness—refuses to do so. Then again, he also lacks the vision to see that his son's plans of inventing paper cups and paper towels for bathrooms are viable economic ventures. So Ferber suggests that Barney's tense and competitive relationship with his son prevents him from perceiving where his future economic success lies. Barney's son Bernie, though not well-developed as a character, represents a kind of progress over his father in the sense that he is more rational, more far-sighted, more genuinely devoted to his wife, and also—interestingly—slightly more androgynous. Bernie never needs to desire a mistress because he is married to the most desirable woman he knows, nor is he a Lydgate character freighted with a gorgeous but insipid wife who cannot understand his ambitions. It is as if Ferber grudgingly rewards him for being more restrained and far-seeing than his father, even though she is not as compelled by him as a character.

In addition to these larger plot contours which indicate Ferber's making a connection between Barney's unbridled desire to harvest as many trees as possible and to possess Lotta, there are at least four identifiable passages from the text which become illuminated by an ecofeminist reading. In these passages, Ferber covers a gamut of attitudes towards women and the environment. Women like the horse-faced Emma Louise are identified as stifling agents of civilization; their association is with smothering domestic interiors which drive Barney to seek the freedom of the almost masculine northern woods. At the same time, insofar as beautiful young women like Lotta are represented as vulnerable, consumable commodities, they are identified with those elements of nature which are, to Barney's way of thinking, "tailor-made" for raping: that is, the forests of pine trees which furnish Barney with lumber. Women also furnish Barney with cheap labor for his rag-paper mills, and they satisfy male appetites—while suppressing their own—in two ways: by feeding the lumberjacks, as Barney's mother does, and by offering men like Barney fantasies of sexual availability and a renewal of youthful vigor, as Lotta does.

Consider the first passage, which occurs relatively early in the novel:

> If the thick, rich routine of the well-ordered household and the feminine possessiveness of Emma Louise and Evelyn threatened to smother [Barney] completely, he escaped to the northern woods whence he had come, and in that pine-laden atmosphere found healing. (12)

Here, manipulative women like Emma Louise are identified as stifling agents of civilization, threatening to smother Barney, virtually forcing him into the healing arms of his mistress, the great outdoors. This theme of Barney's need to escape is developed in the novel: whenever Barney feels oppressed by Emma Louise within the domestic sphere of his home in Butte des Morts, he retreats up north to Iron Ridge, a small camp devoid of the comforts of home but also mercifully devoid of the entrapments and social restrictions imposed by the likes of Emma Louise. Barney feels he can be himself, be authentic, eat simple lumberjack fare, and be bawdy while he is in Iron Ridge. Barney's retreats to Iron Ridge prefigure and foreshadow his illicit desire to make Lotte Lindberg his mistress.

In the second passage, Barney surveys the "Polish and Bohemian" women working in the rag-paper mill:

> Barney had always hated the rag-paper mill over at Grand Chute . . . The rag mill made the finest grade of writing paper obtainable—much superior in texture and quality to the wood-pulp paper manufactured in this Butte des Morts mill. Barney almost never visited it, and only from necessity. He hated the rags piled mountain high; he loathed the rag sorting room with its cloud of dust and lint whirling up from the sorting bins over which the girls bent. They wore pieces of gauze tied across their faces, futilely, to shield mouths and noses. They coughed, and their complexion was a curious clay gray. Polish and Bohemian, most of them, they lived the other side of the tracks or over on the Flats. . . Though the odors of the wood-pulp mill were none too ambrosial Barney did not find them offensive. Of the rag mill he said, "It stinks." He seemed to find something peculiarly obnoxious in the smell of the acids that reduced old rags to the least common denominator of white pulp. Even the magic of the process by which a pair of tattered overalls might be transformed into a fragrant love-missive, or an old shirt or pair of ragged muslin drawers might, Cinderella-like, emerge as a delicately tinted invitation to a ball, did not interest Barney. He liked the process of the wood-pulp mill. Great flat cars out in the yards, loaded with fourteen-foot hemlock spruce, balsam and jack pine, pungent, redolent of the north. (35)

Although the rag paper mill "made the finest grade of writing paper obtainable," Barney rarely visits it. Although the wood pulp mill sends forth fumes every bit as malodorous as those of the rag-paper mill, it is only the latter's fumes that Barney finds offensive. Why the discrepancy between Barney's reaction to the rag-paper mill and the wood pulp mill? Ferber suggests that on some level Barney realizes that his female workers are suffering from their exposures to the chemicals, and he can hardly stand to witness their daily sacrifices of their health for economic survival. Ferber also suggests that perhaps there is something distressingly "feminine" about the rags—a scrounged, found, endlessly folded, and molten set of materials that originate in domestic interiors and that are less "masculine" than the solid, imposing slabs of "fourteen-foot hemlock spruce" found at the wood pulp mills. Lest we miss Ferber's proto-ecofeminist critique, her narrator even imagines how one might more positively view the processing of the rags as a kind of transformative, fairy-tale process by which "an old shirt or pair of ragged muslin drawers might, Cinderella-like, emerge as a delicately tinted invitation to a ball." That allusion to Cinderella underscores the pathetic economic realities of the women who work in Barney's rag-paper mills and the extent to which they perhaps fantasize about the only possible means of escaping their drudgery. Barney is not so much oblivious to their plight as he is sub-consciously shamed by it, hence, his avoidance of the rag-paper mills.

Consider how Ferber rather heavy-handedly underscores the theme of Barney's patriarchal power in this third passage:

> [Barney] was a great grand duke riding toward his duchy—forests, streams, villages. Fish, deer, birds. He liked to survey largely his holdings—his mills, his lands, his crops, his timber, his employees, their families, keeping a firm possessive hand on all. A Goth turned patriarch, but not yet ready to enjoy the benefits of his ravishments. He never looked on his vast possession as an empire, though it was that. To him it was just so many tons of this, acres of that, pounds or square miles or cords of the other. A tree was potential pulp to him, a river something on which to float boats or drive logs. A hill was a rise of ground which might conceal ore, a free waterfall was unharnessed machine power. (66)

Again, this passage most forcefully exemplifies the extent to which we are invited to see Barney as the dominating and dehumanizing patriarch who equates his workers with the stuff of nature—regarding them all in a proprietary light as his possessions, as his subjects, as fodder for his profit, regardless of the short-sightedness of his schemes. The allusion to the Goths, Teutonic peoples who invaded and settled in parts of the Roman Empire in the third to fifth centuries, establishes Barney's transition from invader to settler to patriarch. "Ravishments" nicely concretizes the connection Ferber wishes us to draw between Barney's actual rape of the land and his unrealized desire to rape/seduce young Lotta Lindbeck.

Finally, in the fourth passage, we are treated to an image of woman as provider of the food that she not only cannot enjoy but that sickens her:

> [Barney's mother Nellie] did man's work . . . The great gross mounds of food which daily she provided for the voracious men sickened her. She ate nothing, finally, but a crust of bread and cup after cup of scalding black tea. (84)

Woman is handmaiden to lumber mill productivity though she is alienated from her work; woman is untempted by the highly desired fruits of her labor. That Barney's mother dies of consumption is one of the more interesting ironies in the early parts of this novel; it suggests that what kills her is some self-destructive element as if she has been starved for so long that her body begins to consume itself. Barney never consciously makes the connection between the premature death of his own mother and the short lifespans of the girls working in his rag-paper mill over at Grand Chute—although perhaps he makes it unconsciously, and this is part of his aversion to the rag-paper mill—but we as readers are encouraged to see that he is unconsciously perpetuating a cycle in which poor women are ground up and spit out as they provide cheap labor and profits for the likes of Barney Glasgow.

As in the fiction of her Victorian literary predecessors (and I am thinking more of Charlotte Bronte than of George Eliot now), women are identified with the provision of food for male appetites, but Ferber, unlike her Victorian predecessors, makes a critical distinction between the older female "martyrs" and the younger, more androgynous, more "selfish" females. While the older women in the novel (like Barney's mother and then like Barney's wife) provide ample feasts for the menfolk, they themselves abstain from eating much at all. Barney's wife Emma Louise, though "by nature a stingy woman," "set a lavish table at Barney's insistence" while "sipping coffee and nibbling dry toast" (15). And, as I just noted, Barney's mother, a cook in a lumberjack camp, slowly dies of consumption. But if one is tempted to conclude that Ferber believes that female desire must always be kept in check while male desire runs rampant, one must qualify this generalization by noting that Ferber depicts younger women like Evelyn and Lotta devouring, without restraint, both food and fortunes. Both Evelyn and Lotta have healthy appetites for food and sex—Evelyn committing adultery with her Italian worker on the eve of her wedding, and Lotta doing whatever is necessary to consolidate her social position.

Ferber's Feminism

Just what kind of a feminist is Ferber? Ferber is like George Eliot in being hard to assimilate comfortably under the category of feminist. Both Eliot and Ferber led lives working in a male-dominated profession, but if one examines their novels, one finds that they do not necessarily provide for their heroines the same sort of pathbreaking boldness that they themselves enjoyed. If Eliot's female protagonists are systematically denied the opportunities to fulfill themselves in some sort of meaningful work (their very paucity of options eliciting our sympathies), Ferber's female protagonists in *Come and Get It* take upon themselves the full-time "work" of trying to manipulate wealthy and powerful men. Unlike Eliot, who attempts to penetrate the opacity of even the self-centered Hetty Sorrels and Rosamond de Vincys in her narrative worlds, Ferber invariably caricatures and condemns such female characters who attempt to eschew hard work by playing upon their feminine wiles; her sympathies are always with the under-appreciated working class women (the nannies, the waitresses) who serve such entitled women. Class privilege, then, becomes the dividing line across which Ferber's sympathies cannot pass—unless, that is, the female who inherits such privilege still takes solace in the stabilizing effects of hard work.

Yet as I mentioned earlier, Ferber herself was an unusually outspoken woman and perhaps slightly ahead of her time, insofar as she was able to succeed in a man's world. In one of her autobiographies, she writes: "If men ever discover how tough women actually are they'll be scared to death. And if women ever decide to throw away that mask, wig and ruffled kimono and be themselves, this will be another [female-dominated] monarchy—and perhaps it's about time" (quoted in Gilbert 82). In *Come and Get It,* she is somewhat interested in depicting power struggles between the sexes, and she is sympathetic to smart women who are deprived of the opportunity to make the best use of their talents in the work force. For example, at one point her narrator expresses sympathy for Barney's daughter Evelyn, who is smart enough to run a paper mill but is forced by social convention into marrying a man she does not love: "Born out of her day she could, ten years later, have run one of her father's mills; driven an ambulance in France; started a career of her own choosing. And now Evelyn was to be married" (21). Ferber also represents sympathetically the hard-working, plain Karie Lindbeck because Karie never loses her down-to-earth self, even among the crowned heads of Europe, and because Karie remains with her social-climbing daughter despite the fact that she "work[s] harder than any servant you got, only I don't get paid for it" (431).

Still, it is perhaps a bit wishful for us to call Ferber a feminist or even a proto-feminist. While a woman writer like George Eliot might be willing to soften her judgment towards those beautiful female characters who end up doing great harm to themselves and others, Ferber has little patience for those beauties like Lotta who trade on their looks in order to advance themselves up the social ladder. Given the premium she puts on the value of hard work, it is entirely understandable that she resent those who need do no work other than apply make-up and then go out and seduce lumber barons. However, one cannot help but wonder—politically incorrectly, of course—if her being the plain sister of a beautiful woman might not have played a role in Ferber's scathing contempt for the opportunistic blond bombshell Lotta. Then again, Ferber never makes any effort to represent sympathetically the bourgeois, horse-faced wife of Barney Glasgow either. Indeed, the narrator seems just as judgmental of Emma Louise as Barney is: "It was incredible that any woman—even a plain woman of 56 who has been married years before for her money, and knows it—could be so utterly lacking in coquetry as to appear before a man in such grim habiliments" (10). Disappointingly, there are no moments in the narrative when Ferber's narrator attempts to enter into the consciousness of Emma Louise, never attempts to imagine what it might feel like to be a homely woman married for one's money. Perhaps the topic was a little too close to home for Ferber, who was—again, like George Eliot—widely regarded as a plain, hard-featured woman.

Conclusions

Would it be fair to call Ferber an early ecofeminist? At times, she seems like one, especially when she writes such lines as "A tree was potential pulp to [Barney], a river something on which to float boats or drive logs. A hill was a rise of ground which might conceal ore, a free waterfall was unharnessed machine power" (66). Although he prides himself on exercising great self-restraint when he does not actually rape Lotta, Barney is equally exploitative of both women and nature: in Karie's words, he thinks he can "come along and help [himself]" to a portion of forest and Lotta. As I have also noted, the title "Come and Get It" reflects not just the call to meal time[2] but Barney's greed in acquiring land cheap from the government in order to rape it of its trees. And the "it" in "Come and Get It" takes on clearly sexual undertones when Barney contemplates the seduction of Lotta.

In her developing of the character Barney Glasgow as a power-hungry, dominating, greedy, ruthless, opportunistic, and wasteful patriarch, Ferber certainly seems to be advancing a proto-ecofeminist critique. Barney is a patriarch tailor-made for an ecofeminist critique, although, to be fair, he also provides the novel with its most vital energies: Ferber realized that as an artist she sacrificed the aesthetic design of her novel when she killed him prematurely.

However, and this is why I feel I must qualify my stance by acknowledging that one is only "tempted" to pronounce her a proto-ecofeminist, Ferber never really sustains a pro-woman or pro-environment stance for very long. Perhaps for all her bravado and swagger in her diaries and autobiography, she sensed in this novel that she was engaging in a kind of cultural critique that was, like Evelyn Glasgow, about fifty years ahead of its time. I suspect she had some reservations about making the truly scathing and sustained challenge to patriarchal authority that she could have made if she were, say, Margaret Atwood.

Finally, the novel is not about progressive ideology so much as it is about the sustaining quality of certain values, an ideological stance of a more traditional sort. Women and men who work hard and never lose their appreciation for the moral value of hard work fare best in this novel. Beautiful women who expect their looks to work for them are ostracized and unhappy; successful men who have stopped working with their hands die prematurely. The message is clear: those who continue to work hard, to endure privation, to avoid being seduced by the trappings of material success into becoming what they are not are those who thrive and live to be 85. If there are seeds of a proto-ecofeminist sensibility in the work of Edna Ferber, they remain intact and identifiable but in a largely dormant state.

Endnotes

[1]Interestingly, in the movie version of the novel, that mistake would not be repeated; director Howard Hawkes insured that Barney would remain alive at the end of the film, unpunished for his sins of lust and greed.

[2]At the end of Hawkes' film based on the novel, Barney sadly witnesses the elopement of Lotta and his son, all the while banging tearfully on a triangle and shouting "Come and get it!" to the guests at his party. It is as if the old man is forced to reconcile himself to his newfound role as passive provider for the appetites of others when his own appetites (for sex, for domination over Lotta) cannot be satisfied. The dinner triangle that he bangs also visually reinforces the idea of a triangulated state of affairs between (failed) father, (successful) son, and the love object (Lotta) whom they both desire.

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Ed L. Avery and Kent Niermeyer

Timing of Spawning and Fry Emergence of Brown Trout in a Central Wisconsin Stream

Abstract *The spawning period and timing of peak fry emergence of brown trout* (Salmo trutta) *were studied during 1995–96 in a 1.2-km reach of a central Wisconsin trout stream. This information was collected to help the Wisconsin Department of Natural Resources determine if a potential for egg and pre-emergent fry mortality from angler wading would exist if a special regulation early trout fishing season (1 March to the first Saturday in May) was established in 1997.*

Weekly reconnaissance of the study area was made to count and identify new trout redds. Free-swimming fry counts were made on a weekly basis in three 20-m subsections. The spawning period spanned 3.2 months (12 October 1995 through 19 January 1996) with peak activity (77% of all redds constructed) occurring between 28 October and 8 December. The median date of spawning was 20 November. Emergence of brown trout fry began the week of 15–22 March 1996, peaked around 25 April, and extended into early May. Residence of eggs and pre-emergent fry in streambed gravels approximated five months equivalent to 636 Centigrade thermal units. A potential for trout egg and pre-emergent fry mortalities due to angler wading would exist if an early trout fishing season were implemented. Comparisons of the 1997 year-class strength of trout with long-term average year-class strength in several wisconsin trout streams did not, however, show any effect of an early trout fishing season implemented in 1997.

In 1995, controversy among members of Wisconsin Trout Unlimited chapters, other nonaffiliated trout anglers, and the Wisconsin Department of Natural Resources (DNR) was initiated by a DNR proposal for a special regulation early trout fishing season that would open on 1 March 1997 and extend to the first Saturday in May when the regular trout fishing season started. The proposed "early season" would apply statewide to inland streams and would be limited to catch-and-release only with artificial lures and barbless hooks. The DNR's proposal was made to fulfill a commitment to the angling public to replace a previous (1975–94) early trout fishing season in eight to ten southwestern counties. That early season was closed due to strong local resentment of excessive use of the resource by anglers from outside this small region of the state. Proponents of the new "early season" argued that it would provide additional recreation for anglers, disperse angling pressure over the entire state, not increase annual harvest, and cause little damage to trout populations. Opposing opinion, however, centered around a study done in Montana that revealed high mortality to brown trout, rainbow trout *(Oncorhynchus mykiss),* and cutthroat trout *(Oncorhynchus clarki)* eggs and pre-emergent fry caused by anglers wading on trout redds (Roberts 1988, Roberts and White 1992). This Montana study suggested a linkage between wading-induced egg and fry mortalities in Nelson Spring Creek, a tributary to the Yellowstone River, and reduced adult populations of cutthroat trout in the Yellowstone River.

Unlike cutthroat trout, which is spring-spawning, the two trout species most common in Wisconsin are brook trout *(Salvelinus fontinalis)* and brown trout, both of which spawn in the fall. Because most fry of brook trout and brown trout are free-swimming in Wisconsin when the regular fishing season opens in May, egg and fry mortalities due to anglers wading on redds had not been an issue. However, the proposed early trout fishing season posed a potential for such wading-related mortalities that would be at least partially dependent upon timing of fry emergence from streambed gravels.

A search of the scientific literature on egg incubation-fry emergence periods of fluvial brook trout and brown trout in Wisconsin yielded few papers. Miller (1970) quantified the fry emergence period of brook trout in Lawrence Creek in central Wisconsin, and Hausle and Coble (1976) contributed additional observations on the incubation period of brook trout eggs in both natural and artificially constructed redds in Lawrence Creek. Avery (1980) reported observations on brown trout spawning and fry emergence during 1976–78 in Trout Creek in southern Wisconsin. The objective of the present study was to quantify the duration and peak spawning of brown trout as well as the timing of fry emergence in Emmons Creek in central Wisconsin. This information would help the DNR assess potential egg and fry mortality for brown trout from angler wading in the southern half of Wisconsin, where brown trout are the dominant species and where most angling would occur during the proposed early season because of milder weather and ice-free stream conditions.

Study Area

Emmons Creek is typical of many high quality trout streams in central Wisconsin. It originates from 6.5-ha Fountain Lake in Portage County and flows east-northeast 9.7 km before entering the 293-ha Chain O' Lakes in Waupaca County. Numerous springs augment the flow of Emmons Creek throughout its entire length. Gravel substrates are common and provide ample spawning habitat for a wild resident brown trout population that averages 1,740 fish/km (Avery and Hunt 1981). Sand is the dominant substrate. More than half the

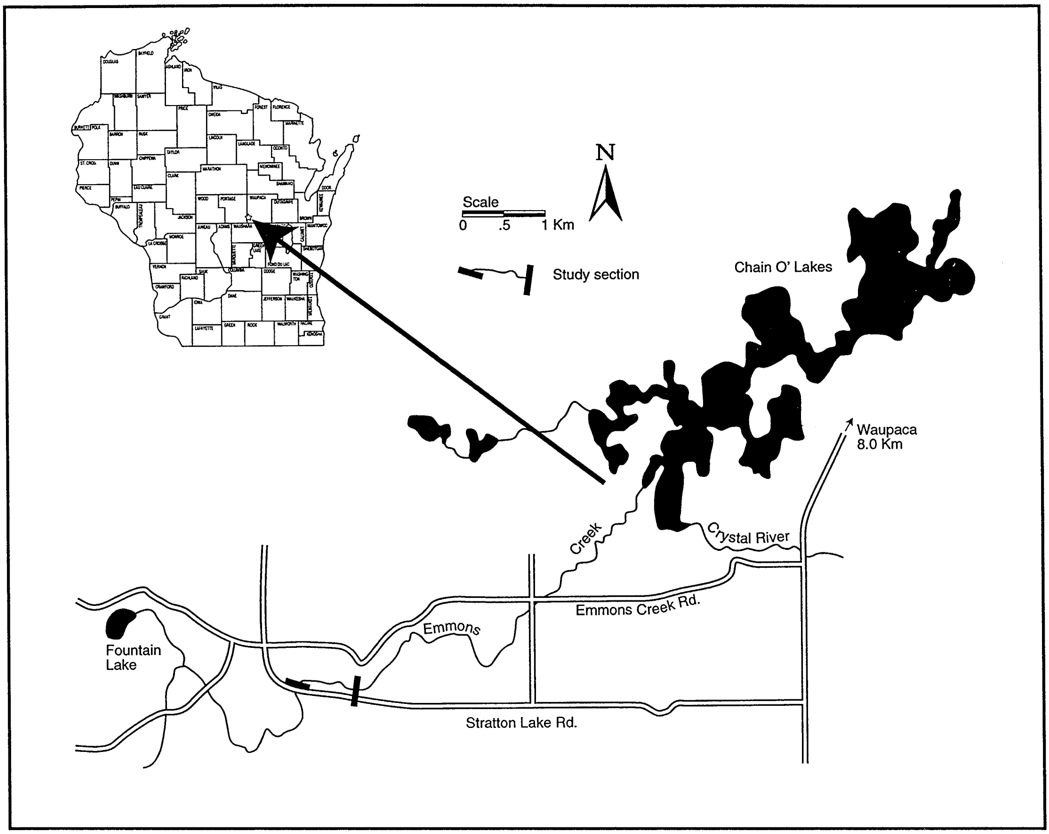

Figure 1. Emmons Creek study area.

stream is in state ownership (public fishing and hunting areas), and little livestock grazing or row-crop agriculture occurs in the watershed. Streamflow is very stable, averaging 0.62 m^3/s. Gradient approximates 2.8 m/km. Stream temperatures rarely exceed 18.5°C, alkalinity ranges from 161–186 mg/l $CaCO_3$, and pH ranges from 7.9–8.2 (Avery and Hunt 1981). Aquatic vegetation is sparse, and the water remains clear except for brief periods following extended heavy rainfall events. The food base for brown trout consists primarily of aquatic and terrestrial invertebrates. Instream habitat is good with undercut banks and woody debris providing important instream cover. In addition to the resident stream population, wild brown trout in the Chain O' Lakes ascend Emmons Creek in the fall to spawn. A 1.2-km reach of Emmons Creek was selected for study in the upper half of the watershed immediately below the Stratton Lake Road bridge (Figure 1).

Materials and Methods

Trout Spawning Period

Weekly reconnaissance of the 1.2-km study area was made between 3 October 1995 and 26 January 1996 to count brown trout redds and determine the spawning period. Each redd identified was numbered consecutively, and the date was recorded. Distance from the "pit" of each redd (Reiser and Wesche 1977) was triangulated (measured) to two numbered wooden stakes driven into the nearest streambank. The two stakes were placed parallel to the streamflow and separated by 3.0–4.5 m. Frequently, from three to six redds were triangulated to the same two stakes. Triangulation of individual redds prevented recounting of previous redds on subsequent visits to the stream and helped determine the occurrence and amount of redd superimposition.

Egg Incubation and Fry Emergence Period

In late January 1996, 20-m stream segments were selected in the upper, middle, and lower reaches of the 1.2-km study area in which trout fry could be visually counted along both stream margins. Stream segments were selected below concentrations of trout redds that had been constructed throughout the entire spawning period. Fry counts were made weekly between 8 February and 25 April. We carefully entered the stream below each study segment and waded slowly up the middle of either the right or left half of the stream, tallying all fry seen within the study segment. Fry were counted in water depths less than 30 cm. This generally excluded the stream thalweg due to its greater depth, higher water velocities, and attendant poor fry visibility. We exited the stream above the study segment, returned to the lower end, and repeated the procedure in the other half of the stream. All fry counts were made between 11:00 and 13:30 hours with the aid of polarized sunglasses. Fry counts were discontinued with the 25 April count because on 3 May fry sought cover so quickly at my approach that an accurate count was impossible.

Stream margins of two of the three 20-m segments were electrofished using a battery-powered, pulsed, dc back-pack electrofishing unit on 15 March 1996 to verify the presence or absence of fry. Similar to the fry counts, electrofishing was conducted in water depths less than 30 cm and excluded the thalweg. Stream margins of all three 20-m segments were electrofished on 19 April 1996 to compare numbers of fry captured with numbers of fry counted.

On 19 April 1996, five redds constructed during the first half of the spawning season were excavated to observe the degree of egg and pre-emergent fry development and to correlate development with the date of redd construction and counts of free-swimming fry. Three additional redds, constructed during the six-week peak spawning period, were excavated on 26 April, and five redds, constructed near the end of the peak spawning period, were excavated on 3 May for the same purposes. A piece of window screen attached to a wooden frame hinged vertically in the middle (effective height and width, 105 x 125 cm) was held downstream from the redds to catch eggs and fry dislodged as the redds were dug up with a shovel. Eggs and pre-emergent fry impinged on the screen were removed either manually with forceps or orally with a plastic suction tube (9.0 mm inside diameter), placed in a container, and counted.

Water temperature was recorded near the lower end of the study area from 29 September 1995 through 17 May 1996 using a RTM 2000 thermograph (Ryan Instruments, Inc., Redmond, Washington) programmed to record hourly. Mean daily water temperatures (MDT) were computed from the hourly readings. Incubation and hatching periods are expressed in terms of both time and accumulative Centigrade thermal units. Centigrade thermal units were calculated as the sum of mean daily water temperatures above 0°C.

Results

The Spawning Period

The spawning period for brown trout in Emmons Creek covered approximately 3.2 months, beginning 12 October 1995 and ending 19 January 1996 (Figure 2; Table 1). During this period, 162 trout redds were constructed in the study area. Peak spawning activity occurred during the six-week period of 28 October through 8 December 1995 when 77% (124) of the identified redds were constructed. The median date of spawning (i.e., the date on which 50% of the redds had been constructed) was 20 November. Spawning began when MDTs dropped below 12.7°C and increased substantially in early November when MDTs dropped below 9.0°C. Mean daily water temperatures during the peak spawning period declined from 8.8°C to 0.6°C.

Approximately 27% (44) of trout redds were at least partially superimposed upon redds constructed from one to six weeks prior (Table 1). Of the superimposed redds, 48% (21) occurred on redds constructed the previous week. Some of the latter redds may have been incomplete when first observed, i.e., part of a multiple-pit spawning site constructed by the same female (Hawke 1978, DeVries 1997), rather than new redds constructed by totally different fish. Peak superimposition, 33 of 44 superimposed redds, occurred during the six-week peak spawning period.

Egg Incubation and Fry Emergence Period

Emergence of brown trout fry from gravel substrates began in mid- to late-March 1996 and peaked during late April (Table 2). Fry were first observed along the stream margins in two of the three reference

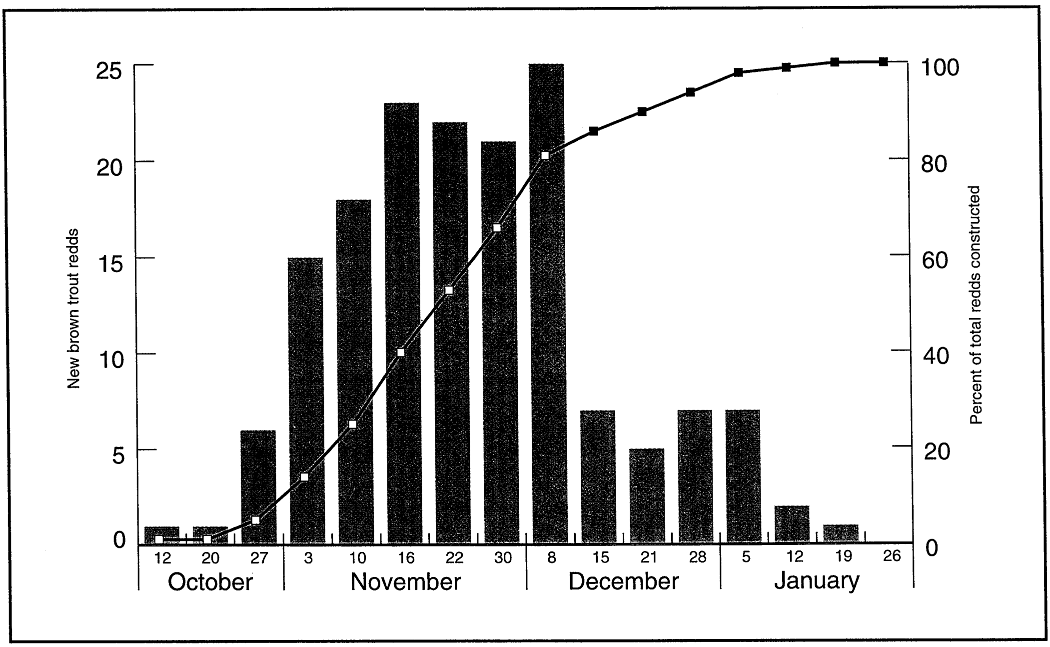

Figure 2. Chronology of brown trout spawning in Emmons Creek, fall/winter 1995–96.

Table 1. Weekly brown trout redd counts, range of mean daily water temperatures (MDT), and accumulative Centigrade thermal units (TU) in Emmons Creek from 10/12/95 through 1/26/96 (superimposed redds in parentheses).

Date	Number of New Redds	Accumulative Redd Total	MDT Range C	Accumulative TU's
1995				
10/12	1	1	9.8-12.7	29[a]
10/20	1	2	8.2-10.6	107
10/27	6 (1)	8	7.5- 9.0	164
11/03	15 (1)	23	4.8- 8.8	212
11/10	18 (6)	41	2.9- 6.2	244
11/16	23 (7)	64	3.2- 4.9	267
11/22	22 (6)	86	1.6- 5.1	291
11/30	21 (4)	107	1.7- 4.4	313
12/08	25 (9)	132	0.6- 5.0	338
12/15	7 (2)	139	0.0- 3.3	346
12/21	6 (3)	145	1.7- 3.8	363
12/28	7 (3)	152	0.9- 3.9	380
1996				
1/05	7 (2)	159	1.4- 4.6	403
1/12	2	161	1.3- 4.8	423
1/19	1	162	1.1- 5.0	451
1/25	0	162	1.0- 4.2	468

[a] Computed from 10/10/95.

Table 2. Weekly brown trout fry counts, range of mean daily water temperatures (MDT), and accumulative Centigrade thermal units (TU) in Emmons Creek from 2/02/96 through 5/03/96 (fry captured with electrofishing gear in parentheses).

	Brown Trout Fry Counted					
	Station Number					
Date	1	2	3	Total	MDT Range C	Acc. TU's
1996						
2/02	0	0	0	0	0.1- 2.4	477[a]
2/08	0	0	0	0	0.2- 5.7	493
2/15	0	0	0	0	2.9- 5.7	525
2/22	0	0	0	0	2.4- 5.6	554
2/29	0	0	0	0	2.4- 5.8	585
3/08	0	0	0	0	1.7- 4.2	607
3/15	0	0 (0)	0 (0)	0 (0)	3.4- 6.9	646
3/22	8	0	3	11	4.9- 6.0	684
3/29	8	1	1	10	2.7- 6.3	718
4/05	6	0	4	10	5.0- 6.9	759
4/12	5	0	3	8	5.9- 9.7	809
4/19	18 (34)	9 (19)	19 (47)	46 (100)	6.0-11.6	866
4/25	27	15	16	58	9.5-10.7	927
5/03		Fry Not Counted				

[a] Continued from Table 1.

stations on 22 March. The week before, fry were neither observed nor captured with electrofishing gear. Fry observed in late March tended to hold their position along the shallow stream margins at the careful approach of an observer.

On 19 April 1996, 46 fry (0.8 fry/m of stream) were observed in the three stations and represented a four- to six-fold increase from fry numbers observed during each of the four previous weekly counts (Table 2). Electrofishing also captured 19–47 fry per station and provided a conservative estimate that only 47% of the fry present were being counted. Numbers of fry counted in the three stations peaked at 58 (1.0 fry/m of stream) on 25 April. Many fry observed on 25 April were extremely wary and quickly found cover when they detected the observer.

Eleven of thirteen trout redds constructed before (two redds) or during (eleven redds) the six-week peak spawning period (28 October to 8 December 1995) and excavated on or after 19 April 1996 contained primarily dead eggs or fry, corroborating the emergence of most live fry during the last two weeks of April (Table 3.) The two remaining redds (numbers 12 and 13 in Table 3) were excavated on 3 May 1996 and contained primarily live, pre-emergent fry. Since 30 redds (19% of the total) were constructed subsequent to the peak spawning period (Table 1), fry from these late redds probably emerged even later in May. Peak spawning and peak fry emergence approximated 22 November 1995 and 25 April 1996, respectively; therefore, residence of eggs and pre-emergent fry in streambed gravels approximated five months or an equivalent of 636 Centigrade thermal units (Tables 1 and 2).

Discussion

The spawning period and peak spawning activity of brown trout in Emmons Creek were similar to those observed for brown trout in Trout Creek located in southern Wisconsin but much later than in Minnesota, Michigan, and Ontario streams. Avery (1980) observed brown trout spawning in Trout Creek between 19 October and 12 January during 1976–77 and 1977–78, with peak spawning activity occurring in November through mid-December. Sorensen et al. (1995) observed brown trout spawning in Valley Creek, Minnesota, between 12 October and 22 November 1990–92. During 1976–78, Anderson (1983) observed brown trout spawning from the first week of October through November in six other Minnesota streams with peak spawning occurring between 13 October and 14 November. The spawning season approximated 15 October to 10 November in a Lower Michigan stream during 1969–71 (Hansen 1975), while Witzel and MacCrimmon (1983) observed brown trout spawning between 8 October and 19 November in five southwestern Ontario streams during 1977–78.

Although peak emergence of brown trout fry occurred in late April 1996 in Emmons Creek, peak emergence of brown trout fry in Trout Creek occurred four to six weeks earlier in late February through March 1976–78 (Avery 1980). Mean weekly temperatures in Trout Creek averaged 2.2°C warmer in December 1975 through early January 1976 than for the same period in 1995–96 in Emmons Creek. Thus, while brown trout spawn about the same time in central and southern Wisconsin, warmer water temperatures in southern Wisconsin generally contribute to earlier

Table 3. Brown trout eggs and pre-emergent fry observed in 13 redds excavated in Emmons Creek on 19 and 26 April and 3 May 1996 (TU = accumulative Centigrade thermal unit; DE = dead eggs; D = dead; L = live; S = sac; F = fry).

Redd Number	*Date Observed*	*Date Excavated*	*Days in Streambed*[a]	*Accumulative TU's*[a]	*Eggs/Fry Present*
1 & 2[b]	10/20/95	4/19/96	185	798	130 DE
	10/27/95		178	730	
3	11/10/95	4/19/96	164	638	45 DE
					4 DSF
					17 LSF
4	11/16/95	4/19/96	158	611	79 DE
					8 DSF
					15 LF
5	11/30/95	4/19/96	145	564	108 E
6	11/10/95	4/26/96	171	708	46 DE
					6 DF
					6 LF
7	11/16/95	4/26/96	165	681	30 DE
					16 DSF
					2 LSF
					2 LF
8	12/08/95	4/26/96	144	610	260 DE
					3 DSF
					4 LSF
9	12/08/95	5/03/06	151	670	16 DE
10	12/08/95	5/03/96	151	670	6 DE[c]
11	12/08/95	5/03/96	151	670	1 DE[c]
12	12/08/05	5/03/96	151	670	6 DE
					1 DF
					8 LF
13	12/08/05	5/03/96	151	670	5 DE
					1 DF
					8 LF

[a] Computed from 10/10/95, two days prior to the date the first redd was observed.
[b] Redd number 2 was superimposed on redd number 1.
[c] Thousands of white sucker eggs present.

emergence of brown trout fry than in similar high-quality trout streams in central Wisconsin.

In relation to the proposed early trout fishing season opening 1 March in Wisconsin, the majority of brown trout eggs and pre-emergent fry will still be in the gravel when the fishing season opens. Although brook trout spawn one to three weeks earlier than brown trout (Witzel and MacCrimmon 1983, Sorensen et al. 1995) and in central Wisconsin emerge from instream gravels three to four weeks earlier than brown trout (Miller 1970), some eggs and pre-emergent brook trout fry will also be in the gravel when the early fishing season opens. This study clearly suggests that anglers wading in Wisconsin trout streams during March and April could increase egg and fry mortalities by walking on trout redds. Whether or not such wading mortality occurs, and to what extent such additional mortality (if it occurs) will express itself at the population level, will be directly related to the wading activity of anglers and the recruitment dynamics of trout in each stream.

Tentative Management Conclusions

The special regulation early trout fishing season proposed by the DNR in 1995 was approved by the Natural Resources Board in May 1996 and took effect beginning 1 March 1997. As approved, the early season has a "sunset clause" after three years, at which time DNR fisheries staff will review the pros and cons of the season and recommend changes if any are determined to be needed. Comparisons of the fall 1997 year class strength in several central and southern Wisconsin trout streams with the long-term average year class strength in the same streams failed to show any detectable effect of the early trout fishing season on year class strength (L. Claggett, personal communication 1998).

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Terry Balding

Detections of Red-Shouldered Hawks *(Buteo lineatus)* Using High Volume Tape-Recorded Broadcasts

Abstract *Conspecific tape-recorded broadcasts (N = 196) were used from 1986 to 1989 to evoke 71 detections of the red-shouldered hawk* (Buteo lineatus). *The objective of this study was to determine the effect of decibel (db) level on detections. During 1987–1989 a significantly greater number* (P < *0.05) of red-shouldered hawk detections occurred with a 130 db tape-recorded broadcast when compared to 95 db broadcast. Results suggest that a 130 db tape-recorded broadcast could be used to increase the number of detections of red-shouldered hawks during the courtship and nesting season.*

The U.S. Fish and Wildlife Service (1987) recognizes the red-shouldered hawk *(Buteo lineatus)* as a species of management concern, and the Wisconsin Department of Natural Resources (1991) lists the red-shouldered hawk as a threatened species in Wisconsin. Therefore, it is important to learn more about this species. One method would be to select a permanent survey route, use a tape-recorded broadcast to evoke detections, and then monitor the trend over a period of years.

The red-shouldered hawk in Wisconsin is often associated with heavily wooded flood plain forests (Robbins 1991). In this habitat it usually spends much of its time below the canopy and does not voluntarily vocalize often; consequently it is typically a difficult bird to locate. Johnson et al. (1981) suggested that a broadcast could increase the chances of encountering some species of birds when compared to conventional survey techniques. Conspecific broadcasts have been shown to elicit detections in the red-shouldered hawk (Fuller and Mosher 1981, Balding and Dibble 1984, Fuller and Mosher 1987, Johnson 1989, Mosher et al. 1990, McLeod 1996). Balding and Dibble (1984) reported more detections to conspecific broadcasts than heterospecific hawk broadcasts with red-tailed hawk *(Buteo jamaicensis),* broad-winged hawk *(Buteo platypterus),* and red-shouldered hawk. Great horned owl *(Bubo virginianus)* broadcasts have also been used effectively to produce red-shouldered hawk detections (Iverson 1987, Devaul 1989, Iverson and Fuller 1991, Mosher and Fuller 1996).

Most studies using broadcasts to elicit a raptor detection used a tape player that produced a broadcast volume, measured in decibels (db), of about 100 db (Fuller and Mosher 1987, Devaul 1989, Johnson 1989, Mosher et al. 1990, McLeod 1996). This db level can generally be heard by humans 750 m from the speaker, assuming the human hears well and there are no barriers or background noises (Mosher et al. 1990). Balding and Dibble (1984) suggested that a broadcast with 130 db, which could be heard by humans at 1600 m (pers. obs.), would result in a greater number of detections. However, that work was with three species and did not focus on the red-shouldered hawk. The focus of this study, conducted 1987–1989, was to test whether more stations would have detections using 130 db volume compared to a conventional portable tape-recorder volume (95 db), specifically on red-shouldered hawks, using a conspecific broadcast.

Study Area

Because of the proximity of the Chippewa River in west-central Wisconsin and the occurrence of red-shouldered hawk habitat in the riparian corridor, the lower Chippewa River was established as the study area (Figure 1). A 70 km reach of the Chippewa River from near Rock Falls, Wisconsin, to the confluence with the Mississippi River was used as a transect. Natural landmarks were used to identify twenty-eight permanent broadcast stations along this transect, approximately 2.5 km apart.

Methods

Two surveys were completed each year (1987–1989) between 4–12 April and 5–15 June. These dates were used because by 4–12 April, migrant red-shouldered hawks have passed through the area, and residents are in courtship (Buss and Mattison 1955). During 5–15 June the birds are with nestlings (Buss and Mattison 1955). The incubation period was avoided because of speculation that study activities might increase the risk of nest predation. Broadcasts were not conducted after the nestling period because they may have generated detections from the fledglings and biased the estimate of the adult population. Surveys began at 0800 hr and were completed the same day around 1600 hr and were only conducted on days with <16 kph wind and no precipitation. Data from April and June surveys were paired by year and analyzed using a paired *t*-test ($\alpha < = 0.05$). Balding and Dibble (1984), using conspecific broadcasts with three *Buteo* species, found when five conspecific broadcasts were given at a broadcast station the majority (93.8%) of the birds were detected during the first three broadcasts. Therefore, in this study only three conspecific broadcasts were used at each station with one-minute intervals between broadcasts to detect red-shouldered hawks either aurally, visually, or both. If a red-shouldered hawk was detected, no further broadcasts were given at that broadcast station. During surveys the speaker was directed toward one shoreline (arbitrarily decided), then the

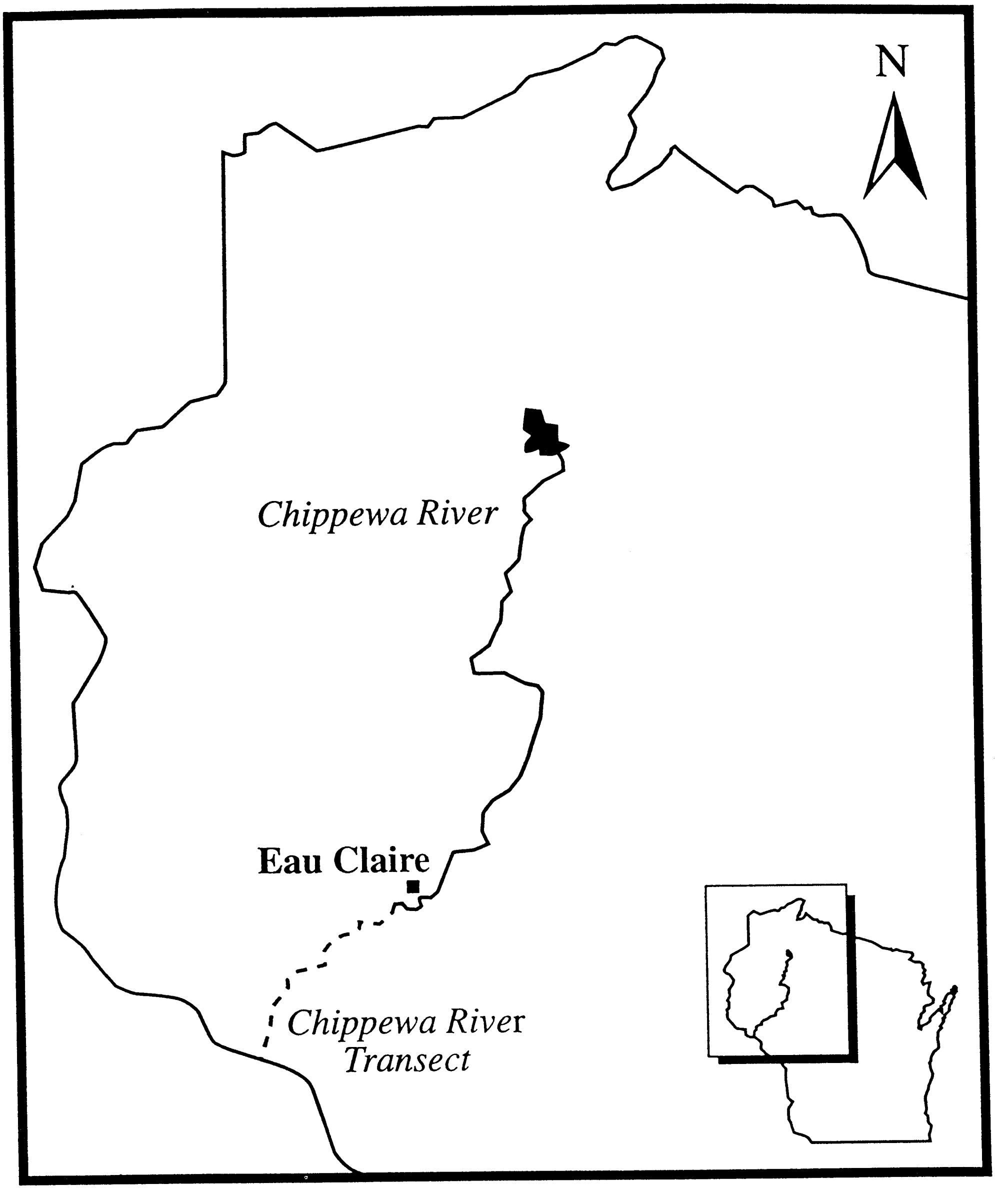

Figure 1. Seventy kilometer transect on the Chippewa River, Wisconsin, for tape-recorded call census of the red-shouldered hawk, 1986–1989.

opposite shoreline, and finally back to the original direction. A boat with an outboard motor was used to carry equipment and move between stations.

At each broadcast station there were two series of three conspecific broadcasts used. The first series of broadcasts used the maximum volume of a Marantz Superscope tape recorder. A Simpson model 886 sound level meter was used to determine that this volume, hereafter referred to as low db, registered 95 db one meter from the speaker. If no response occurred to the first series of low db broadcasts at a station, then a second series of three broadcasts were given, this time using the tape recorder connected to a Sanyo P6060 amplifier and a hand-held Atlas 30-watt speaker. With this combination a broadcast was generated that was 130 db one meter from the speaker, hereafter referred to as high db broadcast. Within years the proportion of detections from high db were paired with the proportion of detections from low db and analyzed using a paired *t*-test ($\alpha < = 0.05$).

The experimental design used (three low then three high db broadcasts at one station) was based on the assumption that detection probability would not increase with the number of broadcasts. This assumption is supported by data from Balding and Dibble (1984), where five sequential high db broadcasts from each station resulted in detections of 38, 26, 28, 2, and 2. Johnson (1989) and McLeod (1996), working with the red-shouldered hawk and using methodology with four conspecific 100 db broadcasts and six conspecific 100–110 db broadcasts, respectively, also observed there was not an increase in birds detected with an increase in the number of broadcasts.

The above design was chosen over visiting the same broadcast station several times and each time randomly choosing three high or three low db broadcasts. Repeated visits to the same broadcast station risk habituation, when animals become non-responsive or less responsive because of repeated exposure to the same stimuli. Johnson et al. (1981) suggested that habituation to repetitive broadcasts may lower detection rates. However, Johnson (1989), Devaul (1990), and Mosher et al. (1990) found little evidence of habituation in the red-shouldered hawk. Additionally, subsequent replications may be broadcast in a different part of the breeding cycle where response rates may be different. McLeod (1996) observed that response rates dropped as the season progressed.

Data collected at each station included date; weather; time of day; broadcast volume; number of birds detected per station; number of broadcasts given before detection; number of vocalizations given per bird; direction from the speaker when the bird was detected; whether the bird was detected aurally, visually, or both; and estimated distance of the broadcast from the detected bird.

The red-shouldered hawk tape recording used in this study was purchased from the Cornell Laboratory of Ornithology and manipulated by University of Wisconsin-Eau Claire media development to consist of three "keeahh's" and four "keeyip's" (Crocoll 1994). Using high db broadcasts, a preliminary survey was completed on 26 June 1986 to determine if red-shouldered hawks were present along the transect.

Results and Discussion

Over all years combined, the 1986 preliminary survey and the 1987–1989 surveys, red-shouldered hawks were detected at 36% (71 of 196) of the broadcast stations. Sixty-seven percent (48 of 71) of the responding red-shouldered hawks vocalized more than twice, 38% (27 of 71) moved closer to the broadcast, and 73% (52 of 71) vocalized but were never seen. Likewise, Johnson (1989) reported 70.6% of red-shouldered hawks vocalized but were not seen. In this study, on only one occasion was a bird detected by visual means but not heard vocalizing. It appears the red-shouldered hawk is more likely to be detected when it vocalizes in response to a broadcast rather than be detected only visually.

Comparison of Detections Between Courtship and Nestling Stage

Using high db broadcasts, there was no significant difference (paired *t*-test = 1.73, N = 3 years, $P > 0.05$) in the number of red-shouldered hawks responding between courtship stage and nestling stage. Therefore, in this study high and low db broadcasts from April and June were pooled within years. Mosher et al. (1990), using 100–110 db broadcasts, also noted no difference between red-shouldered hawk contacts among breeding stages, pre-incubation through post-incubation. However, Johnson (1989) and McLeod (1996), using 100 and 100–110 db respectively, found more detections during courtship.

Effect of Volume

Results from the three survey years (1987–1989) indicate that significantly more detections (paired *t*-test = 4.78, N = 3 years, $P < 0.05$) occurred while using high db (mean = 16.3/year) than with low db broadcasts (mean = 3.0/year). On five occasions birds within an estimated 100 m did not respond to the three initial low db broadcasts, but were subsequently detected during the high db broadcasts. It is not known from what distance the red-shouldered hawk can hear a low db broadcast, but if we assume that the red-shouldered hawk can hear the low db at 100 m, it would appear that it responds to the high db and not the low db, because of greater volume. Anecdotally, it is possible the bird is responding to a loud noise similar to the gobbling response wild turkeys *(Meleagris gallopavo)* have to loud noises (pers. obs.).

All detections resulting from low db broadcasts were from an estimated distance of 400 m or less, while 22 of the 49 detections resulting from high db broadcasts were from an estimated distance of more than 400 m. Probably some detections resulting from the high db broadcast were from birds that may not have heard the three low db broadcasts.

The direction that the speaker was pointed also influenced detections. For the years 1987–1989, significantly more birds (38 of 58; $\chi^2 = 5.59$, $P < 0.05$) responded when the speaker was directed toward them, regardless of whether the broadcast was low or high db. Since, when the speaker is pointed toward the bird, it is louder than when it is pointed away, it may have caused the birds to perceive the call as closer than it really was. Because initial speaker direction was arbitrarily decided, it is possible there was a bias of pointing the speaker in the direction a bird was expected. However, there was no significant ($\chi^2 = 0.71$, $P > 0.05$) relationship between the number of birds detected and the direction the speaker was initially pointed.

These data suggest using a high db broadcast (130 db) red-shouldered hawk tape-recording will result in more red-shouldered hawk detections than with the standard portable tape recorder volume. Further, the data indicate there may be more detections from birds that are very close, as well as from more distant birds.

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A History and Vascular Flora of Mitchell Glen, Green Lake County, Wisconsin

Abstract *Mitchell Glen supports a climax forest "island" that occupies a narrow post-glacial gorge along the Platteville-Galena escarpment three miles southeast of Green Lake in Green Lake County, Wisconsin. Since the time of European settlement in the Green Lake region, circa 1840, and before then by Native Americans, the glen area has been recognized for its high quality natural features and admired for its scenic aesthetic landscape.*

Although a modern-day county flora exists (Eddy 1996), no formal study of the Mitchell Glen flora had been previously undertaken. A total of 234 vascular plants were identified from plant collections obtained during 1997 and 1998, representing 75 families and 177 genera. Voucher specimens are deposited in the University of Wisconsin-Oshkosh Herbarium (OSH).

The known distribution ranges were extended for 23 species previously unreported for the county, including plants with boreal affinities (Eddy 1996). Mitchell Glen's shaded cliffs with cold-air drainage and springs at the base of the gorge render a moist, cool microclimate that sustains certain species more typical of northern Wisconsin.

Oak savanna and tallgrass prairie covered most of the immediate area surrounding Mitchell Glen (Finley 1976). Although most of the prairies and oak openings were placed into cultivation during the latter half of the 1800s, original maple-basswood forest occupies Mitchell Glen and represents the only significant tract of climax woodland in Green Lake County.

The main feature of this report is a catalog of vascular plants, supported by vouchers, that grow in Mitchell Glen, Green Lake County, Wisconsin (Figure 1). Despite its noteworthy geology, prominent topographical features, and apparently rich biological diversity, no systematic collecting or formal study

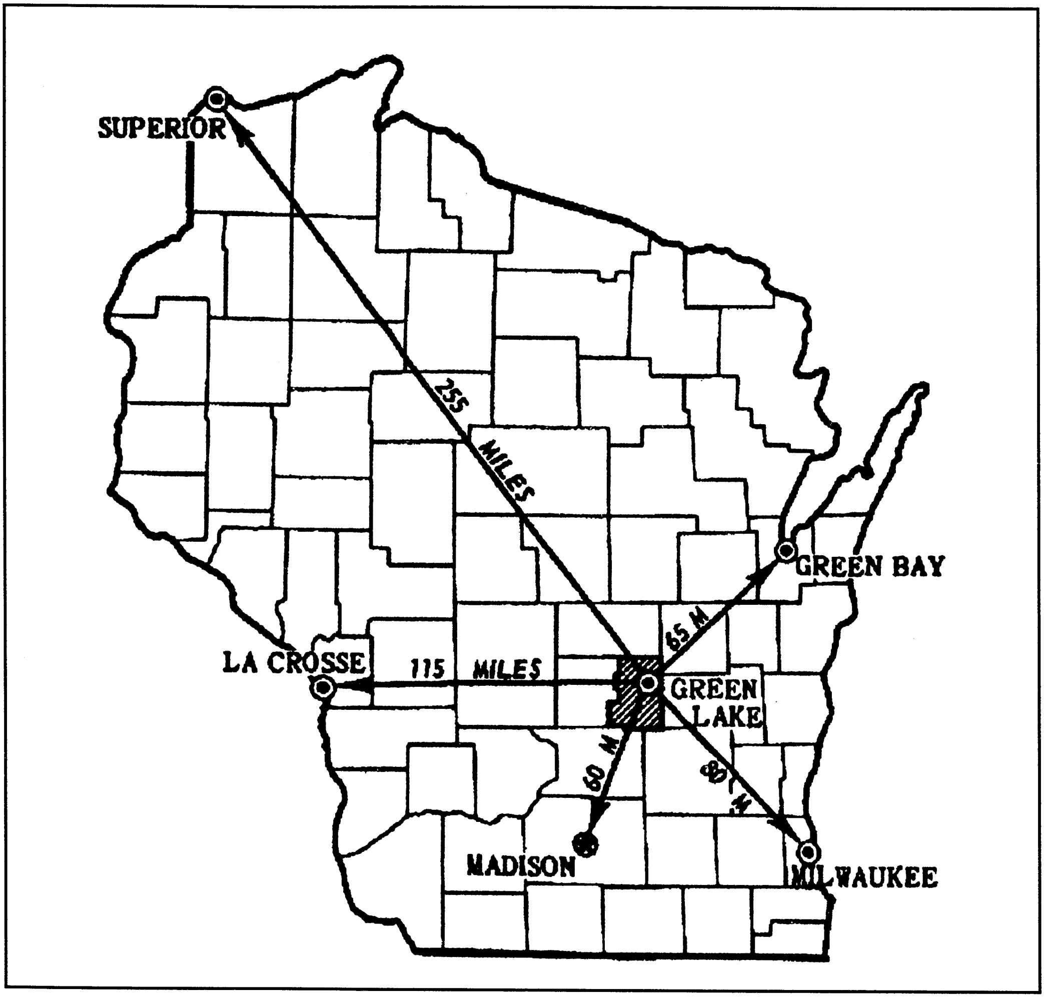

Figure 1. Location of Green Lake County in east central Wisconsin (U.S. Department of Agriculture 1977).

of the Mitchell Glen flora had been previously undertaken. Besides contributing to the broader regional botanical record, the catalog of species serves as a basis of comparison with the flora of the same area in the future and with the flora of similar southern mesic forests in the upper Midwest.

A secondary objective of this study examines the presettlement flora of Mitchell Glen, circa 1834. The names of specific plants, notably trees, and general references to the vegetation that are mentioned in the original land survey records, old letters and books, and earlier studies, specifically reports of Indian antiquities, are used to establish a historical record of the local flora. Along with this evidence an examination of the history of land use in and around Mitchell Glen documents the environmental impact of both natural processes and human-related activities on the glen flora.

During this study the known distribution ranges were extended for 23 species that had been previously unreported for the county

(Eddy 1996). New county records are mainly due to the fact that rich mesic climax woodlands are scarce in the county and until recently have not been closely examined and methodically botanized.

In contrast to the surrounding open uplands, Mitchell Glen's shaded cliff habitat with cold-air drainage and springs at the base of the gorge render a moist, cool microclimate that sustains certain plants with boreal affinities. Among the species more typical of northern Wisconsin but which occur at Mitchell Glen are *Acer spicatum, Aster macrophyllus, Dirca palustris, Diervilla lonicera, Equisetum pratense, Lycopodium lucidulum,* and *Taxus canadensis.*

The oak savannas and tallgrass prairies that once covered most of the immediate area surrounding Mitchell Glen (Finley 1976) were placed into cultivation during the latter half of the 1800s, but original maple-basswood forest survives in Mitchell Glen and represents the only significant tract of climax woodland in Green Lake County. Although the Mitchell Glen flora is comprised of communities representative of the original vegetation cover that include rare species, no state threatened and endangered plants were observed during the study.

Location

Mitchell Glen is located in the town of Brooklyn, Green Lake County, Wisconsin at parallel 43°48'57" north latitude and the meridian 88°54'54" west longitude. It is situated in NW 1/4 SE 1/4 section 35, Township 16 North and Range 13 East (Figure 2). The study area is comprised of approximately 20 acres.

Two state geographical provinces divide Green Lake County roughly in two (Martin 1965). The northwestern half lies on the western edge of the Central Plain and is characterized by gently rolling topography. The southeastern half of the county, which includes Mitchell Glen, is part of the Eastern Ridges and Lowlands and is interrupted by numerous escarpments and valleys.

Nearly all of Green Lake County, including the area surrounding Mitchell Glen, is classified as natural division 5c (Hole and Germain 1994). Characteristic of this natural division is undulating to rolling topography that supports oak savannas and prairie growing on silt loams over calcareous till. Land classified as division 5cp, directly south and east of Mitchell Glen, historically supported extensive prairies.

The county is slightly below Wisconsin's tension zone, a region of transition between Wisconsin's northern hardwood province and the prairie-forest province (Curtis 1959). Although oak savanna is the dominant vegetation cover throughout the county, some species that are more typical north of the tension zone are established here.

In a 1977 report by the East Central Wisconsin Regional Planning Commission, Mitchell Glen was one of two sites in the region (from a list of 10 potential locations) that were recommended for development as a regional park. While there are no current plans for developing such a park at or near Mitchell Glen, the fact that the area was recognized for its unique aesthetic and natural features underscores the high quality natural landscape for which Mitchell Glen is renowned.

Geology, Soils, Water Resources

Mitchell Glen occupies a narrow post-glacial gorge that was eroded by glacial meltwater from the Green Bay Lobe approximately 12,500 years before the present. The upper bedrock is Platteville-Galena dolomite; beneath this is St. Peter sandstone, which forms

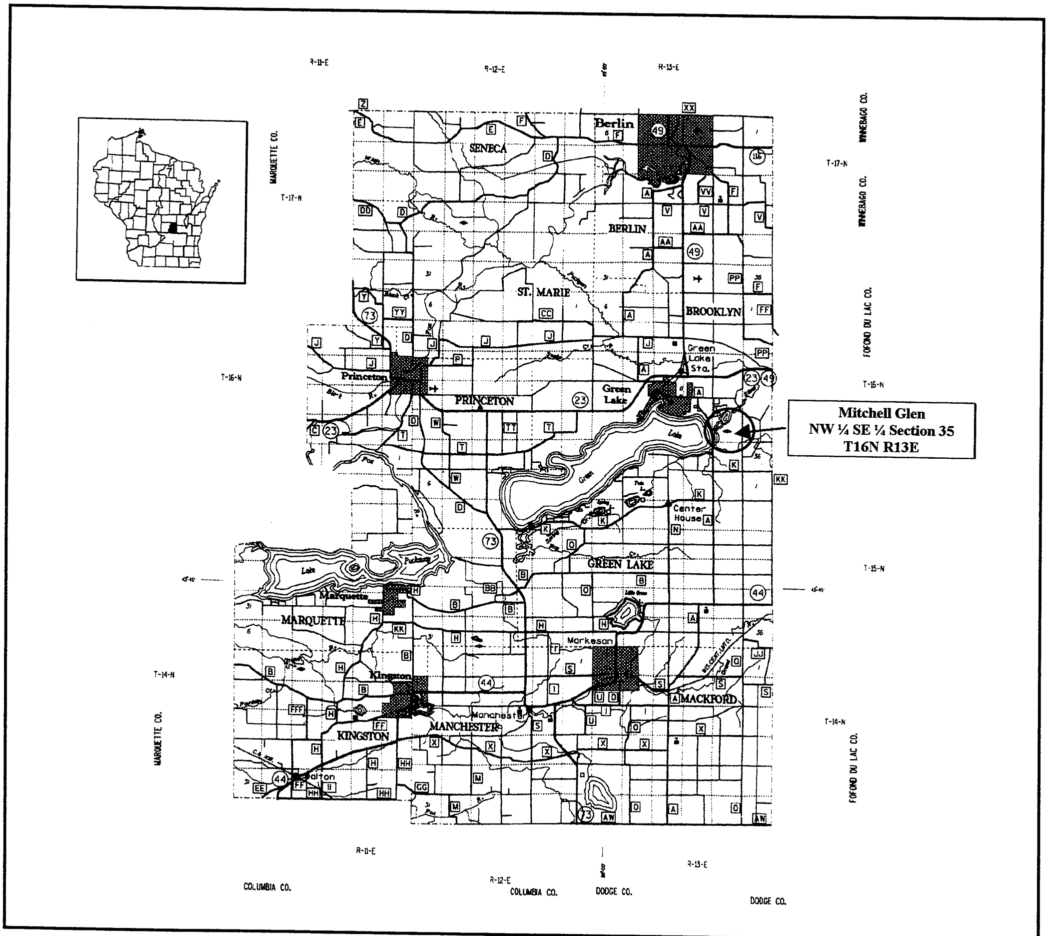

Figure 2. Green Lake County, Wisconsin (Adapted from the Wisconsin Department of Transportation 1988).

the steep-sided walls of the glen. Mitchell Glen, which is approximately 100 ft deep from the floor to the top of the Platteville-Galena escarpment, drains the cultivated uplands that are to the southeast (Figure 3).

Torrential surface runoff that cascades from the crest of the glen empties into Mitchell Glen Creek, a small spring-fed rivulet that begins at the base of the falls. Mitchell Glen Creek is a tributary of Dakin Creek, a minor stream that enters Green Lake's inlet, Silver Creek at NW 1/4 NW 1/4 Section 35, R13E, T16N (Figure 3).

According to the county soil survey (1977), soils of the Kidder-Rotamer-Grellton association that are found at Mitchell Glen vary from moderately well-drained to well-drained loams. The subsoils are mainly of loam, clay loam, and sandy clay loam underlain by calcareous, gravelly sandy loam glacial till.

Three marl pits in the vicinity of Mitchell Glen were excavated in the past and used as a source for "sweetening" acidic soils and as an ingredient for mortar cement and whitewash.

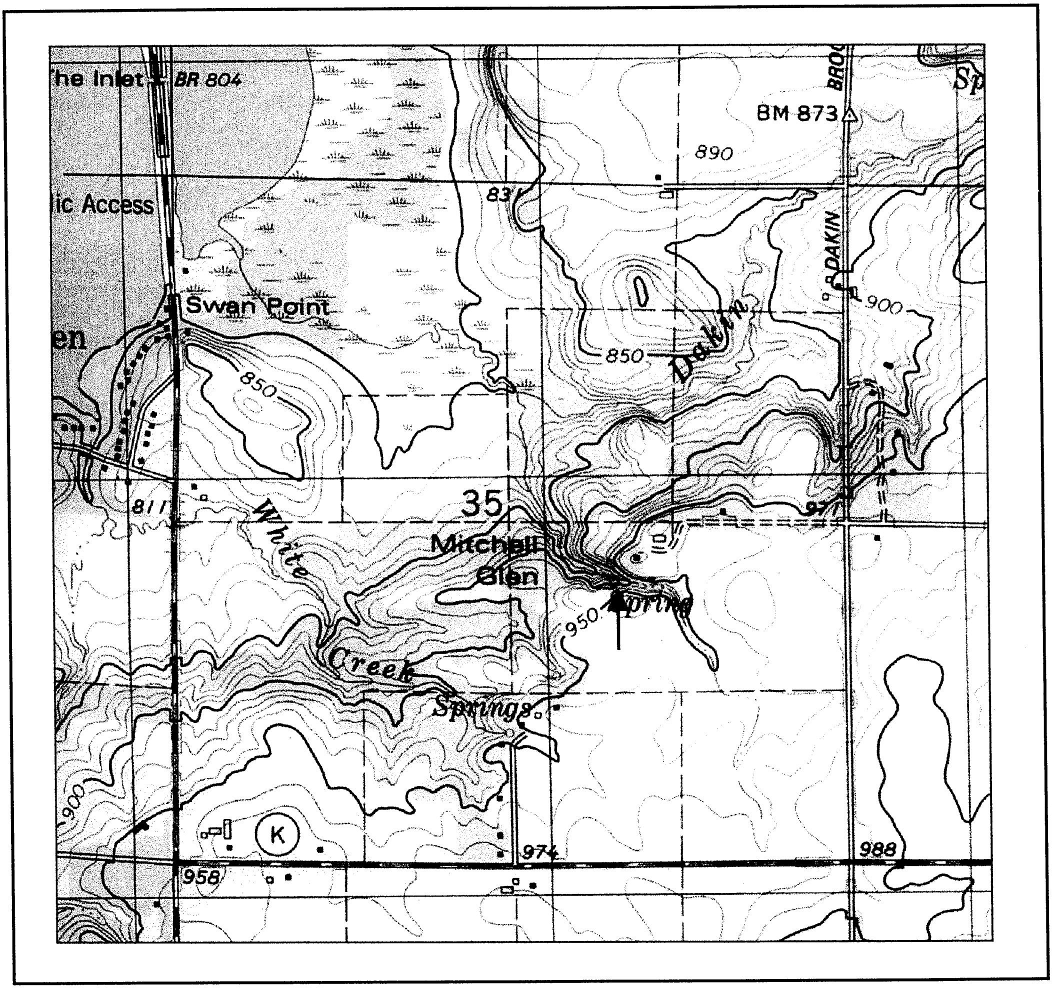

Figure 3. Topographic features of Mitchell Glen and immediate surrounding area. The glen is a post-glacial gorge eroded by glacial meltwater. Note that the elevation at the crest of Mitchell Glen is 950 feet above sea level—the base of the glen is 850 feet. Mitchell Glen Creek (unnamed) begins at the southeast base of the gorge (arrow) and drains into Dakin Creek, a tributary of Silver Creek, Green Lake's inlet (United States Geological Survey 1980).

Original Vegetation Cover

Original Land Survey Records

The original government land survey for the Mitchell Glen area, certified in 1835, contains the most comprehensive record of the vegetation prior to European settlement. The field notes of the surveyors contain references to the vegetation, as well as to specific trees, making it possible to interpret the general vegetation cover for the Mitchell Glen area (Figure 4). Wherever possible, individual trees that intersected section lines were recorded, along with bearing trees that helped identify corners. To supplement and verify entries, surveyors recorded a summary of the vegetation along the section lines and often included sketch maps of each township (Figure 5). When the survey of interior section lines of a township was completed, a general summary of the vegetation for the township was written.

According to the surveyors' field notes, the original vegetation cover of Green Lake County was predominantly oak savanna (Finley 1976) (Figure 6). Oak forest was prevalent throughout much of the county, giving way to wetlands vegetation along the lower Grand River and throughout most of the Fox River Valley and its tributaries. Where the canopy was one-half or more open, surveyors often acknowledged the scattered spacing of trees and recorded the vegetation as oak opening, a transitional community between oak forest and grasslands. Because the field notes fail to consistently mention the spacing between trees, it is possible that areas of what is mapped as oak forest may have actually been oak opening (Finley 1976).

Where the oaks diminished in numbers, notably on the flat uplands in the southeastern townships, the landscape was essentially treeless and covered by tallgrass prairie. In the northern half of T15N R13E the prairie succeeded into oak forest and openings. A short distance farther north, in the southwestern quarter of T16N R13E, where the Platteville-Galena escarpment overlooks Silver Creek, the oak openings abruptly gave way to a small area of sugar maple-basswood forest known as Mitchell Glen. Prior to European settlement the forest may have been spared from periodic conflagrations, due in part to prevailing northwest winds, the presence of wetlands to the north and northwest, which helped to contain the blazes, and the irregular topography that may have acted as a natural firebreak.

Completion of the survey of interior lines for T16N R13E, which includes Mitchell Glen (NW 1/4 SW 1/4 section 35), was certified March 31, 1835, by Deputy Surveyors James H. Mullett and John Mullett (General Land Office 1834). Based upon written summaries of the vegetation along section lines and the marker trees recorded in the original land surveys for quarter section and corner posts, section 35 was bounded by tallgrass prairie on the south and southeast (Figure 7). As the grasslands approached Mitchell Glen they graded into oak openings, which were established up to the rim of the glen. Large tracts of oak opening habitat were reported northeast and southwest of Mitchell Glen, while floodplain forest and other wetlands occupied the lowlands to the northwest.

In short, maple-basswood forest at Mitchell Glen existed then, as now, as an "island" climax woodland. A similar climax forest island, South Woods, occurs three miles northeast along the southeast edge of Ripon. Both tracts of maple-basswood forest are established along the Platteville-Galena escarpment where post-glacial gorges indent the edges of the escarpment.

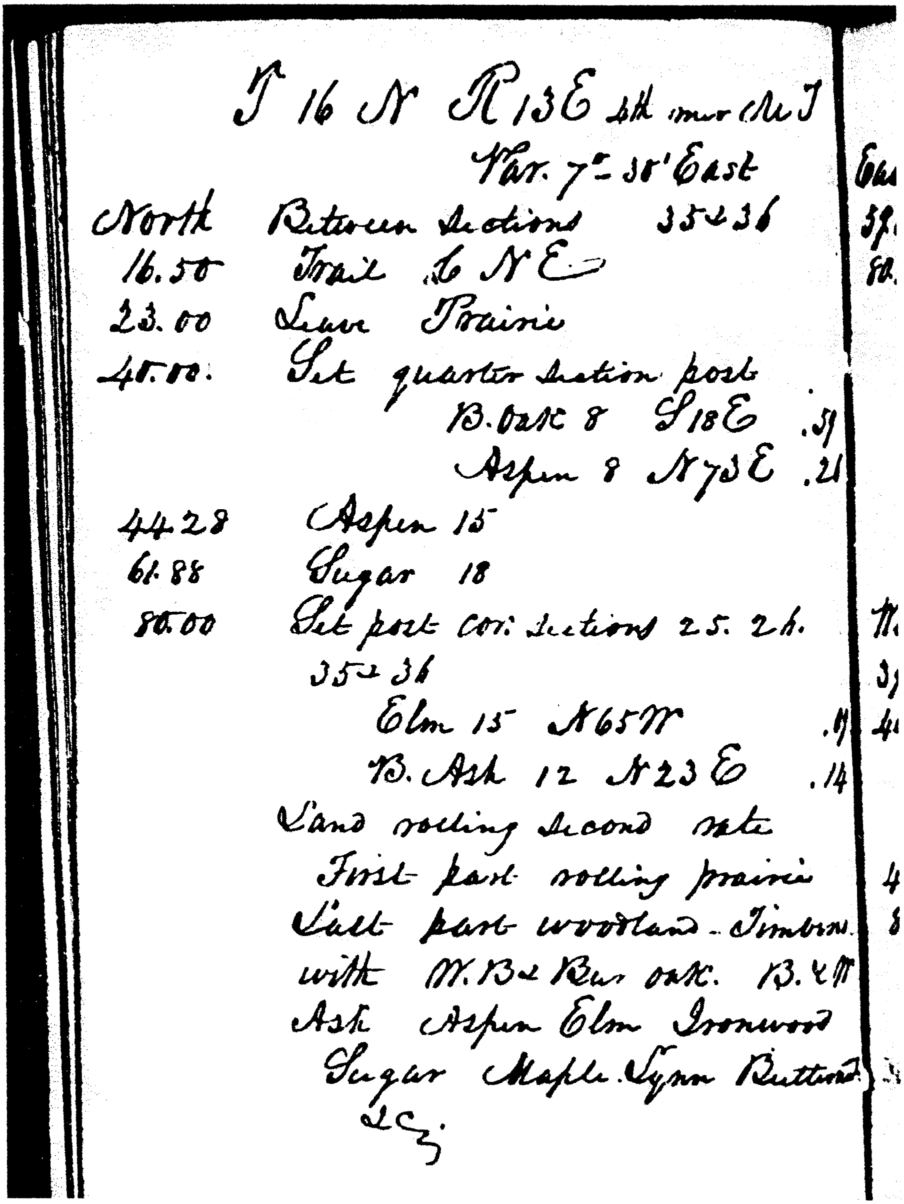

Figure 4. A copied page from the original land survey field notes for T16N R13E. The entry begins by surveying the section line north between sections 35 (Mitchell Glen) and 36. Note the vegetation changes from prairie to oak opening, then to woodland, all within a mile distance (General Land Office 1834).

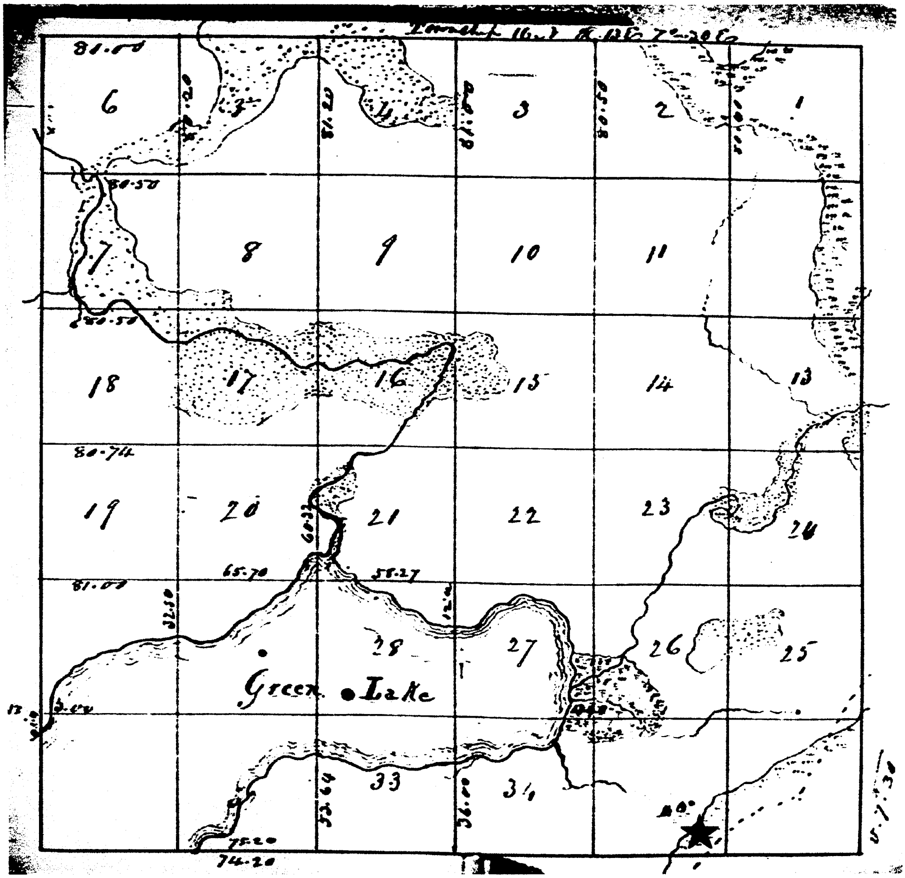

Figure 5. A copy from the original land survey map for "Township No.16 North Range No.13 East in the Territory of Michigan. . . Certified this 31 day of March 1835," showing Mitchell Glen (star), part of present-day Green Lake County, Wisconsin (General Land Office 1834).

Tallgrass prairie is well-documented immediately south and southeast of Mitchell Glen where surveyors "Set post corners Sections 35 and 36 in Mound in Prairie Land High Rolling first Rate." Land along the south section line of section 35 was characterized as ". . . Rolling first rate Prairie and Timbered White Black and Bur Oak." Near here, the field notes refer to a "trail" that occupied the southwest quarter of section 35 and ran diagonally from southwest to northeast of section 36. The trail was originally an Indian trail between Fort Howard, Green Bay and Fort Winnebago, Portage, then later become known as part of the Military Road. Within sections 35 and 36 the trail generally followed the Platteville-Galena escarpment across upland prairies and oak openings.

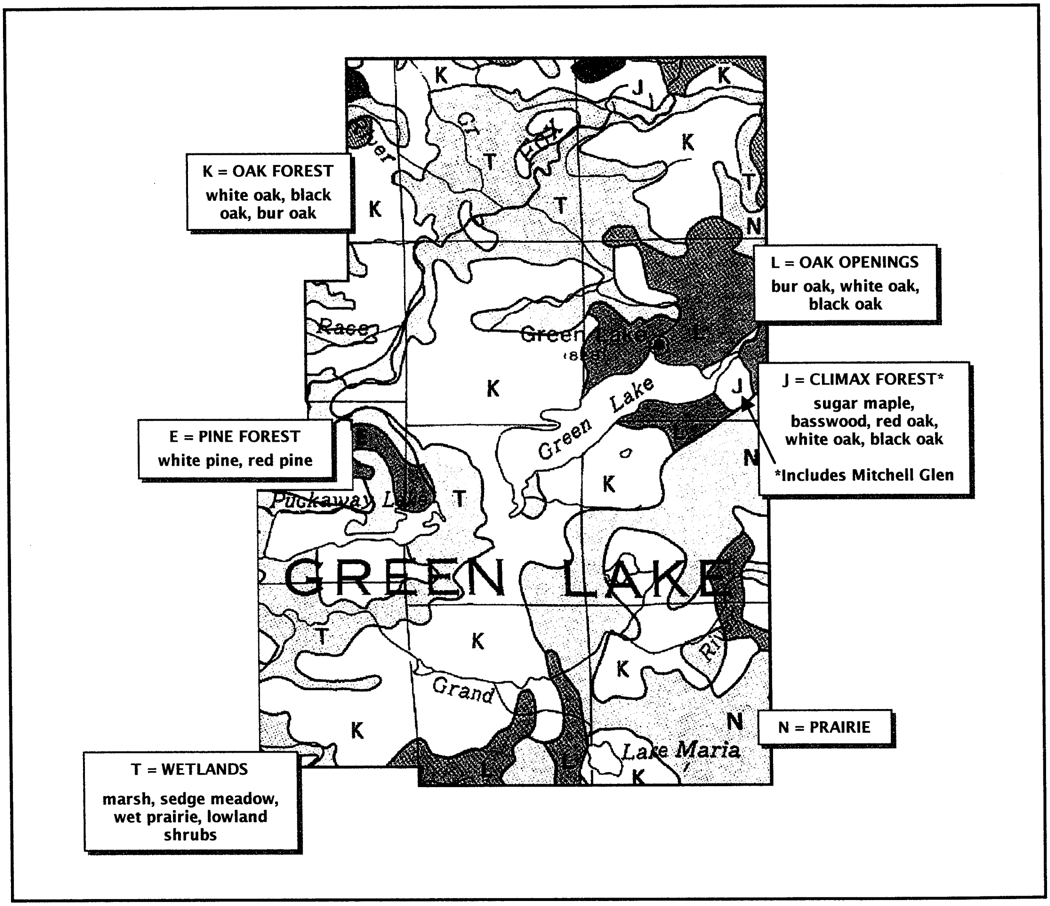

Figure 6. Original vegetation cover of Green Lake County, Wisconsin, circa 1834 (Adapted from Finley 1976).

Surveying north between sections 35 and 36, the land was described as "... rolling second rate First part [southern half] rolling prairie Last part [northern half] woodland—Timbered with W. B & Bur oak [white, black and bur oaks, *Quercus alba, Q. velutina, Q. macrocarpa*]. B. & W Ash [*Fraxinus nigra* and probably green, not white ash, *F. pennsylvanica*] Aspen *[Populus tremuloides]* Elm [*Ulmus* sp.] Ironwood *[Ostrya virginiana]* Sugar Maple *[Acer saccharum]* Lynn [probably linden, i.e., basswood, *Tilia americana*] Butternut *[Juglans cinerea]* etc."

The field notes confirm that oak openings occupied the area between grassland and forest. South of the north corner post between sections 25 and 36 the "... First 20.00 [20 chains or one-quarter mile] Timbered with sugar Maple Lynn [basswood] W & B Ash Ironwood etc. Last part—Thinly timbered with W. B and Bur oak." Following this same section line one mile south (T15N R13E) the field notes state: "Woodland rolling second rate. Scattering W. B & Bur oak Prairie level second rate—Red root *[Ceanothus americanus]* rosin-weed [*Silphium* sp.] rose-willow [*Salix bebbiana*?] etc."

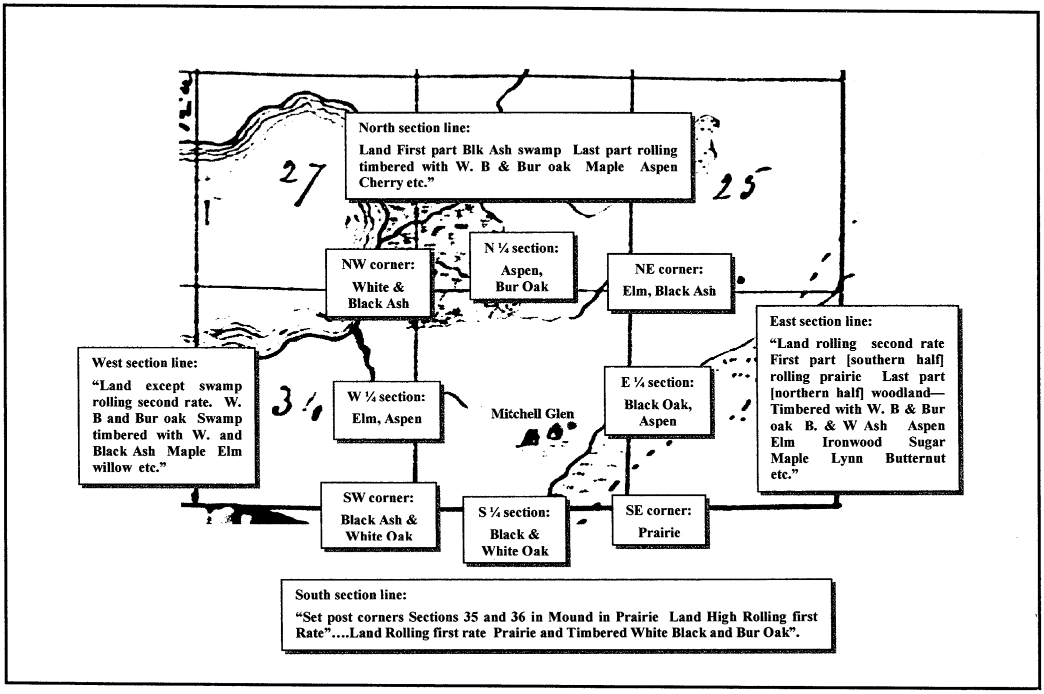

Figure 7. An enlarged portion of original land survey map for section 35 T16N R13E, the area occupied by Mitchell Glen, Green Lake County, Wisconsin. Marker trees and prairie at quarter sections and corner posts, as well as section line summaries from the field notes are displayed (General Land Office 1834).

Floodplain forest was encountered along the north section line between sections 26 and 35. From west to east the surveyors described "Land First part Blk Ash swamp Last part rolling timbered with W. B & Bur oak Maple Aspen Cherry [*Prunus serotina*?] etc." Further evidence of floodplain woodlands was noted at post corner sections 26, 27, 34 and 35: "Land except swamp rolling second rate. W. B and Bur oak Swamp timbered with W. and Black Ash Maple [*Acer saccharinum*?] Elm willow [*Salix* sp.] etc."

Based upon the original land survey records it is apparent that the vegetation cover for most of the immediate area surrounding Mitchell Glen was oak savanna and tallgrass prairie. Upland prairie, which graded into oak opening, flanked the southern margin, while extensive oak openings occupied the areas southwest and northeast of Mitchell Glen. Historically, recurrent fires greatly influenced the vegetation cover by diminishing woody climax succession and favoring oak savanna. Although most of the prairies and oak openings were placed into cultivation during the latter half of the 1800s, the dominant vegetation cover for Mitchell Glen remains maple-basswood forest. It is the only significant tract of climax forest in Green Lake County.

Native Americans and European Settlement

Mitchell Glen and the surrounding lands are noted for having been the site of the largest camp of Winnebago Indians in the Green

Lake area (Heiple and Heiple 1978). There is strong circumstantial evidence that the use of fire by Winnebago Indians, the primary inhabitants of the region, indirectly influenced the vegetation cover (Dorney 1981). The presence of oak savanna and open wetlands throughout Green Lake County, including those surrounding Mitchell Glen, support this view because all of these plant communities originate from recurrent fires and depend on periodic burnings for their continuation.

Among the Indian antiquities in Green Lake County, thirteen Indian campsites, three main planting grounds, and numerous food caches have been discovered within the immediate vicinity of Mitchell Glen (Brown 1917). The Indian planting grounds, which yielded much corn, were found in oak openings and on the prairie where fire may have been utilized to maintain open habitat (Dorney 1981). The nearby oak forests yielded great quantities of acorns, which were ground, dried, and stored in buried caches for use in winter.

In 1840 Anson Dart and his family established the first permanent European settlement on Green Lake. A son, Richard Dart, then twelve years old, later reflected on the resourcefulness of local Native Americans:

> The Winnebago used to make small mounds to preserve their provisions. When plentiful, they dried fish in the sun till they were as dry as powder, then put them in big puckawa sacks. The squaws also picked up bushels of acorns. In deep holes, below frost-line, they would bury their fish and acorns together, twenty bushels or so in a place, and cover them over with a mound of earth. When the deer had gone south, and game was scarceæ they would come and camp on these mounds and dig up fish and acorns for their winter food, and live on this provender until spring opened or game appeared. (Dart 1910)

Maple sugar was made from *Acer saccharum* in at least two localities west and north of Mitchell Glen, SW 1/4 section 35 and SW 1/4 section 26 (Brown 1917). The maple sugar was stored in birch bark baskets that were fashioned from *Betula papyrifera*. ". . . We had no sugar, save maple made by Indians, and this was very dirty. The natives used to pack this sugar in large baskets of birch-bark, and sell it" (Dart 1910).

The area woodlands also supplied wood for fuel, poles and bark for wigwams, and wood for making tools and weapons. Wooden bowls were carved out of ash, *Fraxinus* spp., and American basswood, *Tilia americana* (Heiple and Heiple 1978). Shagbark hickory, *Carya ovata,* and red cedar, *Juniperus virginiana,* both of which are found at Mitchell Glen, were utilized to make hunting bows (Brown 1917).

In 1835, one year after the township was surveyed, the first European settler to occupy land that included the glen was a trader named James Powell (Heiple and Heiple 1978). Twenty-six years later, Archibald and Laura Mitchell purchased 160 acres of land, which included the glen, NW 1/4 SE 1/4 section 35. The Mitchells' third son, Stephan Decatur Mitchell, or S.D. Mitchell, eventually acquired the glen, and this is when the name "Mitchell Glen" became attached to the site.

S.D. Mitchell was an amateur collector and enthusiastic student of Indian antiquities. His letters and reports to Charles E. Brown, then President of the Wisconsin Archaeological Society, were incorporated into Brown's 1917 paper, "The Antiquities of Green Lake." Numerous references to specific trees and the vegetation cover appear in Mitchell's letters to Brown as he related his findings. In a letter dated February 4, 1903, Mitchell described the forest nearby his home: "About Eighty rods to the North west of my residence on same Section [35] you will observe a conical mound this mound was in the limets [sic] of what at one time was one of the finest shugar [sic] bushes *[Acer saccharum]* that I ever saw . . ." (State Historical Society of Wisconsin 1888).

In 1903 Mitchell posted a draft to Brown entitled "Green Lake Report," which included a list of Indian sites and descriptions of the vegetation cover, as well as specific uses of local plants by the Winnebago tribe in and around Mitchell Glen. Mitchell related how the Native Americans utilized local plants and animals, as explained to him by Richard Dart (then 77 years old):

> Before the building of the dam at Dartford there was a bar at the north east portion of the lake to the South and east of where the Plasant [Pleasant] Point Hotell [sic] now stand which was at that time grown up to rushes the watter [sic] about five feet in depth here during the summer the Indians speared thousand and thousands of huge dog fish these they Jurked [sic] or dried over a slow fire and together with acorns they cached or buried these in pits when winter came one [on] and food became scarse [sic] they built their huts or Wigwams over these caches and boiled these fish and acorns together which became a black mass. . . . (State Historical Society of Wisconsin 1888)

Continuing, Mitchell went on to explain the loss of floodplain forest north of Mitchell Glen by the damming of Green Lake:

> It might be well to state here that the intire [sic] shoar [sic] line of the lake was changed by the building of a dam across the out let called the Pucyann [Puchyan] River at Dartford in the year 1844. This dam Raised the level of the lake some Four feet or more flooding a large tract of very heavy timber. . . some years since parties removed the over flowed stumps in the shallow watter [sic] between this [Silver Creek inlet, SW 1/4 section 26] and the Lake. . . . (State Historical Society of Wisconsin 1888)

South from the inlet "This whole tract [NW 1/4 section 35] to the south and west also to the east dureing [sic] the knowlage [sic] of the writer has been one vast tract of heavy timber portions of which has been since removed (from) the land and converted into plowed fields. . . " (State Historical Society of Wisconsin 1888).

Mitchell's references to maple trees further underscored the dependence of Native Americans and early settlers on the tract of climax forest in and around Mitchell Glen. Approximately one mile northwest of Mitchell Glen, a campsite on Silver Creek, SW 1/4 section 26, used by the Winnebago tribe was described as

> . . . a small island known as sugar creek island this is surrounded on the north and west by silver creek and on the south and east by swamps this island formerly was covered with heavy maple timber here again was shown the hacking gouging present of the Indians mode of taping [sic] the maple with his rude implements. . . . (State Historical Society of Wisconsin 1888)

About a quarter mile north of Mitchell Glen, SE 1/4 NW 1/4 section 35, Mitchell states that "This site was one of the finest maple groves *[Acer saccharum]* in the state my Father at one time cut one Maple that made 7 1/2 cords of 4 ft wood These trees all showed that they had been taped [sic] for ages by the Indians. . . . (State Historical Society of Wisconsin 1888).

Oak woods and openings bordered edges of the maple-basswood forest. In a letter to Brown on March 4, 1904, Mitchell described five trees around Indian corn hills in SW 1/4 NW 1/4 section 35 as "... three of Oak [*Quercus* sp.] and two of Cherry *[Prunus serotina]* the largest oak is four ft eight inches in circumference the other is smaller (State Historical Society of Wisconsin 1888).

As the Green Lake area became more settled, more land surrounding Mitchell Glen was placed into pasture and cultivation. By reporting the date when an Indian site was disturbed or destroyed, Mitchell inadvertently documented destruction of the vegetation cover and changes in land use surrounding Mitchell Glen. In 1904, for example, Mitchell laments that "... the timber has been removed [SE 1/4 NE 1/4 section 34] and in the early spring the Octogon [sic] the wolf and part of the cornfield [Indian corn] will be plowed for the first time ... Nearly all the damage [to effigy mounds] ... has been done within the last three years" (State Historical Society of Wisconsin 1888). Mitchell noted even earlier changes to the prairie southeast of Mitchell Glen, NW 1/4 SW 1/4 section 36:

> 1862 first Plowed and yearly since ... The peculiarity about these mounds is their isolation from other mound and distance from watter [sic] they are about one and a half miles east a little south of the lak [sic] on high table land about 400 feet above the lake on the edge of Green Lake Prairie. Alass [sic] there is but little sembalance [sic] to a mound left the distructive [sic] plow has for more than 40 year been accomplishing their ruin. ... (State Historical Society of Wisconsin 1888)

Elsewhere, about a quarter mile northwest of Mitchell Glen, SE 1/4 NE 1/4 section 34, Mitchell reports that "... two of the lizard tails [effigy mounds] were plowed about 1858. More were plowed 1903 and more ... will be Plowed this season."

Post-settlement to Present-day

The earliest known formal study to include the Mitchell Glen flora is from 1889 by Mrs. C.T. Tracy, a Ripon College botany instructor. While many of the plants listed in her Catalogue of Plants Growing Without Cultivation in Ripon and the Near Vicinity are known from Mitchell Glen, Mrs. Tracy specifically cites Mitchell Glen as the location for two species: *Impatiens capensis* Meerb. *(I. fulva* as listed by Tracy) and *Coreopsis tripteris* L. While *I. capensis* is common on wet soils along Mitchell Glen Creek, there are no known vouchers of *C. tripteris* for Green Lake County, or Wisconsin for that matter (Theodore S. Cochrane, personal communication, 2 April 1999). (Other old specimens, e.g., *Carex shortiana, Phoradendron serotinum,* and *Silphium asteriscus,* bearing identical Ripon College labels, whether collected by "J. Clark," "Mrs. C. Tracy," or someone else, also must be excluded from the Wisconsin flora for lack of specimen vouchers (Theodore S. Cochrane, personal communication, 2 April 1999).

Although many of the typical woodland ephemerals that grow at Mitchell Glen occur elsewhere in the county, some species are exclusive to the glen. Showy orchis, *Orchis spectabilis,* for example, was "discovered" in 1994 and is known only from Mitchell Glen (Eddy 1996). Similarly, *Hamamelis virginiana, Symphoricarpos albus,* and *Symphoricarpos occidentalis* are not rare in the southern half of Wisconsin but are recognized in the county only from Mitchell Glen.

Cold-air drainage along the shaded cliffs and cold springs at the base of the gorge create a boreal micro-habitat for certain northern plants. Among the species more typical of northern Wisconsin, and which may be viewed as northern relics, are *Acer spicatum, Aster macrophyllus, Dirca palustris, Diervilla lonicera, Equisetum pratense, Lycopodium lucidulum,* and *Taxus canadensis.* The fact that *T. canadensis* is nearly inaccessible because of the very steep slopes on which it grows may explain why it has not been extirpated by browsing white-tail deer.

Twenty-three species are "new" to the county, in that they were not known from the county prior to 1996. These county records listed below represent 2.4% of the total county flora (currently 951 species) and are based on voucher specimens collected after publication of the county flora (Eddy 1996).

Acer spicatum Lam.
Aster macrophyllus L.
Aster shortii Lindley
Carex amphibola Steudel
Carex blanda Dewey
Carex projecta Mackenzie
Cynoglossum amabile Stapf & Drumm.
Dirca palustris L.
Equisetum pratense Ehrh.
Erysimum cheiranthoides L.
Galium concinnum T. & G.
Hamamelis virginiana L.
Hydrophyllum virginianum L.
Lactuca serriola L.
Laportea canadensis (L.) Wedd.
Panicum boreale Nash
Phlox divaricata L.
Rubus occidentalis L.
Symphoricarpos albus (L.) S. F. Blake
Symphoricarpos occidentalis Hook.
Taxus canadensis Marshall
Ulmus rubra Muhl.
Viburnum rafinesquianum Schultes var. *rafinesquianum*

Although the vascular plant diversity of Mitchell Glen compared with similar Wisconsin forests is difficult to measure, the site is evidently richer than average. Based upon plant inventories for southern mesic forests in the State Natural Area system, an average number of vascular plants on a 40-acre tract is roughly 150 species (Thomas Meyer, personal communication, 1 April 1998). According to Meyer, in forests grown on calcareous till or where limestone bedrock nears the surface, which is the case at Mitchell Glen, the number of vascular plants is about 175 species. These data may not be in accord with the 234 species cataloged for the glen and bordering uplands. However, when considering the approximately 40 common weeds that were among the 234 plants collected, as well as several prairie and savanna, not forest species, the variety in Mitchell Glen generally corresponds to the number of species suggested by Meyer.

The origin of Mitchell Glen is similar to that of Parfrey's Glen, a 488-acre state natural area in Sauk County. Parfrey's Glen is a post-glacial gorge cut into Cambrian sandstone conglomerate of the Baraboo Hills and, like Mitchell Glen, receives cold-air drainage that supports a collection of northern plants, as well as shaded cliff plants on steep rock outcrops. Eighty-eight vascular plants are reported in a partial list compiled for Parfrey's Glen (Thomas Meyer, personal communication, 11 November 1998). Of these, 32 species or 36% are common to the Mitchell Glen flora, including plants with northern affinities. Combined with the plants on the Parfrey's list that are identified to genus only, there are 45 species or 51% common to the Mitchell Glen flora. Considering its rich plant diversity, coupled to similarities with other preserved southern mesic forests, Mitchell Glen stands as a high-quality refugium for native biota in east-central Wisconsin.

Past and Present Land Use

Land uses that affect the vegetation cover of Mitchell Glen area are ongoing. Four years ago nearly 30 acres of mature hardwood forest was selectively logged directly northwest of the glen, SE 1/4 NE 1/4 section 35. Harvested trees were mainly red and white oak, but included some bur oak, sugar maple, and basswood (John Koerner, personal communication, 7 January 1999). One year earlier area landowners successfully persuaded a local excavator to abandon plans to quarry gravel at a site less than one mile from Mitchell Glen.

Directly south and east of Mitchell Glen is land that has been under cultivation for over a century, an activity that has obviously destroyed the original vegetation cover. Furthermore, because the row-cropped fields fail to slow and contain water during rains and snowmelts, torrents of surface water stream into the southeast corner of Mitchell Glen, further eroding the edges of the soil grade that borders the gorge. The excessive surface runoff causes silting and flooding along Mitchell Glen Creek and intermittently disrupts the bottomland vegetation. Patches of reed canary grass, *Phalaris arundinacea,* and stinging nettle, *Urtica dioica,* have become firmly established on the moist alluvium.

By comparing the present-day vegetation cover of Mitchell Glen with old photographs and postcards it is evident that the edges of the glen and former openings have become more overgrown with woody growth. Alys Gredler, a former resident of the area commented:

> The greatest impression I had in going through the glen was how different it was from the pictures I have. It was quite obvious that it was almost ninety years older than it appeared in the pictures. The trees were much younger and smaller and the glen was very much less crowded with plant life . . . The upper glen where the Mitchell family cemetery is located must have at one time been fairly clear land but is very wooded now. (Alys Gredler, personal communication, 16 November 1998)

Prairie and savanna groundlayer species can still be observed growing along the margins in semi-shade. Along the north and south rims and on gently sloped terraces overlooking Mitchell Glen Creek, pioneer trees are present. The absence of fire and other habitat disturbances that impede woody succession have allowed aspen, black cherry, and boxelder to become established. Ironically, bur, white, and black oaks, trees once common to nearby oak openings, were not observed growing within the study area.

In addition, in oak openings and woodlands that were logged and pastured, European buckthorn, *Rhamnus cathartica,* has become naturalized and at times forming thickets. Left unmanaged, buckthorn develops a dense understory that shades out native species.

Both accidental and deliberate introductions have adversely affected the groundlayer cover. For example, periwinkle, *Vinca minor,* was planted many years ago in the Mitchell family cemetery. It has since spread to the surrounding area, forming large evergreen mats that crowd out native groundlayer species.

The present-day landholders of Mitchell Glen are cognizant of the need for its long-term protection by implementing sustainable land management practices. One option to achieve this aim is to prepare a conservation easement that specifies what land uses are acceptable and unacceptable. When attached to a deed, a conservation easement can assist protecting the land into perpetuity.

Methodology and Catalog Design

Plant collections were obtained during the 1997 and 1998 growing seasons. In addition to the glen, common weeds growing along buildings and lanes, and in lawns and cultivated fields were collected. Voucher specimens were identified and deposited in the University of Wisconsin-Oshkosh Herbarium (OSH). Besides plant collections, numerous 35 mm slide photographs of individual plants and entire communities were taken to further document the Mitchell Glen flora and general vegetation cover.

Plant families in the catalog are alphabetized within the major plant groups, as are the genera and species within a family. Nomenclature strictly follows Gleason and Cronquist (1991). The treatment of narrowly defined species and most infraspecific taxa is avoided, as is the listing of synonyms.

General locations, brief habitat descriptions, and the frequencies are stated for most species. Plants collected during this study that are not included in the Green Lake County flora (Eddy 1996) are noted as county records. Collection numbers cited are my own and correspond to the voucher specimens deposited at OSH.

Summary of Taxa

Presently, the total number of cataloged vascular plants at Mitchell Glen is 234 species (Table 1). A summary of the number of families, genera, and species for the three largest dicot and three largest monocot families is compiled in Table 2.

A single family, the Asteraceae, represents about one-fifth or 21% of the total number of dicots. The monocots are largely represented by the Poaceae and Cyperaceae, which when combined, account for 67% of the total number of monocots. The combined number of species of the three largest dicot and three largest monocot families accounts for 43% of the total Mitchell Glen flora (Table 2).

Table 1. Summary of Major Plant Taxa at Mitchell Glen.

Plant group	*Families*	*Genera*	*Species*
Pteridophytes	6	9	11
Gymnosperms	3	3	3
Dicotyledons	59	129	169
Monocotyledons	7	36	51
Totals	**75**	**177**	**234**

Table 2. A comparison of the three largest dicot and three largest monocot families.

Dicots	*Genera*	*Species*	*% of Total Mitchell Glen Flora*
Asteraceae	23	35	15%
Rosaceace	9	12	5%
Ranunculaceae	8	11	5%
Monocots			
Poaceae	20	24	10%
Cyperaceae	1	10	4%
Liliaceae	9	10	4%
Totals	**70**	**102**	**43%**

CATALOG OF SPECIES

PTERIDOPHYTES

LYCOPODIACEAE (Clubmoss Family)
Lycopodium lucidulum Michx. Rare, one site; moist shaded sandstone shelf above Glen Creek. (4235, 4531)

EQUISETACEAE (Horsetail Family)
Equisetum hyemale L. var. *affinis* (Engelm.) A. A. Eaton. Rich shaded slope, growing beside *E. pratense.* (4604)
E. pratense Ehrh. Rare, one site; rich shaded slope. COUNTY RECORD. (4312, 4533)

ADIANTACEAE (Maidenhair Family)
Adiantum pedatum L. ssp. *pedatum.* Rich wooded slopes. Locally common. (4346)

ASPLENIACEAE (Spleenwort Family)
Asplenium rhizophyllum L. Local on shaded sandstone cliffs. (4497)
Cystopteris bulbifera (L.) Bernh. Shaded sandstone outcrops. Uncommon. (4336, 4494)
Dryopteris carthusiana (Villars) H.P. Fuchs. Rich woods along Glen Creek. Common. (4361)
D. intermedia (Muhl.) A. Gray. Rich woods along Glen Creek. Common. (4535)
Woodsia obtusa (Sprengel) Torr. Locally abundant on shaded sandstone outcrops. (4335, 4492, 4496, 4534)

OSMUNDACEAE (Royal Fern Family)
Osmunda claytoniana L. Rich woods along Glen Creek. Uncommon. (4530)

POLYPODIACEAE (Polypody Family)
Polypodium virginianum L. Locally common on moist shaded sandstone cliffs. (4234, 4493, 4628)

GYMNOSPERMS

CUPRESSACEAE (Cypress Family)
Juniperus virginiana L. Dry disturbed woods. Common. (4279, 4305)

PINACEAE (Pine Family)
Pinus resinosa Aiton. Local on rocky ledge along north rim of glen; four mature trees. (4639)

TAXACEAE (Yew Family)
Taxus canadensis Marshall. Local on steep wooded rocky slopes along south wall of Mitchell Glen. COUNTY RECORD. (4509)

DICOTYLEDONS

ACERACEAE (Maple Family)
Acer negundo L. Common in disturbed woods, fencerows, clearing. (4295)
A. saccharum Marshall. Throughout rich woods. (4300)
A. spicatum Lam. Local on steep wooded slopes along south wall of Mitchell Glen. COUNTY RECORD. (4338, 4347, 4647)

AMARANTHACEAE (Amaranth Family)
Amaranthus hybridus L. Common weed. (4523, 4553)

ANACARDIACEAE (Cashew Family)
Rhus glabra L. Dry opening along northeast rim of Mitchell Glen. Common. (4633)
Toxicodendron radicans (L.) Kuntze. Occasional in disturbed woods, paths, clearings. (4519, 4656)

APIACEAE (Carrot Family)

Cryptotaenia canadensis DC. Rich woods. Uncommon. (4345)

Osmorhiza claytonii (Michx.) C.B. Clarke. Rich woods. Common. (4275)

APOCYNACEAE (Dogbane Family)

Vinca minor L. Planted and escaped about shaded pioneer cemetery. (4241)

ARISTOLOCHIACEAE (Birthwort Family)

Asarum canadense L. Rich wooded slopes along Glen Creek. (4264)

ASCLEPIADACEAE (Milkweed Family)

Asclepias incarnata L. One plant in old field. (4559)

A. syriaca L. Field lanes, old fields. Common. (4478)

A. verticillata L. Field lanes, old fields. (4637, 4660)

ASTERACEAE (Aster Family)

Achillea millefolium L. Field lanes, dry wooded openings. Common. (4464)

Ambrosia artemisiifolia L. Common weed. (4582)

A. trifida L. Common weed. (4589)

Antennaria plantaginifolia (L.) Richardson. Dry wooded openings. (4254, 4280)

Aster ericoides L. Dry wooded openings, field lanes. Common. (4626)

A. lateriflorus (L.) Britt. Open woods, oak openings. Common. (4607, 4616)

A. macrophyllus L. Dry wooded opening along northern rim of Mitchell Glen. COUNTY RECORD. (4617)

A. sagittifolius Willd. Oak openings. Common. (4625, 4636)

A. shortii Lindley. Dry wooded opening along northern rim of Mitchell Glen. COUNTY RECORD. (4622, 4631)

Cirsium vulgare (Savi) Tenore. Common weed. (4502, 4579)

Chrysanthemum leucanthemum L. Common weed. (4293)

Erigeron annuus (L.) Pers. Common weed. (4501)

E. pulchellus Michx. Dry open woods. Common. (4314)

Eupatorium rugosum Houtt. Rich woods, thickets. Common. (4595, 4605)

Gnaphalium obtusifolium L. Dry openings. Common (4621)

Helianthus hirsutus Raf. Dry open woods. Common. (4575)

Heliopsis helianthoides (L.) Sweet var. *scabra* (Dunal) Fern. Open fields. Common. (4356, 4527, 4569)

Hieracium aurantiacum L. Common weed. (4325)

H. caespitosum Dumort. Common weed. (4480, 4482, 4651)

H. scabrum Michx. Dry open woods, oak openings. Common. (4598, 4620, 4658)

Krigia biflora (Walt.) S.F. Blake Oak opening above Glen Creek. Locally common. (4349)

Lactuca canadensis L. Common weed. (4600)

L. serriola L. Field lanes, open disturbed soils. COUNTY RECORD. (4583)

Matricaria matricarioides (Less.) Porter. Common weed. (4557)

Prenanthes alba L. Local on semi-shaded sandstone shelf above Glen Creek. (4615)

Rudbeckia hirta L. Oak openings. Common. (4561, 4653)

Senecio pauperculus Michx. One site; oak opening on natural terrace above Glen Creek. (4296)

Solidago canadensis L. Field lanes, old fields. Common. (4558, 4594)

S. flexicaulis L. Dry woods, oak openings. Common. (4606)

S. rigida L. var. *rigida* One site; dry opening along northeast rim above Mitchell Glen waterfalls.

S. ulmifolia Muhl. Oak openings. Common. (4608)

Sonchus oleraceus L. Common weed. (4591)

Taraxacum officinale Weber. Common weed. (4273)

Tragopogon pratensis L. Field lanes, open habitats. (4499)

Xanthium strumarium L. Common weed. (4545, 4576, 4577)

BALSAMINACEAE (Touch-me-not Family)

Impatiens capensis Meerb. Damp soils along Mitchell Glen Creek. Common. (s. n.)

BERBERIDACEAE (Barberry Family)

Caulophyllum thalictroides (L.) Michx. Rich woods. Common. (4267)

Podophyllum peltatum L. Throughout woods. (4278)

BETULACEAE (Birch Family)

Betula papyrifera Marshall. Occasional along edges of glen. (s. n.)

Ostrya virginiana (Miller) K. Koch. Throughout rich woods. (4567, 4599)

BORAGINACEAE (Borage Family)

Cynoglossum amabile Stapf & Drumm. Garden escape; waste ground along old building. COUNTY RECORD. (4603)

Hackelia virginiana (L.) I. M. Johnst. Dry woods. Common. (4540, 4580)

BRASSICACEAE (Mustard Family)

Barbarea vulgaris R. Br. Common weed. (4242)

Brassica nigra (L.) Koch. Common weed. (4556)

Cardamine concatenata (Michx.) O. Schwartz. Throughout rich woods. (4245)

Erysimum cheiranthoides L. Disturbed habitats. COUNTY RECORD. (4517)

Hesperis matronalis L. Common garden escape. (4274)

CAMPANULACEAE (Harebell Family)

Campanula rapunculoides L. Garden escape. (4571)

Lobelia siphilitica L. Damp soils along Glen Creek. Common. (4613)

L. spicata Lam. var. *spicata* Oak openings. Common. (4471)

CAPRIFOLIACEAE (Honeysuckle Family)

Diervilla lonicera Mill. Dry and rocky wooded openings. Uncommon. (4510, 4619)

Lonicera x *bella* Zabel. Woods, thickets. (4281, 4302)

Sambucus canadensis L. Woods, thickets. Common. (4253, 4488)

S. racemosa L. ssp. *pubens* (Michx.) House. Rich shaded slopes. Common (4573)

Symphoricarpos albus (L.) S.F. Blake Rare county-wide; dry wooded opening along northern rim of Mitchell Glen. COUNTY RECORD. (4614, 4629)

S. occidentalis Hook. Rare county-wide; wooded clearing above Glen Creek. COUNTY RECORD. (4624).

Viburnum lentago L. Occasional throughout woods. (4487)

V. rafinesquianum Schultes var. *rafinesquianum.* Dry woods along southern rim of Mitchell Glen. COUNTY RECORD. (4511, 4623)

CARYOPHYLLACEAE (Pink Family)

Arenaria lateriflora L. Woods, openings. Common. (4344)

Cerastium vulgatum L. Common weed. (4289)

Silene latifolia Poiret. Field lanes, disturbed habitats. Common. (4330, 4505, 4521)

CHENOPODIACEAE (Goosefoot Family)

Chenopodium album L. Common weed. (4518, 4526, 4549)

CLUSIACEAE (Mangosteen Family)
Hypericum punctatum Lam. Field lanes, dry openings. Common. (4568)

CONVOLVULACEAE (Bindweed Family)
Convolvulus arvensis L. Common weed. (4547)

CORNACEAE (Dogwood Family)
Cornus rugosa Lam. Rocky woods. Common. (4532, 4645)

CUCURBITACEAE (Gourd Family)
Echinocystis lobata (Michx.) T. & G. Edges of woods, thickets. Common. (4546)

EUPHORBIACEAE (Spurge Family)
Euphorbia corollata L. var. *corollata.* Dry wooded openings, field lanes. Common. (4592, 4650)

FABACEAE (Bean Family)
Amphicarpaea bracteata (L.) Fern. Throughout woods, openings. (4612)
Coronilla varia L. Roadside. (4515)
Medicago lupulina L. Common weed. (4307, 4525)
M. sativa L. Common along field lanes, old fields. (4481)
Trifolium campestre Schreb. Common weed. (4322)
T. pratense L. Common weed. (4327)
T. repens L. Common weed. (4328)
Vicia sativa L. ssp. *nigra* (L.) Ehrhart. Field lanes. Common. (4483)

FAGACEAE (Beech Family)
Quercus rubra L. Throughout woods. (4564)

FUMARIACEAE (Fumitory Family)
Dicentra cucullaria (L.) Bernh. Rich wooded slopes along Glen Creek. (4262)

GROSSULARIACEAE (Gooseberry Family)
Ribes cynosbati L. Rich woods. (4259, 4339, 4642)

HAMAMELIDACEAE (Witch Hazel Family)
Hamamelis virginiana L. Local on shaded slopes along Glen Creek. COUNTY RECORD. (4529)

HYDROPHYLLACEAE (Waterleaf Family)
Hydrophyllum virginianum L. Rich wooded slopes. Uncommon. COUNTY RECORD. (4308)

JUGLANDACEAE (Walnut Family)
Carya cordiformis (Wangenh.) K. Koch. Rich woods above Glen Creek. Uncommon. (4351, 4528)
Juglans cinerea L. Occasional throughout woods. (4282)

LAMIACEAE (Mint Family)
Leonurus cardiaca L. Common weed. (4465)
Monarda fistulosa L. var. *fistulosa.* Old fields, oak openings. Common. (4550)
Nepeta cataria L. Common weed. (4489)
Prunella vulgaris L. Common weed of damp soils. (4572)

MALVACEAE (Mallow Family)
Abutilon theophrasti Medikus. Common field weed. (4584)

MONOTROPACEAE (Indian Pipe Family)
Monotropa uniflora L. Dry woods, openings. Uncommon. (4562)

OLEACEAE (Olive Family)
Fraxinus pennsylvanica Marshall. Occasional throughout woods. (4472, 4627)

ONAGRACEAE (Evening Primrose Family)

Circaea alpina L. Local on moist shaded sandstone cliff beside waterfalls of Glen Creek. (4491)

C. lutetiana L. Throughout rich woods. (4363)

Oenothera parviflora L. Field lanes, old fields. (4590)

OXALIDACEAE (Oxalis Family)

Oxalis stricta L. Common weed. (4321, 4334)

PAPAVERACEAE (Poppy Family)

Sanguinaria canadensis L. Rich woods. Common. (4266)

PLANTAGINACEAE (Plantain Family)

Plantago major L. Common weed. (4544)

P. rugelii Decne. Common weed. (4504)

POLEMONIACEAE (Phlox Family)

Phlox divaricata L. One site; edge of woods along northeast rim of Mitchell Glen. COUNTY RECORD. (4244)

POLYGONACEAE (Smartweed Family)

Polygonum pensylvanicum L. Field lanes, open disturbed habitats. Common. (4589)

P. persicaria L. Common weed. (4555)

Rumex acetosella L. Common weed. (4585)

R. crispus L. Common weed of damp waste places. (4323, 4485)

R. obtusifolius L. Damp disturbed soils. (4536)

R. salicifolius J.A. Weinm. Wet soils along Glen Creek. (4467)

PORTULACACEAE (Purslane Family)

Claytonia virginica L. Throughout rich woods. (4250)

Portulaca oleracea L. Common weed. (4581)

PRIMULACEAE (Primrose Family)

Dodecatheon meadia L. Locally abundant in dry openings along southern and northern rims of Mitchell Glen. (4277)

PYROLACEAE (Shinleaf Family)

Pyrola elliptica Nutt. Rare, one site; oak opening on natural terrace above Glen Creek. (4652)

RANUNCULACEAE (Buttercup Family)

Actaea rubra (Aiton) Willd. Throughout rich woods. (4261, 4286, 4287)

Anemone quinquefolia L. Throughout rich woods. (4233)

A. virginiana L. Dry wooded openings. Common. (4343, 4357, 4362)

Caltha palustris L. Wet soils along Glen Creek. (4263)

Hepatica americana (DC.) Ker Gawler. Rich wooded slopes along Glen Creek. (4260)

Isopyrum biternatum (Raf.) T. & G. Rich woods. Uncommon. (4248)

Ranunculus abortivus L. Dry woods. Common. (4238)

R. fascicularis Muhl. Wooded openings. Common. (4284)

R. recurvatus Poiret. Rich woods. Uncommon. (4288)

Thalictrum dioicum L. Woods. Common. (4232)

RHAMNACEAE (Buckthorn Family)

Rhamnus cathartica L. Common, generally naturalized in woods and openings. (4297)

ROSACEAE (Rose Family)

Agrimonia gryposepala Wallr. Dry woods, oak openings. Common. (4554)

Amelanchier spicata (Lam.) K. Koch. Dry woods, openings. (4251, 4640, 4644)

Crataegus coccinea L. One site; beside a lane in wooded opening on southwest edge of Mitchell Glen. (4596)

Fragaria virginiana Duchesne. Dry wooded openings. (4237)

Geum canadense Jacq. Throughout dry woods. Common. (4355, 4548)

Potentilla recta L. Common weed. (4484)

P. simplex Michx. Field lanes, disturbed habitats. Common. (4350)

Prunus americana Marshall. Wooded openings, thickets. (4240)

P. pensylvanica L. f. Fencerow. (4643)

P. serotina Ehrh. Occasional throughout woods. (4301)

Pyrus ioensis (A. Wood) L. H. Bailey. Woods. Uncommon. (4271)

Rubus occidentalis L. Dry woods along southern rim of Mitchell Glen. COUNTY RECORD. (4337)

RUBIACEAE (Madder Family)

Galium aparine L. Woods. Common. (4272)

G. concinnum T. & G. Occasional in dry woods. COUNTY RECORD. (4473)

G. triflorum Michx. Throughout dry woods. (4655)

RUTACEAE (Rue Family)

Zanthoxylum americanum Mill. Disturbed woods, openings along northern rim of Mitchell Glen. Common. (4316)

SALICACEAE (Willow Family)

Populus tremuloides Michx. Disturbed woods. (4503)

Salix humilis Marshall. One site; beside field lane on eastern border of Mitchell Glen. (4294)

SANTALACEAE (Sandlewood Family)

Comandra umbellata (L.) Nutt. var. *umbellata.* Dry wooded openings along southern rim of Mitchell Glen. (4313)

SCROPHULARIACEAE (Figwort Family)

Aureolaria grandiflora (Benth.) Pennell var. *pulchra* Pennell. Adjacent to old lane and local in wooded opening along southern rim of Mitchell Glen. (4593)

Pedicularis canadensis L. Oak opening on natural terrace above Glen Creek. Uncommon. (4352)

Scrophularia lanceolata Pursh. Edge of woods on eastern border of Mitchell Glen. (4578)

Verbascum thapsus L. Common weed. (4520)

Veronica serpyllifolia L. Common lawn weed. (4276, 4490)

SOLANACEAE (Nightshade Family)

Physalis longifolia Nutt. Old field next to field lane. Common. (4479)

Solanum dulcamara L. Field lanes, open woods, thickets. Common. (4160)

S. nigrum L. Open disturbed soils. (4524, 4602)

TILIACEAE (Linden Family)

Tilia americana L. Throughout rich woods. (4299)

THYMELAEACEAE (Mezereum Family)

Dirca palustris L. Locally common in woods along southern rim of Mitchell Glen. COUNTY RECORD. (4649)

ULMACEAE (Elm Family)

Ulmus americana L. Occasional dry woods along southern rim of Mitchell Glen. (4303, 4618)

U. rubra Muhl. Occasional in rich woods. COUNTY RECORD. (4601)

URTICACEAE (Nettle Family)

Laportea canadensis (L.) Wedd. Partially shaded wet soils along Glen Creek. COUNTY RECORD. (4348, 4597)

Urtica dioica L. var. *procera* (Muhl.) Wedd. Disturbed damp soils. Common. (s. n.)

VERBENACEAE (Vervain Family)

Phryma leptostachya L. Throughout dry woods. (4563)

Verbena hastata L. Damp open habitats. Common. (4560, 4565)

VIOLACEAE (Violet Family)
Viola pubescens Aiton. Woods. (4230, 4265)
V. sororia Willd. Woods. (4231, 4239, 4243, 4249)

VITACEAE (Grape Family)
Parthenocissus vitacea (Knerr) A. Hitchc. Throughout woods. (4304, 4469)

MONOCOTYLEDONS

ARACEAE (Arum Family)
Symplocarpus foetidus (L.) Nutt. Wet soils in low woods and openings along Glen Creek. Common. (4258)

CYPERACEAE (Sedge Family)
Carex amphibola Steudel. Woods. Uncommon. COUNTY RECORD. (4311)
C. blanda Dewey Throughout rich woods. Common. COUNTY RECORD. (4298, 4332, 4500)
C. cephalophora Muhl. Dry open woods. (4511)
C. gracillima Schwein. Low woods. Uncommon. (4292)
C. pensylvanica Lam. Throughout woods and openings. (4236, 4246, 4252, 4269, 4270, 4309, 4331)
C. projecta Mackenzie. Low woods. Rare. COUNTY RECORD. (4475)
C. rosea Schk. ex Willd. Low woods. (4310, 4474)
C. sparganioides Willd. Woods, thickets. Common. (4358)
C. sprengelii Dewey. Rich woods. Uncommon. (4290)
C. vulpinoidea Michx. Wet soils along Glen Creek. Uncommon. (4486)

JUNCACEAE (Rush Family)
Juncus tenuis Willd. Various damp habitats. (4466)
Luzula multiflora (Retz.) Lej. Woods, clearings. Common. (4318)

LILIACEAE (Lily Family)
Allium canadense L. Oak opening on natural terrace above Glen Creek. Common. (4353)
A. tricoccum Aiton. Rich woods bordering Glen Creek. (4537)
Asparagus officinalis L. Common garden escape. (4283, 4507)
Erythronium albidum Nutt. Throughout rich woods. (4247)
Hypoxis hirsuta (L.) Cov. Oak opening on natural terrace above Glen Creek. Common. (4315)
Polygonatum biflorum (Walter) Elliott. Open woods, thickets. Common. (4333, 4498)
Scilla sibirica Andr. Planted and spreading about buildings. (4256)
Smilacina racemosa (L.) Desf. Throughout woods, openings. (4317)
Trillium grandiflorum (Michx.) Salisb. Throughout rich woods. (4255)
Uvularia grandiflora Sm. Rich woods along Glen Creek. (4257)

ORCHIDACEAE (Orchid Family)
Liparis lilifolia (L.) Rich. Two sites; local in oak openings. (4342)
Orchis spectabilis L. Rare, one site; beside a wooded path along northern rim of Mitchell Glen. (4181, 4285)

POACEAE (Grass Family)
Agrostis gigantea Roth. Open woods. Common. (4512, 4514, 4543)
Andropogon gerardii Vitman. Dry opening along northeast rim above Mitchell Glen waterfalls. (4634, 4661)
Bromus inermis Leysser. Field lanes, disturbed sites. Common. (4326, 4506)
Cinna arundinacea L. Low woods, thickets. (4320)
Dactylis glomerata L. Common weed. (4306, 4324)
Danthonia spicata (L.) P. Beauv. Old fields, dry woods. Common. (4470, 4566, 4654)

Digitaria sanguinalis (L.) Scop. Common weed. (4587)

Elymus canadensis L. Dry opening along northeast rim of Mitchell Glen. (4632)

E. hystrix L. Woods, openings. Common. (4539, 4570, 4659)

Elytrigia repens (L.) Nevski. Lawns, disturbed habitats. Common. (4508)

Festuca subverticillata (Pers.) E. Alexeev. Rich woods. Uncommon. (4477)

Glyceria striata (Lam.) A. Hitchc. Damp soils along Glen Creek. Common. (4476, 4495)

Leersia virginica Willd. Damp soils along Glen Creek. Common. (4574, 4611)

Lolium perenne L. Common weed. (4516, 4588)

Milium effusum L. Rich woods along Glen Creek. Uncommon. (4542)

Muhlenbergia frondosa (Poiret) Fern. Low woods. Common. (4610)

Panicum boreale Nash. Wooded opening. Uncommon. COUNTY RECORD. (4353)

P. leibergii (Vasey) Scribn. Dry oak opening. Uncommon. (4340, 4341)

P. miliaceum L. ssp. *ruderale* (Kitigawa) Tzvelev. Edge of cultivated field. (4551)

Phalaris arundinacea L. Various damp to wet open habitats. Common. (4329)

Phleum pratense L. Field lanes, old fields, clearings. (4359)

Poa compressa L. Field lanes, wooded openings. Common. (4291, 4319, 4468, 4513)

Setaria glauca (L.) P. Beauv. Common weed. (4609)

S. viridis (L.) P. Beauv. Common weed. (4552)

SMILACACEAE (Catbrier Family)

Smilax herbacea L. Occasional in damp woods. (4635)

S. lasioneura Hooker. Dry woods along northern rim of Mitchell Glen. (4360)

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This paper is dedicated to a young man who loved Mitchell Glen like no other 17-year-old could. For those of us who shared time in the glen with him, a walk through Mitchell Glen will never be the same. So, Augie, this Mitchell Glen flora is fondly dedicated to you.

In Memoriam
August DeForest Zebediah Smith
June 16, 1980 – January 20, 1998

Joan Jass and Jeanette Glenn

Measuring the Degree of Variation in Wisconsin *Pyganodon grandis* (Say 1829) (Mollusca: Bivalvia: Unionidae)

Abstract *Variation in the ubiquitous and abundant freshwater bivalve* Pyganodon grandis *was studied using museum specimens collected across Wisconsin from 1973 to 1977. Data on six shell traits were gathered for each specimen: 1) beak sculpture, 2) overall length, 3) height, 4) width, 5) anterior-to-beak length of the right valve, and 6) darkness of the periostracum. Data from the Wisconsin specimens were subsequently pooled into three regional groupings representing sites from the northeast, the southwest, and an intermediate tension zone. Comparison of three groups revealed statistically significant differences and indicated a high degree of intraspecific variation.*

Variation in populations of the ubiquitous and abundant freshwater bivalve genus *Anodonta* was analyzed in Canada by Clarke (1973). In order to assess the taxonomic importance of such variation, Clarke conducted a statistical analysis of shell traits and compared the results to ecological and geographic data from Canadian collecting sites. In the past the extreme variability displayed by *Anodonta* has given rise to a number of subspecific divisions. In Wisconsin for example, F.C. Baker (1928) found two subspecific level taxa in addition to the standard *Anodonta grandis.* Turgeon et al. (1998) have placed this species in the genus *Pyganodon.*

Clarke's analysis revealed strong correlations between site geography and the following shell traits: 1) beak sculpture, 2) anterior-to-beak length/length overall, 3) width/length overall, and a lesser degree of correlation to 4) height/length overall. He also found good to fair correlations between site ecology and anterior-to-beak length/length overall, as well as darkness of the periostracum.

In Wisconsin, this taxon is also widespread and abundant. Mathiak's five-year survey (1973–1977) (Mathiak 1979) ranked it second in both number of sites from which he collected it (N = 202) and in total number of specimens collected (N = 1039). The Mathiak site map for this species shows collecting localities well distributed over the state. The Milwaukee Public Museum (MPM) subset of the Mathiak collection includes *Pyganodon grandis* (giant floater) specimens from two-thirds of Wisconsin's 72 counties. We measured these specimens to examine the degree of variation present within the state. A high degree of within-state variability in aquatic invertebrate traits was reported by Parejko (1987), who found statistically significant north/south differences in the life history parameters of several Wisconsin species.

Methods

The traits in Clarke's study that showed some significance were those measured in MPM specimens of *P. grandis:* 1) beak sculpture, which Clarke scored 1-4 (1,2 = not in Wisconsin, 3 = double loop, 4 = nodulous); 2) length overall; 3) height; 4) width; 5) anterior-to-beak length, right valve (traits 2-5 measured to the nearest tenth of a millimeter with a dial caliper); 6) darkness of the periostracum, arbitrarily scored as light = 1, medium = 2, dark = 3. Four of these traits (2-5) represent morphometric variables, while traits 1 and 6 represent continuous, nonnumeric traits that have been assigned to numeric classes for purposes of analysis.

For possible correlations with geography, shells collected by Harold Mathiak (1979) in a statewide survey of Wisconsin waterways were chosen for this study (N = 139). Data from these specimens, part of a representative subset of his collection selected for donation to MPM by Mathiak, were expected to give a good indication of the degree of geographic variation to be found within the state, since his study included localities from across Wisconsin. Collecting sites were subsequently pooled into three ecological regions, following Curtis's division of Wisconsin into a northeastern province of northern hardwoods, an intermediate tension zone, and a southwestern province of prairie-forest (Curtis 1971). He divided the state into these three regions by mapping the ranges for 182 species that reached their northern or southern limits in Wisconsin. North of the area where these range lines cross the state is the northeastern province, south of it is the southwestern province, and the summed region covered by the 182 range lines is the tension zone, where geology, climate, and environmental factors have combined to exert a defining selective pressure on those species. Our pooling of Mathiak's collecting sites included creeks and rivers from both Great Lakes and Mississippi River drainage basins in the northeastern as well as in the southwestern region. A *t*-test was used to compare northeastern and southwestern shells, using the means of the six measured traits (SAS 1987), with a *P* value of 0.05 or less as the level chosen to indicate statistical significance.

Results

Table 1 shows the results of *t*-tests on six measured shell traits as well as the results from tests on three ratios derived from the original measurements. All tests showed a statistically significant difference between northeastern and southwestern groups of shells. The *P* values for these tests ranged from a very highly significant level of less

Table 1. North/south comparison of shell traits in Wisconsin.

	North Mean (N)	South Mean (N)	Value of t	Degrees of Freedom	P
Beak sculpture	3.50 (54)	3.18 (44)	3.42	96	0.0009
Width (mm)	31.2 (77)	43.8 (45)	7.53	120	<0.00001
Height (mm)	46.8 (77)	66.9 (45)	8.88	120	<0.00001
Length (mm)	85.0 (77)	115.5 (45)	7.93	120	<0.00001
Anterior (mm)	24.8 (77)	38.1 (45)	9.36	120	<0.00001
Darkness	2.65 (77)	2.24 (45)	3.95	120	0.0001
Anterior/length	0.29 (77)	0.33 (45)	6.72	120	<0.00001
Width/length	0.37 (77)	0.38 (45)	2.04	120	0.0431
Height/length	0.55 (77)	0.58 (45)	4.25	120	<0.00001

than 0.00001 to 0.0431, all falling below the 0.05 level chosen for statistical significance. Northern shells had darker color, beak sculpture less consistently double-looped, and widths, heights, lengths, and anterior-to-beak measurements that were smaller than those in the southern group.

Tension zone shells (N = 17) had means that were generally intermediate between north and south values: beak = 3.21, width = 33.8 mm, height = 52.4 mm, length = 91.0 mm, anterior-to-beak = 27.7 mm, darkness = 2.35, anterior-to-beak/overall length = 0.30, width/overall length = 0.37, height/overall length = 0.58.

Discussion

C.T. Simpson (1896) produced one of the early summaries dealing with classification in the group he called the "pearly freshwater mussels." Among the features he considered key characteristics for this group were the beak with its sculptural details and "remains of the nuclear shell." Simpson followed the biological rule of reliance on the characteristics of embryonic stages to determine the relationships within a group under study.

However, a disadvantage to relying heavily on such traits as beak sculpture is that they may be shown only in very young or well-preserved shells. Though beak details can be definitive for such specimens, by the time they have reached adulthood, many shells have beaks significantly damaged by mechanical erosion and/or dissolution from acidic waters. In certain areas, virtually every shell collected may show such damage. Clarke and Berg (1959) created a key to northeastern North American species of Unionacea that would allow most identifications to be made without the use of beak sculpture characters, because they were so often obliterated in adult specimens. Nearly 20% (N = 27) of the specimens in our Wisconsin dataset had the beak too damaged for scoring.

As other studies had done, Clarke and Berg (1959) compared typical members of this species to its described subspecies on the bases of shell measurements and ratios derived from them. As mentioned previously, Baker (1928) found two subspecies in the state in addition to the typical *A. grandis, A. g. plana* and *A. g. footiana*. He additionally listed as other species entities that today are considered part of the *P. grandis* complex: *A. gigantea, A. kennicottii, A. marginata* and *A. corpulenta*. While our study did not focus on possible taxonomic implications of morphometric variation, data from Wisconsin specimens illustrate the high degree of variability of shell traits within this taxon, whether the material studied is considered to be representative of several species as it was by malacologists of the past such as Baker or as an entity that includes several of those formerly accepted species in synonymy as more recent researchers have done. Table 2 gives a comparison of these variables from Wisconsin specimens.

The most basic geographical correlation with measured shell traits that Clarke (1973) found in his analysis of Canadian specimens was the smaller size of northern populations due to a shorter growing season. Our results show that this contrast can also be seen in the analysis of specimens collected over a much smaller area, in a statewide rather than a countrywide survey. However, an alternate pooling of data from the Wisconsin collecting sites on the basis of their township values, which are calculated simply on distance north of the Illinois state line, yielded a correlation less strong than the results we present in Table 1, which were based on the ecological regions of Curtis (1971). Therefore the regions of Curtis, which were originally derived from plant species ranges, gave the better key to analysis of zoogeographic variability in the state, presenting a more sophisticated picture of the climatic and other similar phenological stresses on Wisconsin species than straightforward north/south differences.

Cummings and Mayer (1992) confirm that *P. grandis* is widespread and common throughout the entire Midwest. Habitats they list as typical range from ponds to creeks and rivers. This ability to survive in widely differing habitats is no doubt key to the widespread distribution of this species. In fact, had *P. grandis* been like many other relatively thin-shelled species that are more restricted to pool habitats, it would not have ranked where it did in Mathiak's tabulated results (Mathiak 1979). Mathiak generated lists ranking all of the species he collected: one list was based on the number of collecting sites where each species was found (frequency), and another was based on the number of specimens collected of each species (abundance). *Pyganodon grandis* ranked sec-

Table 2. Range of measurements, *Pyganodon grandis* complex.

	Length (mm)	*Height/length*	*N*	*Source*
A. grandis	67–190	0.56–0.67	6	Baker 1928
A. g. plana	58–145	0.52–0.59	8	Baker 1928
A. g. footiana	23–115	0.56–0.65	8	Baker 1928
A. gigantea	85–159	0.67–0.72	2	Baker 1928
A. kennicottii	56–90	0.54–0.62	6	Baker 1928
A. marginata	30–120	0.49–0.59	9	Baker 1928
A. corpulenta	103–153	0.67–0.74	5	Baker 1928
P. grandis — North	55–140	0.49–0.69	77	This study
P. grandis — South	50–168	0.49–0.65	45	This study
P. grandis — Tension Zone	66–110	0.51–0.68	17	This study

ond to only one other of the 45 species in both of these lists. The totals for the top-ranked species were 236 sites and 1161 specimens; the third-ranked species' numbers fell to 169 and 721. Further evidence of the wide tolerance of *P. grandis* is the record this species holds for survival at a water depth of very low oxygen and temperature (living at a depth of 102 ft in Lake Michigan, Reigle 1967).

Cummings and Mayer (1992) also point out the extreme variability in this taxon; for example, they note that the umbos are located more toward the center than the anterior in the large-river form of the species they call *P. grandis* var. *corpulenta* (= Baker's *Anodonta corpulenta*, Table 2). Buchanan (1980) still listed *A. grandis corpulenta* as a subspecies, as did Burch (1975). These researchers differentiated the subspecies by its length/height ratio of less than 1.6 and anterior/length ratio almost up to 0.5.

Any wide-ranging species, such as *P. grandis,* is usually assumed to be made up of a series of subpopulations, each with its own morphological as well as physiological characteristics. These characteristics include seasonal growth patterns and reproductive phenology. For example, Surber (1914) reported finding gravid *A. corpulenta* in the spring (April) and fall (October, November) but gravid *A. grandis* in the fall only (September, October). A species complex such as that represented by *P. grandis* may thus be expected to contain considerable diversity in life history traits as well as morphological traits.

In spite of a degree of diversity so high that some prior researchers have divided the taxon into subspecies, we have considered all specimens in our study as simply *P. grandis.* Our focus was zoogeographic rather than taxonomic, to use shell traits to analyze the degree of variation within specimens collected during one five-year survey of Wisconsin's waterways. Statistical analysis of *P. grandis* shell traits showed significant differences correlating with the ecological regions delimited for Wisconsin by Curtis (1971). This met our two goals of highlighting the great deal of variation within this taxon and also, more specifically, of showing that this variability follows a zoogeographic pattern in which significant differences occur between populations in northern and southern ecological regions of Wisconsin.

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Jeffrey J. Ripp

Fisheries Management in the Great Lakes: The Evolution of the Great Lakes Fishery Commission

Abstract *The responsibility for managing the fishery resources of the Great Lakes is fragmented between two national governments, eight states, one province, and two Indian fishery management authorities. The lack of coordination between government agencies that have authority over the fisheries of the Great Lakes has hindered effective fisheries policy in the past. The Great Lakes Fishery Commission (GLFC) was established under the 1955 binational Convention on Great Lakes Fisheries to address issues that were beyond the ability of each agency to deal with singularly. Since the formation of the Commission, the ecology and economy of the Great Lakes basin has changed significantly, and the Commission has changed its focus to address new concerns in innovative ways. The last decade has seen the emergence of a new era of cooperative resource management following the principles of ecosystem management. The GLFC, through the development of the Strategic Great Lakes Fisheries Management Plan, provides a forum for raising fishery issues and coordinating the efforts of the government agencies charged with managing Great Lakes fisheries and habitat. The GLFC has achieved mixed success in fostering the ecosystem management approach. This paper provides an institutional analysis of the Great Lakes Fishery Commission, describes how the Commission's role has changed, and evaluates the Commission's successes in implementing ecosystem management approaches.*

The Great Lakes Fishery Commission (GLFC) is a binational organization that was created in 1955 under the Convention on Great Lakes Fisheries to advise the governments of the United States and Canada on the sustainable management of Great Lakes fisheries, promote fisheries research, and control the sea lamprey *(Petromyzon marinus).* Since 1955, both the political climate and the fisheries of the Great Lakes region have changed, and the institutions for managing the fisheries have adapted to address new concerns. The GLFC has played a quiet but important role in coordinating management efforts among two national governments, eight states, one province, and two Native American fishery agencies. The GLFC's effort to establish an ecosystem-based management approach has allowed it to expand beyond its original study-and-advise mandate. Despite the success of the GLFC in coordinating fishery management, several hurdles must be overcome before fishery management can be integrated with other Great Lakes management efforts such as the Great Lakes Water Quality Agreement.

In the 1980s, the GLFC recognized that maintaining sustainable fish stocks in the Great Lakes would require an integrated, systems-oriented approach focused on the development of stable, self-sustaining fish communities. The approach has been termed "ecosystem management" and can be described as a shift from a media-based, program-focused approach to one that is place-based and ecosystem-oriented (Donahue 1988*a;* MacKenzie 1990; Holland 1996; Regier, unpublished). Ecosystem management has been described in many different ways. In most contexts, ecosystem management is defined as a management philosophy that accounts for the interrelationships among the land, air, water, and all living things, including humans (Hartig et al. 1998). Unfortunately, this definition does not truly describe what ecosystem management "is" or how it is implemented. In practice, ecosystem management represents a shift from single-issue approaches that treat the symptom, rather than the cause, of a problem to more holistic approaches that attempt to address the underlying causes. A good start towards a working definition of the ecosystem approach is "an action-based, adaptive planning and management process that accounts for the interrelationships among ecological components, including humans" (Hartig et al. 1998). This working definition gives some insight into how ecosystem approaches are used in practice. One of the basic tenets of ecosystem management is the reliance on involving stakeholders in the decision-making process. Under ecosystem management, stakeholders are defined as any user or group that is affected by the resource or has the potential to impact the resource. This concept of stakeholder involvement is crucial for the success of ecosystem-based approaches.

The driving force for pursuing an ecosystem approach in fisheries management is the acknowledgment that the traditionally narrow focus of resource management agencies is insufficient to deal with the complexity of the ecosystem. The failure of Great Lakes institutions to effectively confront large scale problems is a result of fragmented authority for managing the resource. In many cases, the authority for regulating pollution and managing fisheries resides in separate government agencies. Further, conflicting social values and uncertainty associated with management initiatives complicate fisheries management. The joint Strategic Great Lakes Fisheries Management Plan (Strategic Plan) was prepared and adopted in 1980 by Great Lakes fishery management authorities under the direction of the GLFC to recognize common agency goals and establish a commitment to interjurisdictional coordinated fishery management based upon the ecosystem approach (GLFC 1997*a*).

In the Great Lakes, fishery management is only one component of a larger integrated environmental management framework. The most studied manifestations of ecosystem management in the Great Lakes are the Lakewide Management Plans (LaMPs) and Remedial Action Plans (RAPs) for the 43 Areas of Concern established under the 1987 amendments to the Great Lakes Water Quality Agreement. Despite considerable overlap with fish management activities, the LaMPs and RAPs have been criticized for not adequately representing fish management goals (Hartig et al. 1996*a*, Hartig et al. 1996*b*). Under the Strategic Great Lakes Fisheries Management Plan, the various state, tribal, federal, and provincial natural resources agencies call upon the GLFC to provide the institutional capacity to coordinate fishery and environmental management and maintain the necessary stakeholder partnerships.

This paper describes the institutions in place for managing the Great Lakes fishery, explains the development of ecosystem-based management approaches, and evaluates the GLFC's efforts to improve the fishery. The focus of this paper is the expanded role of the GLFC under the Strategic Great Lakes Fisheries Management Plan. The paper concludes with a discussion of the challenges facing the GLFC in implementing ecosystem-based fishery management and an investigation of lake trout rehabilitation. The author conducted telephone interviews with eight people involved with Great Lakes fishery management from both the United States and Canada, including current and past GLFC staff, a former GLFC commissioner from Canada, fish managers from Wisconsin, academics, and sport fishery stakeholders. The criteria for evaluating the success of the ecosystem approach are based primarily upon the goals and objectives set forth in the Strategic Plan and the Great Lakes Fishery Commission's Strategic Vision for the Decade of the 1990s (GLFC 1992), but additional criteria have been borrowed from Donahue (1988*a*).

Overview of the Great Lakes Fishery

Every spring and fall, thousands of migrating Pacific salmon (*Oncorhynchus* spp.), steelhead *(Oncorhynchus mykiss),* and brown trout *(Salmo trutta)* surge up the tributaries flowing into the Great Lakes to spawn. None of these fish species are native to the Great Lakes. Historical commercial fishing records show that less than 50 years ago, these species were not among the top catches in these lakes. In fact, many of these species were not even commonly found in the lakes until as recent as the 1980s (Jude and Leach 1993). Over the last 100 years, the aquatic community of the Great Lakes has been drastically altered by human activities, including both planned and accidental species introductions. Deterioration in water quality, loss of habitat, and dramatic changes in aquatic biota parallel the increasing use of the region's resources through mining, fishing, logging, agriculture, hydropower development, and industry. Despite changes in fish communities, the Great Lakes fishery remains today an important resource for the region, contributing to the economies of the eight riparian U.S. states and the Canadian province of Ontario.

Historically, the Great Lakes supported a tremendous commercial fishery of lake trout *(Salvelinus namaycush),* sturgeon *(Acipenser fulvescens),* whitefish *(Coregonus clupeaformis),* walleye *(Stizostedion vitreum vitreum),* lake herring *(Coregonus artedii),* and blue pike *(Stizostedion vitreum glaucum)* (Baldwin et al. 1979). Throughout most of the twentieth century, the reported annual commercial fish harvest in the Great Lakes has remained near 45,000 tons, but the composition of the catch has changed significantly (Kelso et al. 1996). Most native fish populations in the Great Lakes suffered dramatic declines between the mid-1800s and mid-1900s. The collapse of these fisheries has been attributed to the combined pressures of decades of overfishing, habitat degradation, and the invasion of the exotic sea lamprey (Jude and Leach 1993). The sea lamprey is a fish parasite believed to have been introduced into Lake Ontario via the Hudson River and Erie Canal and was first observed in the 1830s. The lamprey migrated into Lake Erie in 1921 after the opening of the Welland Canal and made its way into Lake Superior by 1938 (GLFC 1999). Lake trout became extinct in Lakes Michigan, Ontario, and Erie, nearly extinct in Lake Huron, and reduced to dangerously low levels in Lake Superior by the mid-1950s (Jude and Leach 1993). Basin-wide commercial lake trout harvest declined from 5,248,000 pounds in 1926 to 503,100 pounds in 1960, forcing Great Lakes states to ban commercial lake trout fishing (Baldwin et al. 1979).

In 1955, the United States and Canada signed the binational Convention on Great Lakes Fisheries, establishing the Great Lakes Fishery Commission to implement lamprey control measures, coordinate fishery research activities, and advise the two governments on how to best manage their common fish stocks for maximum sustained productivity. By 1966, the lamprey population had been brought under control through selective lampricide treatment of spawning streams in Lakes Superior, Michigan, and Huron. Concurrently, stocking programs were underway to introduce Pacific salmon into the Great Lakes to control burgeoning alewife *(Alosa pseudoharengus)* populations, an exotic forage species that responded favorably to the disappearance of lake trout from the ecosystem. Eventually, lamprey control and salmon stocking were undertaken in all five of the Great Lakes (Jude and Leach 1993).

Today, the sport fishery based on non-native salmonids is an important component of the regional economy. The expanding sport fishery generates between two to four billion dollars annually in the Great Lakes region (Talhelm 1988). The American Sportfishing Association estimates that in Wisconsin alone, the total economic impact of the Great Lakes sport fisheries is $199 million, which includes angler spending and subsequent stimulated economic activity (Maharaj and Carpenter 1996). In contrast, the annual commercial harvest in the Great Lakes region is valued at $270 million (Talhelm 1988). While these numbers are not directly comparable, they demonstrate the increasing importance of sport fishing in the region. As a result, fishery managers have felt increasing pressure to expand sport fishing opportunities (primarily non-native species), often at the expense of commercial fishing.

Despite significant improvements in water quality since 1970 and a resurgence in some native fish populations, rehabilitating native fish stocks and stabilizing the aquatic ecosystem remain elusive goals that are often at odds with one another. Lake trout rehabilitation efforts, with the exception of Lake Superior, have generally failed to achieve stable reproducing populations due to loss of genetic strains, poor habitat, and competition with non-native species (Jude and Leach 1993). Overfishing remains a concern for many species. Exotic nuisance species, such as the sea lamprey, continually challenge natural resource agencies' budgets and ability to manage the resource. Long-lived toxic chemicals affect the wholesomeness of fish as human food. Habitat degradation through wetland loss and shoreline development continue to reduce the available spawning and rearing habitat for many species. Further, changing social conditions over the last 40 years have forced management institutions to address new public values and concerns. These changes include a reduction in commercial fishing of native stocks in favor of recreational fishing of introduced species, the emergence of tribal groups exercising legitimate commercial and subsistence rights that did not exist 50 years ago, increasing public concern about Great Lakes environmental quality issues, and well-organized environmental groups.

Authorities for Great Lakes Fishery Management

Donahue (1988*a*) describes the complex milieu of actors involved with managing the Great Lakes as an "institutional ecosystem" consisting of local, state, federal, and international entities. In the Great Lakes region, management responsibilities for the fishery resource fall primarily under the jurisdiction of eight states and one province, although tribal agencies and the two federal governments play a major role in many aspects of fishery management.[1] Great Lakes management is particularly complicated by the fact that the responsibility for environmental protection and resource management are often divided between separate agencies. Experiments in regional government are also common in the Great Lakes. Organizations such as the Great Lakes Fishery Commission, International Joint Commission, Great Lakes Commission, and Council of Great Lakes Governors all play a role in Great Lakes management.

Canadian responsibilities for managing the fishery resource are divided between the federal government and the Province of Ontario. Under the British North America Act of 1867, the federal government has exclusive legislative jurisdiction over protection and development of the fisheries. The federal government also has indirect jurisdiction through its authority to intervene in interprovincial and international matters. Under British common law, the provinces are the proprietors of the natural resources within their boundaries. The Canada-Ontario Fisheries Agreement clarified the dual federal-provincial responsibilities somewhat; the federal government may legislate for the regulation and protection of the Great Lakes fishery, but the provinces may exercise their proprietary rights to allocate the fish under their jurisdiction as long as these acts are consistent with federal legislation (Thompson 1974). Canadian federal authority is demonstrated primarily through its focus on research, environmental quality, habitat issues, and the establishment of treaties with the United States. Provincial authority is manifest through licensing, permitting access to the resource, and setting harvest restrictions and goals (Dochoda, unpublished). On the southern side of the border, the Great Lakes states have supreme control over fisheries, including the right to stock fish, manage habitat, and regulate harvest with one limitation, the Commerce Clause of the United States Constitution. The U.S. federal role for managing the Great Lakes fishery is still being defined but is expressed primarily in matters of navigation, environmental quality, habitat protection, endangered species, exotic species, and international treaties. The U.S. federal government has played a role supportive to the states and tribal governments through research, fish stocking, and law enforcement. In the U.S., these arrangements reflect a strong states' rights bias in fishery management.

Native American rights in the Great Lakes basin vary widely between the U.S.

and Canada. In the U.S., off-reservation fishing rights are rooted in treaties with the federal government. The U.S.-Ottawa treaty of 1836 preserves tribal fishing rights in the northern Michigan waters of Lakes Superior, Michigan, and Huron. In Wisconsin, the 1842 treaty with the Chippewa preserves tribal fishing rights for the Red Cliff and Bad River tribes in Lake Superior. Tribes with off-reservation fishing rights have established intertribal agencies to regulate their members' activities. The Great Lakes Indian Fish and Wildlife Commission and the Chippewa-Ottawa Fishery Management Authority have considerable authority to manage fisheries and, for the most part, operate independently of state regulations. The rights of Native Americans in Canada are much less clear and are still being defined in the Canadian Supreme Court. In these cases, the Court has devised a test that assigns aboriginal fishing rights a high priority along with commercial fishing, and less priority to recreational fishing. In general, the provinces retain authority to regulate Indian fishing, and it is unlikely that Canadian Native Americans will achieve the same control over fisheries that has been reserved by the U.S. tribes (Dochoda, unpublished).

The Great Lakes Fishery Commission

In spite of obvious declines in shared fish stocks, efforts to establish an international fishery authority for the Great Lakes between 1893 and 1952 failed repeatedly. Ontario, being outnumbered by the states, desired a convention that would allow full representation of its interests on a one-to-one basis with the states. Attempts at establishing a convention between Canada and the U.S. included the 1908 Treaty between the United States and Great Britain on Fisheries in the U.S. and Canadian Waters and the 1946 Convention between the United States of America and Canada for the Development, Protection, and Conservation of the Fisheries of the Great Lakes. The U.S. Congress failed to ratify these agreements due to the unwillingness of the states to relinquish management authority to an international body (Dochoda, unpublished). Initiatives by the states and provinces to coordinate among themselves were opposed by the U.S. Department of State and the U.S. Congress on the grounds that they violated the Supremacy Clause of the U.S. Constitution.[2] The crisis that precipitated true cooperation on fisheries management in the Great Lakes was the destructive power of the exotic sea lamprey. Recognizing that state and provincial fish managers were incapable of responding effectively to the sea lamprey, the governments of the United States and Canada ratified the 1955 Convention on Great Lakes Fisheries, establishing the binational Great Lakes Fishery Commission.

The Commission was charged with a set of duties that can be characterized as primarily "study-and-advise" (GLFC 1983). Under the 1955 Convention, the Commission was authorized to formulate a research program designed to determine what measures were necessary to maximize the sustained production of fish stocks of concern in the Great Lakes, publish results of this research, and recommend appropriate management measures to the United States and Canada. In addition to the Commission's general role in coordinating fisheries research, the Commission was charged with the specific task of formulating and implementing a comprehensive program for the purpose of eradicating or minimizing the impacts of the sea lamprey in the Great Lakes.

The Commission consists of four[3] appointed commissioners from each nation for a total of eight, each with a single vote. Appointments to the Commission are made by the President of the United States and the Privy Council of Canada for staggered six-year terms. Two commissioners in each section represent federal interests and two represent state or provincial interests. Carroll D. Besadny, former secretary of the Wisconsin Department of Natural Resources, served as a United States commissioner between 1990 and 1996. The Convention stipulates that any decision or recommendation from the Commission requires approval from both the U.S. and Canadian sections. The Convention allows each section of the Commission to establish an advisory committee for each of the Great Lakes, and the advisors have the right to attend all sessions of the Commission. To carry out the duties set forth in the Convention, the GLFC has the authority to conduct investigations, implement lamprey control measures, and hold public hearings in the United States and Canada. The Convention authorizes the Commission to appoint an executive secretary, retain staff, acquire facilities, contract with other parties, and spend money to cover the joint expenses of carrying out its duties.

The U.S. enabling legislation, the Great Lakes Fisheries Act of 1956, established a mechanism for appointing advisors to the GLFC and defined the terms of reference for advisors. Under the terms of reference, advisors are appointed to the Commission from each lake, based upon recommendations of the governor of each state. Each state is allowed up to four advisors for each lake, representing the state agency with jurisdiction over the fishery, the commercial fishery, the sport fishery, and one public-at-large interest. Typically, the advisors are agency officials and influential fishery people. The Canadian section has never established a strong relationship with its advisors nor has it developed a structured mechanism for choosing advisors. Dr. Henry Regier, a former Canadian commissioner, believes that this lack of interest in advisors can be attributed in part to the absence of strong federalism objections from Ontario with respect to Canadian federal involvement with Great Lakes fisheries (Henry Regier, former GLFC commissioner, personal communication 11 Oct 1998).

The Commission is jointly funded by the U.S. and Canada. Administrative costs are split evenly among the two nations, while sea lamprey control costs are split 69% from the U.S. and 31% from Canada, according to historic lake trout harvest records. U.S. appropriations come primarily from the U.S. State Department, and Canadian funding comes out of the budget of Fisheries and Oceans Canada. This funding arrangement is vehemently supported by the eight Great Lakes states and the tribes, who view the State Department as being a neutral force in the dynamic interactions of the region, as opposed to a competitive funding source among the state, tribal, and federal fisheries programs (Jim Addis, director, Wisconsin Department of Natural Resources Bureau of Integrated Science Services, former Wisconsin fisheries director, personal communication 3 Nov 1997). Additional funding is sometimes available through grants from agencies such as the U.S. National Oceanic and Atmospheric Administration under the Department of Commerce and through partnerships with federal and state agencies implementing the GLFC's programs.

The GLFC maintains a full time staff (the Secretariat) in Ann Arbor, Michigan. The Secretariat carries out the administrative responsibilities of the GLFC, providing support, leadership, and institutional memory for the various management committees and technical boards. The Secretariat also plays an important role in carrying out the Commission's duties under the joint Strategic Plan. The Commission is required by the Convention to "in so far as feasible, make use of the official agencies of the Contracting parties and of their Provinces or States and may make use of private or other public organizations, including international organizations, or of any person" (GLFC 1983). The Commission has contracted with the U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Army Corps Engineers, and the Department of Fisheries and Oceans Canada to conduct fisheries research, implement lamprey control measures such as lampricide application in spawning streams and construction of lamprey barriers, and maintain fish hatcheries for use in rehabilitative lake trout stocking programs.

The Commission supports the work of several management committees and boards to carry out its responsibilities. The Sea Lamprey Integration Committee is responsible for coordinating the GLFC's lamprey management program and consists of a variety of members from academia and government agencies. The Board of Technical Experts serves as an independent, expert, and professional panel to advise the GLFC on technical matters relevant to the Commission's mandate. Board members are selected without consideration of agency or institutional affiliation. The Board currently has established four task groups dealing with biodiversity, habitat, lake trout rehabilitation, and alternative sea lamprey control. The Habitat Advisory Board is charged with identifying current and emerging habitat issues that may impede fishery goals, proposing strategies for habitat rehabilitation, assisting Lake Committees develop environmental objectives in fish management plans, and communicating the GLFC's habitat goals to resource managers, interest groups, and the public. Habitat Advisory Board members represent federal environmental agencies, federal fishery agencies, academia, tribal management agencies, the International Joint Commission, and non-governmental environmental organizations. Members of these boards are appointed by the Great Lakes Fishery Commission. The Commission also supports several state and provincially appointed boards and committees, including the Lake Committees, Fish Health Advisory Committee, and Law Enforcement Committee. Decisions on these boards and committees are made by consensus of the members, and when consensus cannot be reached, all viewpoints are presented to the Commission in technical reports.

State, provincial and tribal authorities participate on formal Lake Committees that exist independently of the GLFC. These Lake Committees are arguably the most important management institutions with respect to the Great Lakes fishery. Although the Lake Committees do not report directly to the GLFC, their activities are intricately linked to the Commission's mission. Thus, the Lake Committees are often viewed as the implementing arms of the Commission. The GLFC originally helped to establish a Lake Committee for each of the Great Lakes to coordinate implementation of the sea lamprey control program and to carry out many of its research and advisory duties. The Lake Committees consist of one senior fish manager from each agency with jurisdiction over the lake and include tribal representation.[4] The federal governments are not represented on the Lake Committees. The Council of Lake Committees is comprised of twenty-one members selected from the various Lake Committees. The Council's primary function is to coordinate activities among the Lake Committees, respond to requests made by any of the Lake Committees, and consider issues pertinent to or referred by the GLFC. The Council provides a forum for state, provincial, and tribal agencies to develop and coordinate joint research projects, share data, establish harvest objectives, and consider issues of common concern to member agencies. The Lake Committees have been tremendously successful at bringing the managers together to discuss fish management issues. Dochoda reports that state and provincial satisfaction with progress under the Lake Committees was so high that the Great Lakes states rejected an opportunity to form a regional fishery management council under the U.S. Magnuson Fishery Act of 1976 (Dochoda, unpublished). Instead, the state and provincial agencies requested, through the Lake Committee forums, that the Commission assist with the development of the joint Strategic Great Lakes Fishery Management Plan (Fetterolf 1988).

Emerging Roles: The Joint Strategic Plan

The signing of the joint Strategic Great Lakes Fishery Management Plan was the most important advance in Great Lakes fishery management. Francis and Regier (1995) claim that such advances occur when ecosystems, institutions, and societies become congruent. These advances are characterized by "inevitable bursts of human learning" that proceed with "less conflict and more creativity" (Francis and Regier 1995). The Strategic Plan was developed during the era of New Federalism in the early 1980s, as federal oversight in state and regional management activities was finding disfavor. The states saw an opportunity to delineate their authority and preclude intervention from well-funded federal agencies with broad mandates (Jim Addis, personal communication 3 Nov 1997). The development of the plan was a logical activity for the GLFC under its study-and-advise mandate.[5] The GLFC facilitated the plan by providing funding, policy guidance, and a neutral forum to develop mutually beneficial strategies for fishery management. The Commission secured the commitment of each agency by creating a Committee of the Whole, consisting of natural resource agency directors, each with veto power (Fetterolf 1988). This support was necessary to ensure that the agencies would take ownership of the plan and become implementers and advocates (Jim Addis, personal communication 3 Nov 1997).

The original Strategic Plan was signed in 1981 by top-level state, provincial, and federal agency directors to express their mutual commitment to interjurisdictional and interdisciplinary coordinated fishery management. In 1986, the Chippewa-Ottawa Treaty Management Authority and the Great Lakes Fish and Indian Wildlife Commission joined the original twelve fishery agencies in endorsing and signing the memorandum of acceptance for the plan. Prior to the establishment of the joint Strategic Plan, arrangements for coordinating Great Lakes fishery management among the array of actors were informal, typically involving meetings among state fish biologists with jurisdiction over common lakes. These arrangements did not fully address the binational profile of the resource, nor did they regularly involve non-fishery–related Great Lakes managers (Carlos Fetterolf, retired executive secretary, Great Lakes Fishery Commission, personal communication 6 Nov 1997). The plan remained essentially the same until 1997, when it was revised at the request of the signatories to establish a stronger ecosystem management focus, ensure mutual accountability in steps to implement the plan, enable periodic review of the plan, and provide guidance to the implementing agencies.

While ceding none of their statutory and constitutional authority, the agencies agreed to work with the Great Lakes Fishery Commission through the Lake Committees and the Council of Lake Committees. These became the primary forums for addressing management problems that exceeded each agency's authority and ability to address individually. These problems include lost fishing opportunities, overharvest, instability of fish communities due to sea lampreys, introduction of exotic species, inadequate environmental quality due to conflicting objectives of fishery and environmental managers, competition and conflicts among users of the fishery resource, and climate change. The agencies agreed that changes to the plan should be made by consensus of all of the signatories. The Strategic Plan establishes four fundamental strategies for achieving common goals. These strategies deal with the following areas: consensus-based decision making, agency accountability, ecosystem focus, and information management (GLFC 1997*a*):

> Consensus must be achieved when management will significantly influence the interests of more than one jurisdiction. . . . Fishery management agencies must be openly accountable for their performance. . . . The Parties must exercise their full authority and influence in every available arena to meet the biological, chemical and physical needs of the desired fish communities. . . . Fishery agencies must cooperatively develop means of measuring and predicting the effects of fishery and environmental management decisions.
>
> —Strategic Great Lakes Fishery Management Plan, 1997

The Great Lakes Fishery Commission pledged to maintain and support the goals and processes outlined in the Strategic Plan and facilitate the plan's implementation. The Strategic Plan calls upon the Great Lakes Fishery Commission to resolve differences among the jurisdictions, undertake research for measuring and predicting the effects of management decisions, and provide institutional memory to avoid repeating past management errors. The Commission's specific duties under the Strategic Plan include the following:

- Maintaining and supporting the activities of the Lake Committees for the development of fish community objectives and identification of environmental issues impeding fish community objectives.
- Providing a mechanism for conflict resolution. If the Lake Committees cannot reach consensus on fish community objectives, the problem will be taken to the Great Lakes Fishery Commission for non-binding mediation or arbitration.
- Representing fishery interests in unresolved environmental issues to the appropriate body (e.g., the International Joint Commission, U.S. Environmental Protection Agency, Environment Canada).
- Establishing the expert Habitat Advisory Board to assist each Lake Committee in developing ecosystem objectives and identifying critical habitats essential to achieving its fishery objectives.
- Coordinating the development and implementation of standards for recording and maintaining fishery management and assessment data.
- Maintaining current internet links to the parties' databases and a catalog of fishery assessment and research data to facilitate access by the parties.

- Publishing a summary of the Lake Committee reports in the Commission's annual reports to the federal governments and the public.

In 1992, the GLFC issued its Strategic Vision for the Great Lakes Fishery Commission for the Decade of the 1990s (GLFC 1992). The vision statement renewed the Commission's commitment to the ecosystem approach and covered three interrelated areas: 1) maintain healthy Great Lakes ecosystems, 2) continue to apply integrated pest management approaches for sea lamprey control, and 3) develop and maintain institutional and stakeholder partnerships. The purpose of the Strategic Vision was to focus the direction of the Commission's programs and provide a framework to ensure that the programs were consistent with and complimentary to the Strategic Plan. The Strategic Vision provides milestones for measuring the progress towards implementation of the Strategic Plan. These milestones set goals for no net loss of habitat, lake trout restoration, reduction of toxic substances, integrated lamprey management, and delivery of complimentary programs through the Lake Committees. In summary, the Strategic Vision emphasizes the GLFC's commitment to providing leadership to the Lake Committees, coordinating fish management programs, developing coordinated programs for research, and strengthening partnerships among fish management agencies and non-agency stakeholders.

Implementing Ecosystem Management: Evaluation of the GLFC

In addition to maintaining its ongoing programs for Great Lakes research and lamprey control, the major activity of the GLFC in recent years has been implementing the Strategic Plan. The Commission has undertaken several initiatives under the Strategic Plan and the Strategic Vision, with variable success. These can be grouped into three broad categories: 1) facilitating interjurisdictional cooperation among fishery agencies, 2) establishing interdisciplinary coordination among natural resources and environmental agencies, and 3) implementing unilateral initiatives for ecosystem management and developing partnerships with non-agency stakeholders.

Interjurisdictional Cooperation

Overall, the GLFC and its various boards and committees enjoy a mutually beneficial relationship with state, provincial, and tribal agencies. An informal survey conducted by the Commission shows that the agencies generally believe that the Lake Committees, Council of Lake Committees, and the Commission's technical boards are serving a useful purpose, providing adequate forums for discussion and are appropriately charged (GLFC, unpublished). State and provincial support for the Great Lakes Fishery Commission can be attributed to the limited role assigned to the Commission under the terms of the 1955 Convention. Specifically, the Commission's limited autonomy and lack of regulatory power pose little threat to state management authority (Donahue 1998*b*). Because each nation has chosen to retain the sovereign right to manage its own resources in the way that maximizes national interests, the Great Lakes Fishery Commission has often played a quiet role in Great Lakes management, serving mainly as a forum for coordinating management activities through the Lake Committees and allowing the states to take the credit (Carlos Fetterolf, personal communication 6 Nov 1997). State fishery interests feel that the Lake Committees provide a valuable, non-hierarchical forum for high-level fish managers to share data, develop fish community objectives, and test new fish management approaches in the basin.

One of the most important initiatives under the Strategic Plan is the development of fish community objectives (FCOs) through the Lake Committees. The FCOs are essentially lake-wide fish management plans that describe the desired state of the resource. Fish community objectives are described by a species mix and the necessary ecological qualities (stability, balance, sustainability, and diversity) that will enable the communities to persist. Fish community objectives also contain measures of the fishing opportunities that the community offers (yield, allowable harvest, and recreational fishing hours). The objectives reflect the understanding that natural systems are dynamic and attempt to provide some flexibility to allow the agencies to adjust management approaches to meet changing conditions. Fish community objectives serve as the mechanism through which the states, tribes, and provinces work out their specific fish community, allocation, and harvest goals for the resource. The development of objectives requires each agency to identify its operational plans for achieving the FCOs and to submit changes to these plans to the Lake Committees. The Strategic Plan stipulates that the fish community objectives be determined by consensus. Any management activity that may affect one of the other parties must be brought forward in the Lake Committees. The Lake Committees are to work in concert with the lake-wide management plans (LaMPs) established under the Great Lakes Water Quality Agreement to identify issues that may impede achievement of the fish community objectives.

The Lake Committees have been successful in establishing fish community objectives for Lakes Superior, Huron, and Michigan. Draft fish community objectives have been established for Lakes Ontario and Erie, but have not been finalized because they have not been supported by the public and local politicians (Margaret Dochoda, fisheries biologist, Great Lakes Fishery Commission, personal communication 5 Nov 1997 and 17 Nov 1997). The establishment of fish community objectives represents significant progress towards interjurisdictional cooperation on fishery management. However, fish community objectives have been criticized as being an inadequate tool for coordinating habitat management, controlling exotic species, and meeting public demands for the resource. One of the criticisms is that the fish community objectives often lack adequate support (political and public) in the home jurisdiction. In particular, the decision to emphasize lake trout restoration in the fish community objectives was reached by the state and provincial fish chiefs, who were not always in a position to negotiate their agency's interests, especially in states with vocal sport fishery interests (Lee Kernen, retired Wisconsin Department of Natural Resources fisheries director, personal communication 4 Nov 1997). Several managers have questioned the effectiveness of establishing quantitative objectives in light of the rapidly changing resource conditions. Many managers feel that the fish community objectives are not sufficiently comprehensive and principle-based to serve as the basis for environmental planning in a dynamic resource (Lee Kernen, personal communication 4 Nov 1997). Further, there is no formal commitment to follow the fish community objectives in the home state until they are promulgated as state law, and there is no regulatory "hammer" to enforce the plans once they are published. The GLFC's sole influence in the development of fish community objectives is the technical assistance provided by the Habitat Advisory Board, and its financial support of the Lake Committees.

Nonetheless, the lack of enforceability has not impeded the implementation of the fish management plans. One of the unquantifiable advantages of the formal Lake Committees is that the agencies have been able to exert peer pressure on one another to improve cooperation in allocating the resource among jurisdictions, establishing common consumption advisories, coordinating lamprey control efforts, and identifying the best use of federally stocked fish (Carlos Fetterolf, personal communication 6 Nov 1997). A good example of how the Lake Committees function to manage the fishery is the recent announcement of chinook salmon stocking decreases in Lake Michigan for 1999. Concern over the forage base (primarily alewife) and a desire to avoid a population crash similar to what was experienced in the 1980s led Wisconsin and Michigan fish managers to agree on 27% decreases in chinook salmon stocking (*Wisconsin Outdoor Journal* 1999).

The cooperation among the different jurisdictions on the Lake Committees has been forced, in some instances, by the possibility of using the Commission to mediate differences on the Lake Committees, as provided for in the Strategic Plan. To date, the Lake Committees have only requested the Commission's intervention twice: once pertaining to the introduction of disease through stocked fish and once in Lake Erie due to a dispute over the allocation of yellow perch between Ohio and Ontario. In both cases, the parties settled their disagreements before the Commission could produce a non-binding recommendation (Margaret Dochoda, personal communication 5 Nov 1997 and 17 Nov 1997). The non-use of the Commission's mediation powers suggests that the states and province are unwilling to set a precedent by using the Commission to formally settle differences, for fear of relinquishing their authority to a regional institution. However, the results of a 1995 survey conducted by the Great Lakes Fishery Commission indicated that the Lake Committees have been frustrated by the lack of the Commission's ability to arbitrate differences on fish community objectives (GLFC, unpublished). The Strategic Plan was revised in 1997 to broaden the possibilities for alternative dispute resolution, including appointing a third party mediator or arbitrator. This provision has not been used, and it is difficult to predict how successful conflict resolution will be in the future. In all likelihood, the conflict resolution mechanisms will not be used, but the fact that they are present may exert enough pressure on the Lake Committees to reach consensus.

Interdisciplinary Coordination

Resource management and environmental protection have evolved under separate auspices. In an attempt to restore and maintain the chemical, physical, and biological integrity of the Great Lakes Basin ecosystem, the International Joint Commission (IJC), U.S. Environmental Protection Agency (EPA), and Environment Canada have undertaken comprehensive, lake-wide management planning activities (LaMPs). Remedial Action Plans (RAPs) have been developed to rehabilitate the severely degraded 43 Areas of Concern (AOCs) that do not meet one or more of the beneficial uses established by the Great Lakes Water Quality Agreement. Of the fourteen impairments to beneficial uses, several pertain directly to fishery management and fish habitat. These include restrictions on fish consumption, degradation of fish populations, fish tumors and deformities, degradation of phytoplankton and zooplankton communities, and loss of fish habitat. The RAP and LaMP initiatives have often failed to include fishery managers in the decision-making process. The concern over lack of participation is not new. In 1976, the GLFC issued a brief to the IJC titled "Environmental Quality and Fishery Resources of the Great Lakes." The brief addressed eutrophication, power plants, thermal pollution, dredging and spoils disposal, shoreline and nearshore habitat modification, toxic contaminants, and flow regulation (Johnson 1980). The primary concern was with the command-and-control approach to water quality management. The GLFC wanted to be able to influence water-quality management decisions, and the brief called for the development of a mutually productive consultative mechanism to address habitat issues. One of the thrusts of the Strategic Plan was to provide this consultative mechanism using the Lake Committees and the newly created Habitat Advisory Board. In 1986, the Habitat Advisory Board developed guidelines for fish habitat management and planning in the Great Lakes and actively engaged the Lake Committees to become more involved in habitat issues. Increasingly, RAP teams, the LaMPs, and the Lake Committees have mutually acknowledged that the loss of habitat is a serious concern (Hartig et al. 1996). However, many habitat rehabilitation efforts undertaken in the Areas of Concern (AOCs) are still not directly related to fish community objectives.

In an effort to achieve greater coordination and strengthened partnerships between environmental and fishery planners, the U.S. EPA, Environment Canada, and the GLFC's Habitat Advisory Board held a workshop in 1993 to discuss fish community goals in RAPs and to develop recommendations for achieving better coordination (Hartig 1993). Although fishery management planning has been initiated in all 43 AOCs, successful integration of fish and water quality goals has only occurred in Green Bay, Hamilton Harbor, and several AOCs in Canadian Lake Superior. The success of these remedial action plans was attributed to the availability of sufficient funding, numerous dedicated individuals who moved the RAP forward, and the proximity to high quality research facilities (Hartig 1993). Attempting to build upon the success of these RAPs, workshop participants emphasized that agreement on clear, quantifiable fish community and habitat objectives was necessary to direct remedial efforts and measure progress. The workshop called for accelerating the establishment of fish community objectives to guide water-quality planning efforts. Another recommendation was for fish managers with responsibilities in AOCs to work directly with the RAP teams to set quantitative targets. The workshop recognized that both top-down (senior agency staff) and bottom-up support (coordinated by local RAP teams) were required for successful integration of management activities.

Integrating water quality and fishery management in the Great Lakes continues to be one of the most difficult challenges, not only for the Great Lakes Fishery Commission, but also the parties involved in developing RAPs and LaMPs. One reason for the difficulty is that the RAPs and LaMPs tend to be planning-led activities that set specific targets for water quality and define actions to achieve those targets, while the fish management plans and fish community objectives tend to be more adaptive and learning-led (Margaret Dochoda, personal communication 5 Nov 1997 and 17 Nov 1997). This distinction is best demonstrated by the difference in time scales expected to achieve the goals. The RAPs often focus on short-term goals, while the fish community objectives address long-term ecosystem objectives. Another difficulty is that many of the fish community objectives were drafted before undertaking a complete assessment of physical habitat needs. The effort involved in reaching consensus on these objectives among the fishery agencies may preclude revisiting and redesigning the plans to accommodate the LaMP and RAP processes (GLFC, unpublished). Coordination has been achieved to some degree, with the Lake Superior Committee providing the Binational Program (Lake Superior LaMP) with aquatic ecosystem indicators and feedback on proposed initiatives. The best opportunities for coordination exist in Lakes Erie and Michigan, where the LaMP team has actively engaged the Lake Committees (Margaret Dochoda, personal communication 5 Nov 1997 and 17 Nov 1997). On a more basic level, many fish managers are simply not interested in participating in the RAP and LaMP processes because they view them as endless planning cycles with no teeth. In some cases fishery management agency personnel are already stretched too thin to participate in the RAP teams. Those fish managers that do participate in the process often do so on their own initiative, with no support from their agency (Lee Kernen, personal communication 4 Nov 1997).

Both the Great Lakes Fishery Commission and the International Joint Commission continue to attempt integration of these efforts, but the development of habitat objectives to link water quality and fish communities ultimately depends upon the state or province's ability to designate resources to address the problem. Neither the IJC nor the GLFC has any formal authority to coordinate these activities. The biggest challenges for integrating management initiatives are the lack of formal recognition of each other's authority and the absence of rules of engagement for consultation between planning groups. The GLFC continues to represent fishery interests on advisory and decision-making groups involved with environmental quality, but the Commission cannot force fishery managers to get involved with these groups (Fetterolf 1988). The 1993 workshop recommended that the terms of reference of either the GLFC or the IJC be expanded to ensure integration of environmental quality initiatives. This has not happened. In the meantime, more informal mechanisms including Lake Committee-LaMP initiatives and the IJC's biennial State of the Lakes Conference continue to be the primary mechanisms for integrating fisheries and water quality management.

Unilateral Initiatives

Underlying all fishery management activities in the Great Lakes is sea lamprey control. The lamprey problem has been described as a "coiled spring" that must be constantly managed or the population will bounce back. Without lamprey control, all of the other fishery management activities would be pointless (Carlos Fetterolf, personal communication 6 Nov 1997). Under the Strategic Vision, the Commission is attempting to move away from the use of expensive lampricides that are publicly unfavorable to more integrated lamprey control measures, including the release of sterile males and barrier dams, such as those found on the Brule River in northwestern Wisconsin. Integrated lamprey control draws on the experiences of integrated pest management strategies that use multiple mechanisms to control pest species. The GLFC relies heavily on input from the Lake Committees and technical committees to direct its lamprey efforts. Almost all parties would agree that the Commission has done a fine job in implementing its lamprey control strategy. In addition to lamprey control, the GLFC has sponsored a series of successful symposia on a wide variety of topics pertaining to the Great Lakes. These symposia have generated considerable interest in ecosystem management initiatives and have allowed fishery managers to interact with environmental managers on a professional level. The GLFC has also been successful in implementing the Strategic Plan's management information strategy. The Habitat Advisory Board has developed standard methods for evaluating habitat, and other technical committees have devised standards for stocking fish and measuring lamprey wounding rates. These activities have allowed the fishery agencies to share data. The GLFC has provided an on-line database of fish stocking efforts and sport and commercial harvest data from each state and for each lake in the basin. Lee Kernen, former director of fisheries for the State of Wisconsin, believes that the sharing and standardization of information has been the biggest success of the Great Lakes Fishery Commission (Lee Kernen, personal communication 4 Nov 1997).

Another priority under the Strategic Vision is improving the GLFC's partnerships and strengthening the role of its advisors in Great Lakes management. The Canadian Section has not established a strong advisory committee. According to Carlos Fetterolf, retired executive secretary of the GLFC, Canada did not clearly define the role for its advisors and none were initially appointed. Fetterolf pushed for the Canadian section to name an advisory committee. In the 1980s, the section authorized five appointments, although only two have been filled (Carlos Fetterolf, personal communication 6 Nov 1997). In contrast, the states have appointed advisors to the U.S. section, but the U.S. advisors have suffered from a lack of direction and guidance. In general, the advisors have not been effective in shaping the Commission's policies. The U.S. advisors are supposed to provide alternative viewpoints on the Lake Committees but generally represent a narrow range of vocal commercial and sport (primarily charter boat) fishing interests (Ed Michaels, Trout Unlimited, personal communication 18 Nov 1997). Despite the enhanced emphasis on the advisors, many people believe that the Commission failed to bring the right representation into the process from the start. One of the criticisms of the advisors is that they do not represent non-consumptive uses of the fishery, such as environmental interests, local citizens, navigation, and other industry (Ed Michaels, personal communication 18 Nov 1997; Dan Thomas, Great Lakes Sportfishing Council, personal communication 5 Nov 1997).

Achieving the 1955 Convention's goal of maximizing the sustained productivity of the fishery depends upon promoting healthy ecosystems and controlling the sea lamprey. The Strategic Plan recognizes that this will require flexible, adaptive management to deal with changing environmental conditions and scientific uncertainty. Adaptive management strategies are becoming widely used where management actions often have unintended consequences. Because managers rarely fully understand the complexity of the system they are trying to manage, adaptive management provides a way for assessing the impacts of management decisions and redirecting efforts as research demonstrates that change is needed. Hartig et al. (1996*b*) maintain that adaptive management requires adequate assessment, research, and monitoring to define the problems, establish cause and effect relationships, evaluate remedial options, and document effectiveness.

The Commission has continued to develop a research program to determine the appropriate measures for supporting healthy Great Lakes ecosystems and for controlling the sea lamprey. Commission-sponsored research takes advantage of the skills of a variety of fisheries experts. The GLFC cooperates with governmental and non-governmental agencies to carry out its research program. For instance, the Commission contracts with the Great Lakes Science Center, the Department of Fisheries Oceans, the Ontario Ministry of Natural Resources, universities, and tribal agencies. The states rely on the Commission's research to investigate issues that they cannot tackle alone. This research provides vital information for both the Commission and fish managers to develop science-based fishery programs and has been used to improve coordination among fish management agencies. Based on its research programs, the Commission distributes funds to the Lake Committees through its Coordinated Activities Program. Recent research initiatives have addressed the need for tighter ballast management to prevent exotic species introductions, examined the life history of the sea lamprey to develop integrated control techniques, investigated fish diseases transmitted through stocked fish, and supported the development of environmental objectives through partnerships with the Habitat Advisory Board, Board of Technical Experts, U.S. EPA, and Environment Canada (GLFC 1995). The level of research support the Commission will be able to provide is threatened because funding for the GLFC's research activities has not kept pace with needs. This has hindered many initiatives that are critical to evaluating new management actions and supporting current programs in the Great Lakes.

The Great Lakes Fishery Commission, like many agencies, is being forced to do more with less. Table 1 demonstrates the funding level for the Fishery Commission for 1995, the latest year for which numbers are readily available. Sea lamprey management is the largest expense for the GLFC. Beginning in 1992, the Commission began submitting budget requests based upon actual program needs instead of anticipated government contributions. The annual program requirements and cost estimates are submitted at two levels: one that will deliver a base program of lamprey control and one that will deliver the base program plus additional initiatives necessary to meet the Commission's mandate. In 1997, the Commission requested a 66% funding increase (over 1995) to offset level funding throughout the 1990s. The 1997 budget requested $21.5 million to deliver the objectives outlined in the Strategic Vision for the 1990s (GLFC 1997*b*). Despite this request, funding for 1996, 1997, and 1998 remained stagnant at $12.5 million. This trend may be changing. The minister of Fisheries and

Table 1. 1995 Funding.

	United States	Canada	Total
Sea lamprey management	$8,173,750	$ 3,748,177	$ 11,921,927
Administration and general research	$ 629,250	$ 549,250	$ 1,178,500
Total	$8,803,000	$4,4297,427	$ 13,100,427

Source: GLFC 1995 Annual Report.

Oceans, Canada, announced that Canada will provide $6 million in fiscal year 1999 to support the sea lamprey control program. This represents a substantial increase over the previous year and will allow the Commission to continue to fund other programs and important research in 1999 (GLFC 1998).

Without additional funding, the Great Lakes Fishery Commission will find it increasingly difficult to commit resources to non-lamprey–related Great Lakes research and the Lake Committees. As is typical of learning-led management institutions, the Lake Committees have limited autonomous financial resources. The individual agencies have cooperated to pool resources, but these activities are threatened as state government cutbacks force agencies to use their resources in other areas. As support dwindles, the Lake Committees will not be able to constructively engage the relatively well-funded LaMPs (Dochoda, unpublished). The commitment to adaptive management made in the Strategic Plan requires a strong commitment to research to evaluate the results of management activities. As funds become limited, the Commission must focus a larger proportion of its budget on lamprey control (Carlos Fetterolf, personal communication 6 Nov 1997). The Great Lakes states, Province of Ontario, and tribal agencies have supported the Commission's requests for additional funding to provide for more sea lamprey control and research, especially in the St. Mary's River, which produces lampreys that kill nearly 50% of the lake trout in Lake Huron. It is estimated that it will cost $1.2 million annually to treat the St. Mary's for lamprey (GLFC 1997*b*). The additional resources provided by Canada for fiscal year 1999 will allow the Commission to begin necessary lamprey control programs on the St. Mary's River.

Challenges for the Future

The Commission was initially established to eliminate the sea lamprey and, indirectly, to protect the commercial fishery. Since 1980, the Commission has been able to transform itself into an integral partner in Great Lakes management, and its programs have undergone a transition away from lamprey control towards ecosystem management. This transition has been possible because the broad scope of the 1955 Convention allows the GLFC considerable flexibility in implementing its responsibilities for "maximizing the sustained productivity" of fish stocks. Even with the flexibility afforded to the Commission under the Convention, implementing an ecosystem approach to fishery management in the Great Lakes will require overcoming many institutional challenges. Francis and Regier (1995) recognize that Great Lakes organizations are driven by their policy and legal mandates, not intergovernmental agreements. These agreements are not accountability-forcing documents, and nobody is ultimately responsible for achieving ecosystem integrity or ecosystem health. The challenge for the Great Lakes Fishery Commission will be to improve interjurisdictional cooperation and interdisciplinary coordination on issues of common concern without regulatory oversight. Past efforts to coordinate water quality and fishery goals have not been entirely effective, and new mechanisms for achieving integration must be sought. One feasible approach would be to combine the Great Lakes Fishery Commission's State of the Lakes Reports with the International Joint Commission's Biennial Report on the Great Lakes Water Quality Agreement or cosponsoring a State of the Lakes Conference, similar to the IJC's State of the Lakes Conference but with expanded terms of reference to engage the other management interests.

Another challenge will be to clearly define the goals of ecosystem management for the Great Lakes Basin and translate these goals into implementable actions. Since there is a general reluctance to relinquish state and provincial authority to a regional authority such as the GLFC, this will necessarily include fostering greater stakeholder participation in fishery management activities. Experience has shown that successful ecosystem management requires effective coordination among multiple resource management authorities, participatory planning by local interests, consensus-based decision making, interdisciplinary team building, conflict resolution, and adaptive strategies for dealing with unforeseen consequences of management activities (MacKenzie 1990, Hennessey 1994, Holland 1996). The success of the Strategic Plan and, ultimately, ecosystem management in the Great Lakes will depend on engaging the appropriate stakeholders in management decisions. The Commission has failed to achieve the milestones set forth in the Strategic Vision for improving stakeholder participation. Without public support for the ecosystem approach, it is unlikely that the Commission will be able to secure the necessary support from the governments of the United States and Canada to continue many of its critical research and coordinative functions.

One way to improve cooperation among the participating agencies and stakeholders would be the adoption of a Great Lakes code of conduct for responsible fisheries under the model developed through the United Nations Convention on the Law of the Sea (United Nations 1982). The Canadian Department of Fisheries and Oceans has already adopted a Canadian Code of Conduct for Responsible Fisheries. Many of the articles of the United Nations Convention have been informally implemented in the Great Lakes Basin, and the GLFC should play a key role in bringing the United States and Canada together to fully develop a workable code of conduct for the Great Lakes (Henry Regier, personal communication 11 Oct 1998). Bringing the necessary parties to the table to discuss a Code of Conduct is a daunting task. The difficulty in defining the role of public participation in ecosystem management can be illustrated by briefly reviewing the controversy that exists regarding lake trout rehabilitation, which has been termed a metaphor for the larger issue of whether fishery management should be principally concerned with the optimization of human uses of the resource or with the restoration and protection of ecological structure and function (Lange and Smith 1995).

The oligotrophic Great Lakes fish communities were traditionally dominated by lake trout, and lake trout restoration is the cornerstone of the fish community objectives developed by the various Lake Committees. In spite of a concerted effort in all of the Great Lakes to rehabilitate lake trout with stocking, lake trout populations, with the exception of Lake Superior, have not responded as well as mangers had hoped (Kernen 1995). The management rationale for lake trout rehabilitation continues to be that an ecosystem that ensures abundant, reproducing diverse stocks of lake trout would certainly protect most other constituents of the cold-water community. The lake trout is a long-lived predator species that could naturally reproduce and lend ecosystem stability that is not obtainable under an artificial stocking program. But it is also a species that, because of its fatty flesh, concentrates lipophilic substances and may not provide a safe-to-eat sport fish. Fish managers have come to realize the dichotomy of the two distinctly different goals of restoring self-sustaining populations and providing recreational fishing opportunities (Lange and Smith 1995). The impediments to lake trout restoration are not only biophysical, but socioeconomic.

A recent survey showed that state and provincial Great Lakes fish managers remain committed to rehabilitating lake trout (Knuth et al. 1995), but many are reevaluating their fish community priorities in light of increasing political pressure from sport fishing interests. State and provincial managers showed stronger support for maintaining artificial fish communities than federal agencies, due to the traditional relationship between anglers and state managers (i.e., the license fee). Although fragmented, sport fishing interests (particularly charter boat captains) view lake trout rehabilitation as in direct competition to their preferred species, the Pacific salmon, and are often vehemently opposed to rehabilitation efforts (Dan Thomas, personal communication 5 Nov 1997). Some in the sport fishing community would rather see the money spent on propagating and stocking non-native species, rather than continuing to fund failing rehabilitation efforts. Other sport fishing groups, such as Trout Unlimited, view the re-establishment of native fisheries as the ultimate goal for fish management in the Great Lakes (Ed Michaels, personal communication 18 Nov 1997). Commercial fishermen view the lake trout as a hindrance to capturing their preferred species, due to restrictions placed on gillnetting for perch and whitefish. Although the lake trout have historically been a large portion of the commercial catch, for the foreseeable future, there will not be a sufficient population to allow a directed harvest. Sport and commercial fishing interests are in direct competition with each other for a limited resource. As the sport fishery expands, sport fishermen view the commercial harvest as a threat to their fish and blame the state managers for failing to control commercial harvest. Another important stakeholder in the fish community includes non-consumptive users, such as environmentalists and environmental agencies working to improve water quality. They support lake trout rehabilitation because the lake trout serves as a way to measure water quality improvements and ecosystem health (Marshall et al. 1987).

The fish-community objectives are an attempt to give direction to management actions undertaken by the various fishery agencies by focusing on a set of ecological principles. But these ecological principles must be tempered by social values. Historically, the states have not opened up the decision-making process to a wide range of fishery stakeholders. Fish managers have assigned differing priorities to stakeholder viewpoints, with the state or provincial fishery agency being the most important, followed by the GLFC, federal fisheries agencies, provincial or state environmental agencies, agency-appointed advisory groups, the angling public, commercial fisheries, tribal governments and local legislators, sportsmen's associations, Great Lakes environmental groups, and lastly, charter boat captains (Knuth et al. 1995). Public support can only be guaranteed by involving all of the stakeholders in the decision-making process to set the priorities for fish management activities through the Lake Committees. Although the GLFC does not have direct authority to implement management programs, it can encourage discussion between government managers and fishery stakeholders through the Lake Committees. The Great Lakes Fishery Commission should encourage discussion among the fish managers about their role in educating the public about the value of maintaining native stocks. The Commission could play a larger role in publishing information about the value of native fisheries, using their web site, press releases, and technical reports.

Simply engaging and educating the stakeholders will not be sufficient to meet everyone's goals for the resource. Lee Kernen, former Wisconsin Department of Natural Resources fisheries director, believes that a native lake trout and Pacific salmon fishery are not exclusive, but merely different routes to the same goals. Instead of an all-or-nothing approach, Kernen recommends following a more balanced management scheme that will continue to provide sport fishing opportunities while allowing more time for lake trout rehabilitation to occur. This approach recognizes that the fish communities will never return to what they were before human perturbations, and public perceptions about the fishery should be included in management decisions. The approach advocated by Kernen is similar to the rapid biotic and ecosystem response strategy proposed by Doppelt et al. (1993) for the Pacific Northwest, which calls for protecting refuges of undisturbed habitats first and then attempting restoration on a priority system. If this approach is to be successful in the Great Lakes, fish managers must manage sport anglers' expectations for the resource, rather than increasing stocking to meet demands. They must also tighten commercial harvest quotas to compensate for the efficiency of modern technology. Kernen believes that the future of the fishery will depend on managers listening more to both consumptive and non-consumptive users because management decisions based on science alone cannot provide resolution for competing values (Kernen 1995). Regardless of scientific soundness, policies that lack support within society's views and values will fail.

> The public doesn't identify well with a [mayfly] hatch or a one-meter improvement in Secchi-disk value. The public is pragmatic. Their support is needed to fund programs to clean the Great Lakes. . . . the current challenge is to develop strategies without destroying the fisheries and losing public support.
>
> — Lee Kernen, 1991

Conclusion

The Great Lakes have been managed as an international resource for over 90 years by the United States and Canada. Both countries are proud of their history of cooperation in managing this shared multipurpose resource. The continuation of the Great Lakes Fishery Commission is critical to maintaining this cooperation on fishery issues. In the short term, fish management goals may be in conflict with ecosystem management. This can be resolved by expanding the temporal scale of fish rehabilitation. The life span of lake trout is over twenty years long, and efforts to rehabilitate the species will expand over more than one professional career. Thus, long-term political support and institutional memory will be required to fully rehabilitate the Great Lakes. Fishery managers need to expand their definition of stakeholders and fully include all interests in the decision-making process. Improved communication and participation with stakeholders can be achieved by emphasizing successes and fostering a sense of public ownership in the process. Building an ecosystem management framework in the Great Lakes will require developing institutional mechanisms that enable long-term agency commitments. This task is difficult because the arrangements for Great Lakes management reflect the dispute over centralized (regional and federal) versus decentralized (state and provincial) control. Further, Donahue (1988*a*) claims that political realities cannot be avoided while searching for the optimal management framework for the Great Lakes. These realities include the experimental nature of regional institutions, aversion to large-scale institutional reform, lack of commitment to cooperative management, and the failure of existing institutions to exercise their full powers under their mandates. While the ideal management framework may be indescribable and unattainable, the GLFC's flexible mandate will allow it meet the needs of the resource and provide the institutional leadership for fishery management. The GLFC's activities continue to be supported by tribal, state, provincial, and federal agencies, and the Commission is uniquely poised to emphasize ecosystem management for the entire region.

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Endnotes

[1] Government agencies responsible for Great Lakes fish management are (alphabetically): Canada Department of Fisheries and Oceans, Chippewa-Ottawa Treaty Fishery Management Authority (U.S.), Great Lakes Indian Fish and Wildlife Commission (U.S.), Illinois Department of Natural Resources, Indiana Department of Natural Resources, Michigan Department of Natural Resources, Minnesota Department of Natural Resources, National Marine Fisheries Service (U.S.), New York State Department of Environmental Conservation, Ohio Department of Natural Resources, Ontario Ministry of Natural Resources, Pennsylvania Fish and Boat Commission, U.S. Fish and Wildlife Service, U.S. Geological Survey (Biological Resources Division), and the Wisconsin Department of Natural Resources.

[2] The Great Lakes Basin Compact of 1955 was not ratified by the U.S. Congress until 1964, after provisions allowing membership for Ontario and Quebec were rewritten to give the provinces solely a consultative role. Although not specific to fishery issues, the GLBC was an attempt to coordinate many aspects of Great Lakes management.

[3] The number of Commissioners was increased by a diplomatic memorandum from three to four per section, with one U.S. alternate, primarily to address U.S. concerns about inadequate representation from the lower lakes.

[4] Lake Ontario Committee: New York, Ontario. Lake Erie Committee: Michigan, New York, Ohio, Ontario, Pennsylvania. Lake Huron Committee: Michigan, Ontario, Chippewa-Ottawa Treaty Fishery Management Authority. Lake Michigan Committee: Illinois, Indiana, Michigan, Wisconsin, Chippewa-Ottawa Treaty Management Authority. Lake Superior Committee: Michigan, Minnesota, Ontario, Wisconsin, Chippewa-Ottawa Treaty Management Authority, Great Lakes Indian Fish and Wildlife Commission.

[5] Initially, recalcitrant states claimed that the agreement was a violation of Article I of the U.S. Constitution which states "No State shall enter into any Treaty, Alliance or Confederation." However, the U.S. State Department construed the Strategic Plan to be simply rules of engagement, and not to empower the GLFC with new authorities or create a new alliance.

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