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From the Editor

Rocks and more rocks! That phrase provides an apt description of the two weeks my spouse and I enjoyed in England's West country and in Wales this past summer. During the first of those weeks, we were among the thirty people enrolled in a course on "West Country Geology and Scenery" taught by Peter Hardy for the Summer Academy 2000 at Bristol University. Armed with information and images from rock and fossil samples we examined in the classroom, from Peter's fascinating slide-illustrated lectures, and from his book on *The Geology of Somerset* (Bradford on Avon: Ex Libris Press, 1999), we thirty amateur geologists eagerly embarked on our daily bus trips. We climbed and crawled, slogged and scrambled, from Burrington Combe and Cheddar Gorge in the Mendip Hills to Portishead along the Severn estuary, from the coast at Watchet to the Malvern Hills in Worcestershire, and from the wetlands of Somerset and the sandy formations at Bridport on the English Channel to the high quarries and mining sites at Ham Hill and the Forest of Dean. We reentered the Paleozoic and Mesozoic Periods as we studied Devonian red sandstones, carboniferous shales and oolitic limestones, siltstone and red and gray banded marls from the Triassic, and the fossil-rich dark-gray shales and limestones of the lower Lias, the first unit of the Jurassic.

Rocks and more rocks! A highlight of our second week was the time we spent in breathtakingly beautiful Snowdonia National Park in Wales, including a full day's outing up and down the flanks of magnificent Mt. Snowdon, which reaches to some 3500 feet above sea level. Up we went in 90 minutes by Snodownia Railway (steam-driven); down we returned by foot, hiking for four hours along a rocky pathway trodden by thousands of others over the years.

Our rocky vacation was notable, too, for the fascinating fossils we came across on several of our outings. We were especially taken by the scores of ammonites we encountered, especially in the shales of the tidal flats at Watchet. These cephalopod molluscs with coiled plane-spiral shells lived in the sea during the Jurassic and Cretaceous Periods and then became extinct. At Watchet, site of the first scientific recording of the species *Psiloceras planorbis,* the ammonites range in size from some only as big as a fingernail to others nearly a foot and a half across and in variety from smooth to strongly-ribbed types. The specimens that garnered most of our oohs and aahs, however, were those of *Caloceras johnstoni,* amazingly preserved with their original mother-of-pearl luminescence that shimmers in shades of red and green.

Rocks and more rocks! One of the realizations that came to us during our visit to the English West country was that we were treading on land that, millions of years ago, had been sandwiched much more closely between what are now the continents of Europe and North America. In fact, we were in a place that, like the place we now call Wisconsin, may have lain astride or been near the equator in Paleozoic times! The old roadsign we used to pass in Door County, "Halfway to the North Pole," still brings a chuckle when we consider the Silurian limestone, rife with fossils of ancient tropical reefs, that is visible all over the county.

The current issue of *Transactions*, it must be admitted, is not devoted to rocks! Furthermore, unlike those long-extinct ammonite fossils at Watchet, the life-forms discussed in this year's articles generally are still with us. Some of them, however, are under threat of extinction in Wisconsin or elsewhere. **James Evrard and M. Eloise Canfield** provide information about the status of the Blanding's turtle, a threatened species in Wisconsin, in the wetlands of the Crex Meadows Wildlife Area. In a second article, **James Evrard** surveys archaeological and historical records to document the wildlife found in the Northwest Pine Barrens of Wisconsin during the period 1650–1850. In a third article **Evrard** reports survey results on the status of several species of birds and amphibians that currently inhabit the little-known pine barrens wetlands in and adjacent to the Namekagon Barrens Wildlife Area. Another of Wisconsin's protected areas, the Necedah National Wildlife Refuge, is a home to the Karner blue butterfly, listed as a federally endangered species. **Richard King** evaluates the reliability of three standard survey methods used to monitor the populations of these endangered beauties and to provide information that might be useful to helping their recovery. One common threat to the native biodiversity of any region comes from invasions of exotic species. **D. Timothy Gerber** reports on the extent and impact of the exotic eurasian watermilfoil on the distribution and abundance of native aquatic plants in Forest Lake within Kettle Moraine State Forest in Fond du Lac County. Archaeologist **James Theler** provides a survey of the abundance of animal species evident in occupational remains at nearly three dozen archaic, woodland, and Oneota Native American sites in western Wisconsin and neighboring areas. One sobering statistic is provided by the large shell "middens" (refuse heaps) that testify to the great quantities of freshwater mussels (several species of which are now unknown in the region) that once were harvested by native peoples in parts of the Upper Mississippi River Valley.

A major contribution towards mapping and understanding the mosaic of ecoregions in our state is provided by **James Omernik, Shannon Chapman, Richard Lillie,** and **Robert Dumke**, in their presentation on "Ecoregions of Wisconsin." This study is designed to aid integrated assessment and management of Wisconsin's environmental resources across agency and program lines.

In an article rich in human interest, **Cathleen Palmini** brings together the self-narrated migration stories of four women from Scotland, Germany, Vermont, and New York. Their writings convey fascinating descriptions of the ups and downs of their challenging boat journeys—including seasickness, homesickness, and shipwreck—

across the Atlantic Ocean and through the Great Lakes on the way to settlement in Wisconsin during the mid 1800s.

Finally, as a parting salute to the many special events that marked last year's observance of the fiftieth anniversary of *A Sand County Almanac,* we are pleased to feature one more article on Wisconsin's now legendary "Land Ethic" proponent Aldo Leopold. **Curt Meine**, of the International Crane Foundation in Baraboo, provides an insightful assessment of how a variety of responses to and adaptations of Leopold's work and ideas reflect developing trends in conservation history. Meine's concluding question, "Whither Leopold's legacy?," invites all who care about Earth (including the rocks!) to remain actively engaged in discovering how best to live on and with the land.

Rocks and more rocks—and turtles and butterflies and mussels and aquatic plants and ecoregions and pioneering women and Aldo Leopold! All of us who worked together to produce this issue of *Transactions* hope that its contents will inform, delight, and challenge all its readers.

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.

Curt Meine

The Secret Leopold, or Who Really Wrote *A Sand County Almanac?*

"Aldo Leopold was a forester and wildlife ecologist who wrote *A Sand County Almanac,* a collection of essays about the natural world and conservation. The book was published posthumously in 1949. *A Sand County Almanac* went on to become one of the key texts of the environmental movement. Leopold is closely identified with 'The Land Ethic,' the final essay in the *Almanac,* in which he argued that people are part of the 'land community,' and so bear moral responsibilities that extend beyond the realm of the human to include the nonhuman parts of that community."

This would be a fair and accurate answer to the question "Who was Aldo Leopold?" But is it a sufficient answer? To conservationists and historians, at least, the question is increasingly urgent. Leopold defined challenges that remain at the core of conservation thought and practice more than a half-century after his death, even as conservation concerns increasingly overlap other issues in contemporary life. The social, philosophical, political, economic, and cultural demands being made upon Leopold's legacy are increasing. At the same time, the living memory of Leopold must inevitably fade as direct connections to Leopold slip into the all-welcoming past. Paradoxically, it will become both harder and easier to answer the question: "Who *really* wrote *A Sand County Almanac*?" What we may gain in detachment and critical judgment, we shall lose by having first-hand impressions no longer available to us.

That these concerns are of more than passing importance is plain. We may turn, for example, to the January 1998 issue of the *Journal of Forestry,* the field's premier professional journal. Its cover featured Aldo Leopold and beckoned with the question: "Has Leopold Supplanted Pinchot?" (i.e., as the guiding philosophical force behind American forestry). The lead article, by a professor of forestry, offered "Another Look at Leopold's Land Ethic"—a harsh critique of the ideas in

Leopold's famous essay. The first sentence of the article read: "Aldo Leopold's influence is based largely on a brief essay, 20 pages long, that outlines what he calls the 'land ethic.'"[1] The author's argument, and a counter-argument by environmental philosopher and Leopold scholar J. Baird Callicott in the same issue, prompted intense discussion among foresters and others, and led to further rounds of discussion within the journal.[2]

The point here is not to examine the play in this particular volley of critique and response, but to note that our knowledge of Leopold is, and must be, increasingly contingent not on the reality of the living human being, but on the received images and impressions of that reality. Leopold the human being belongs to the ages. Leopold the source and symbol has been and will be shaped according to the ideas, questions, and requirements—and also the fears, blind spots, and prejudices—of subsequent generations.

The above-quoted lead sentence from the *Journal of Forestry* article illustrates how time inevitably narrows the field of impressions of the rich, complex, multi-dimensional reality that is an individual human life. In the case of Aldo Leopold, attention has often focused largely on his writings in *A Sand County Almanac* (or even, as in the above instance, just one essay within the *Almanac*). This focus has profoundly shaped our ways of thinking about Leopold. There is Aldo Leopold, who lived a life, and wrote toward the end of it a memorable book. Then there is "The Author of *A Sand County Almanac,*" a figure who for fifty years has been a mirror to our relationship with the natural world, and has borne the burden of our environmental hopes and fears. There is some confusion between the two.

A Legacy Entire

For readers, reviewers, and scholars, Aldo Leopold displays as many facets as there are perspectives. Consider the variety of fields that can—and do—legitimately claim Leopold as an important figure in their development: forestry, wildlife ecology and management, outdoor recreation, range management, sustainable agriculture, wilderness protection, conservation biology, restoration ecology, environmental history, environmental ethics, environmental law, environmental policy, environmental education, literature.[3] Leopold remains a compelling figure, and *A Sand County Almanac* an irresistible focal point, in part because all these perspectives were tightly integrated in his personality and prose. There are, in a sense, many Leopolds. How, then, do we reconcile these many Leopolds with the singularity of Aldo Leopold as a human being?

We may begin with a brief review of the basic facts of Leopold's life and the wide range of his contributions. For those who know of Leopold purely through *A Sand County Almanac,* the story bears retelling.[4]

Leopold belonged to the first generation of trained American foresters, graduating from Yale University's Forest School in 1909. In a nearly twenty-year career with the U.S. Forest Service, he gained expertise in a wide range of sub-fields, including soil and water conservation, game protection, range and watershed management, and recreational planning. Leopold earned a reputation within the Forest Service as one of its most able and creative leaders, highly regarded for his innovations in forest administration. In the 1920s he spearheaded the movement to protect wildlands under the jurisdiction of the Forest Service, and was largely responsible for designation of the nation's first wilderness area, the Gila, on the

Gila National Forest, in 1924. A decade later, in 1935, he helped to found the Wilderness Society, providing a broad philosophical and professional base for the new organization. Leopold also conducted important field research in forest ecology during his Forest Service years, and in 1924 was appointed assistant director of the Forest Products Laboratory in Madison, Wisconsin. He remained in that position for four years.

After leaving the Forest Service in 1928 Leopold devoted himself to game (later wildlife) management as it emerged as a distinct field within conservation. Drawing upon contemporary advances in animal ecology, Leopold provided the field with its first textbook, *Game Management,* published in 1933.[5] He was named the nation's first professor of game management, also in 1933, at the University of Wisconsin. He guided the field through its first important decade, leading it beyond its original mission of perpetuating populations of game animals and integrating it with other conservation fields. In the process he provided foundations for later developments in ecology, sustainable agriculture, and conservation biology.

Leopold was also an early advocate and practitioner of ecological restoration—professionally at the University of Wisconsin's arboretum and other lands, and personally at his farm property in Sauk County, Wisconsin (which the Leopold family acquired in 1935). He was a widely respected communicator, constantly writing and speaking to varied audiences on a wide range of conservation topics. As a teacher he instructed leading professionals as well as hundreds of undergraduate students at the University of Wisconsin. He participated actively in dozens of professional societies and conservation organizations at the local, state, national, and even international levels, and was a prominent player in the development of conservation policy throughout his career.

As notable as Leopold's achievements were, all of the foregoing (and much else besides) occurred before he had even begun to contemplate the collection of essays through which the world would come to know him. Leopold's list of professional accomplishments was impressive long before he began work on the manuscript that became *A Sand County Almanac*—before, in fact, the voice of the *Almanac* had matured.

When did that voice first emerge, and how did it find its full expression in the *Almanac*? *A Sand County Almanac* was the product of the last ten years of Leopold's life.[6] Leopold would work some earlier materials into his evolving manuscript, but he began to sound the new tone in his essay-writing only after two hunting trips, in 1936 and 1937, to Mexico's Sierra Madre Occidental. After the first trip, Leopold prepared an essay he called "The Thick-Billed Parrot of Chihuahua," published in the ornithological journal *The Condor* in early 1937 (it would eventually appear in the *Almanac* as "Guacamaja"). Shortly thereafter, Leopold composed "Marshland Elegy," his moody reflection on Wisconsin's cranes and wetlands. *American Forests* published it later in 1937.

These new expressions reflected a new turn in Leopold's work. Increasingly in the late 1930s Leopold found himself teaching and writing toward a non-professional audience. In 1938, he published the first in an ongoing series of popular essays on wildlife conservation for the *Wisconsin Agriculturist and Farmer,* and in 1940 he wrote two more essays about Mexico and the Arizona, "Song of the Gavilan" and "Escudilla."[7] Leopold was not yet thinking about collecting these essays into a book. However, he was encouraged by the positive response of friends and colleagues and continued to write in this new vein.

The voice of Aldo Leopold in *A Sand County Almanac,* then, was late in its development. It first emerged in the late 1930s, just as Leopold was fully integrating his conservation ideas (a phase culminating in 1939 with publication of his essay "A Biotic View of Land" in the *Journal of Forestry*).[8] The Aldo Leopold that most of the world knows, admires, and criticizes is really the late Leopold, and then only that part of himself that is found in the pages of the *Almanac.* It was of course one of the ironies of Leopold's life that he would not live to see *A Sand County Almanac* published or to know its influence. Indeed, he would never even know his book by that title, which was assigned posthumously; his name and the book title became paired only after Leopold's death in April 1948.

Changing Perspectives on Leopold

What perspectives on Aldo Leopold's legacy do we inherit? How has public understanding and appreciation of his work changed? Because Leopold's legacy is still being discovered by environmental professionals and by the general public, and is revisited constantly by those who do know it, the answers to these questions remain dynamic. In retrospect, however, we can identify several general phases in the evolution of Leopold's public reputation. Those phases, in turn, tell us much about what various audiences have sought out—or neglected—in the record of Leopold's experience.

Leopold among His Contemporaries

We can begin by assessing Leopold's reputation during his own lifetime, or more precisely in the last years of his life, as he was pulling together the manuscript that became *A Sand County Almanac.* It is useful to distinguish between Leopold's local and "more-than-local" reputation. Within the state of Wisconsin, and especially at the University of Wisconsin, Aldo Leopold was a recognized figure, though by no means "famous." He had played a leading role in several important conservation policy initiatives at the state level in the late 1920s. In 1933 he joined the university, assuming a new and experimental Chair of Game Management within the College of Agriculture's Department of Agricultural Economics. Leopold was not an academic by background, and his field of expertise had not yet gained intellectual definition or professional acceptance. Securing wildlife conservation's foothold in academe would be one of Leopold's premier accomplishments in the remaining fifteen years of his life.

For some time, Leopold remained, according to Arthur Hawkins, one of his early graduate students, "suspect." Hawkins recalled that Leopold was "not part of the academic crowd" and "a real novice" in understanding the social ecology of the university campus.[9] In the words of another student of the time, Frances Hamerstrom, he was "very thoroughly respected by a rather small, select group; in general, he wasn't even noticed."[10] By the late 1930s and early 1940s, when Hawkins and Hamerstrom worked most closely with him, Leopold had acquired a large circle of good friends and colleagues within Madison, but continued to lead a relatively quiet academic life.

By contrast, Leopold was very well known and highly regarded among his professional colleagues in conservation around the country. His national reputation had risen steadily over the decades, especially as wildlife management staked out its own territory among the conservation professions in the

1930s. Another student, H. Albert Hochbaum, with whom Leopold collaborated during the early stages of the *Sand County Almanac* manuscript, saw that this wider reputation had to color Leopold's writing. He wrote to Leopold in 1944: "If you will put yourself in perspective, you might realize that within your realm of influence, which is probably larger than you know, Aldo Leopold is considerably more than a person; in fact, he is probably less a person than he is a Standard. . . . Just for fun, then, as you round out this collection of essays, take a sidewise glance at this fellow and decide just how much of him you want to put on paper. . . ."[11]

Of those few who were reading Leopold's draft essays, Hochbaum most deeply appreciated the task of self-reflection and self-expression Leopold had taken on. He may also have had the keenest sense of how others viewed Leopold. In 1947, after attending a conference of wildlife managers, Hochbaum wrote to Leopold, "For a long time the crowd has been more or less following (and sometimes objecting to) the *rules* of wildlife management that you have prescribed. Now they are beginning to follow your *philosophies*, by and large without realizing whence they came. That is progress!"[12] Hochbaum, a pioneer in waterfowl biology who was also a skilled illustrator and writer, saw into dimensions of Leopold's private life and public persona that others missed, and he understood well the larger creative challenge that Leopold had assumed in the *Almanac* essays.

During his lifetime, Leopold's reputation reflected many qualities: his facility with words, the effectiveness of his teaching, the breadth of his conservation philosophy, and especially the degree to which he matched word and thought with deed. His professional impact was far-reaching, especially within wildlife management and forestry. By the end of his life Leopold was well aware of his professional prominence, and it is fair to say that he was quietly proud of it. At the same time, the older he grew—particularly in the last three years of his life, from the end of World War II until his death—the more he could look back on his accomplishments with a mature and self-confident modesty. He was certainly humbled by his own earlier mistakes. He communicated this most notably and famously in the essay "Thinking Like a Mountain," in which he recounted his role in the extirpation of the wolf from the American Southwest.[13]

Leopold, however, was far from universally admired by his contemporaries. He often found himself caught in thickets of controversy. The most prominent instance of this derived from his role in Wisconsin's "deer wars," the drawn-out and vitriolic battles over the state's deer management policy in the 1940s. Leopold's determined advocacy of herd reduction made his name well known—and oft-blasted—among some portions of Wisconsin's populace (including many hunters, anti-hunters, and resort owners). Leopold neither welcomed nor enjoyed the notoriety. Although decades of front-line conservation battles had thickened his skin, he now felt as viscerally as ever the difference between his view of conservation and that of "that collective person, the public."[14] Out of such controversies came the self-awareness that Leopold expressed only rarely and guardedly, the calm sadness in his observation that "one of the penalties of an ecological education is that one lives alone in a world of wounds."[15]

The deer management fight was only one of many instances in which Leopold staked out unpopular or controversial positions. He continued to wage wilderness protection battles up until the end of his life. He did not hesitate to use his voice directly and forcefully to protect threatened wild lands, to counter indiscriminate wartime incursions into untrammeled country, to slow the post-war juggernaut of dam-building, to restrict what he saw as inappropriate uses of designated wilderness areas. He remained an adamantly active member of the Wilderness Society until his death. The cause of wilderness protection had not yet achieved the wider acceptance that would come with the battle of the early 1950s over the proposed Echo Park dam within Dinosaur National Monument. As America entered the era of post-war economic boom and political paranoia, Leopold occasionally found himself at odds even with old colleagues within the conservation movement over the wilderness issue.

Leopold was known among his peers as a hard-headed critic, though a fair, constructive, and thoughtful one. In the last decade of his life Leopold became increasingly blunt in his view of the direction taken by universities and government agencies. He was notably critical of the trend toward increasing specialization and toward what he called "power science" within the academy. He wrote in 1946, "Science, as now decanted for public consumption, is mainly a race for power. Science has no respect for the land as a community of organisms, no concept of man as a fellow passenger in the odyssey of evolution."[16] Some of Leopold's most forceful prose (published and unpublished) addressed this theme. In many ways, "The Land Ethic" itself was the ultimate expression of his concern.

At the end of Leopold's life, then, his conservation work was well known, widely appreciated, and occasionally contentious, but he himself was little known outside of the professional conservation world. He was one of several voices from within the movement (including especially William Vogt and Fairfield Osborn) that in the immediate post-war years sought to communicate the importance of the science of ecology to a broader public. As the manuscript of *A Sand County Almanac* went to press, however, its author remained "very thoroughly respected by a rather small, select group."

Leopold Reaches a Broader Audience

A second phase in public awareness of Leopold began with the publication of *A Sand County Almanac* and extended roughly to the mid-1960s. This spans the time from the first appearance of *A Sand County Almanac* to its later re-publication as a mass paperback. During these years two essentially opposing trends played out: on the one hand, the level of popular environmental awareness rose dramatically; on the other hand, the traditional conservation fields found themselves internally divided over the fundamental principles that Leopold and others had sought to define.

A Sand County Almanac helped to stimulate environmental literacy among the American public; conversely, readership of *A Sand County Almanac* and recognition of Leopold's contributions grew along with that increasing awareness. This mutually reinforcing process can be traced back to the earliest reviews of the book. The book was widely reviewed both locally and nationally, both by readers familiar with Leopold and by those learning of him for the first time. Because of the confluence of events, many reviews served in essence as obituaries of Leopold, as reviewers used the occasion to reflect upon Leopold's legacy. The reviews of the day thus provide a fair portrait of the state of his public persona.

August Derleth, perhaps Wisconsin's best known regional writer, reviewed *A Sand*

County Almanac for Madison's *Wisconsin State Journal.* Derleth knew of Leopold's work and was well familiar with the Wisconsin landscapes described in the *Almanac.* Although he and Leopold were not themselves intimates, they shared many acquaintances. Derleth wrote in his review, "All genuine conservationists throughout Wisconsin and the Midwest generally realize that in the death of Aldo Leopold, Wisconsin lost one of its most able men in the field of conservation. Posthumous publication of his book offers ample evidence that his death deprived us *also of an author of no mean merit.* His book is one of those rare volumes to which sensitive and intelligent readers will turn again and again"[emphasis added].[17] Derleth's phrasing is instructive. For most readers, Aldo Leopold would be known first and foremost, and often only, as an author. For Leopold's contemporaries, and especially local contemporaries, Leopold was known primarily as a conservationist.

Many of the national reviews of *A Sand County Almanac* were marked by a similar tone of surprise, delight, and deep respect, although the reviewers knew little if anything of Leopold's professional accomplishments. Lewis Gannett, in the *New York Herald-Tribune,* wrote: "Aldo Leopold died fighting a neighbor's fire in the spring of 1948. I am sorry, for I should like to have known him. I do not recall ever hearing his name until I stumbled on this book; to read it is a deeply satisfying adventure. This was a man who wrote sparsely, out of intense feeling and long experience. You will find here no statistics about erosion, no screaming warnings to 'do something about the soil.' Aldo Leopold was primarily concerned with the importance of feeling something. He himself felt deeply, and his feeling gives a rich texture to this too-short book."[18] Gannett did not know, of course, about Leopold's years of devoted statistic-taking on erosion, his many forceful pleas for action, his constant emphasis on the vital role of scientific research in conservation. Yet, all that was beside the point. Gannett was quite correct; in *A Sand County Almanac,* Leopold *was* "primarily concerned with the importance of feeling something."

It is an important point. New readers from beyond Leopold's personal or professional circles found here something unusual. The tone and style of *A Sand County Almanac* were quite different from that of other prominent conservation books of the time, in particular Vogt's *Road to Survival* and Osborn's *Our Plundered Planet,* both of which were published in 1948. These two prescient books on the state of the global environment were chock-full of statistics and warnings. Their authors read the future, and it was not pretty. Both books gained an immediate, sizable, and influential audience. Leopold shared their profound concern—he in fact knew both Vogt and Osborn and had read Vogt's book in manuscript—but he spoke in subtler tones. Leopold's book sold more modestly but, as it turned out, more steadily. *A Sand County Almanac* continued to gain readers through the 1950s and into the 1960s. By the mid-1960s, some twenty thousand copies had been sold, but mostly among dedicated conservationists and readers of natural history.

The significance of the *Almanac* becomes clearer when viewed in relation to the second general trend in this period: the ambivalence with which many conservation professionals regarded (if they regarded it at all) the path that Leopold and his like-minded colleagues had blazed. Through the 1950s, the professions in a sense left behind Leopold and those who shared his more integrated outlook on conservation challenges and solutions. In "The Land Ethic," Leopold had expressed concern over the growing division between conservationists who "[regard] the land as soil, and its function as commodity production," and those who "[regard] the land as a biota, and its function as something broader."[19] The former were gaining a firm upper hand.

Through the post-war era, the professions and disciplines became increasingly segregated. Engineering solutions replaced more agronomic or naturalistic approaches. "We are remodeling the Alhambra with a steam-shovel," Leopold lamented in "The Land Ethic, "and we are proud of our yardage." Soil conservation, agriculture, forestry, recreational planning, and range, fisheries, and wildlife management bent increasingly toward utilitarian ends, while ecology turned increasingly experimental, quantitative, and model-oriented. As the professions "modernized," Leopold and his generation came to be seen as important albeit old-fashioned predecessors. The kernel of their legacy—the integration of the natural sciences and humanities in the service of conservation—fell under the heavy tread of the steam-shovels.[20]

Leopold and the Environmental Awakening

That seed, however, would prove hardy. A third phase in public appreciation of Leopold began in the mid-1960s and would last roughly into the mid-1980s. Paperback editions of *A Sand County Almanac,* published in 1966 and 1970, brought Leopold to the very forefront of the incipient environmental movement. Rachel Carson's *Silent Spring* (1962), Stewart Udall's *The Quiet Crisis* (1963), and other books of the period created a growing critical mass of readers as *A Sand County Almanac* reappeared in its more accessible and affordable form.

As the paperback worked its way into the backpacks and reading lists of the baby boomers, a generation gap began to emerge in perceptions of Leopold and the application of his ideas. On one side were the more senior conservationists, many of whom personally knew and worked with Leopold or his contemporaries. On the other side stood the growing corps of younger environmentalists who knew of Leopold only through the *Almanac* essays. These younger devotees came into their environmental awareness as the landmark legislation of the era—the Wilderness Act (1964), the National Environmental Protection Act (1970), the Clean Air Act (1970), the Clean Water Act (1972), the Endangered Species Act (1973)—redefined the context of the older conservation movement.

Older and younger readers alike would invoke Leopold in support of their causes and adapt him in their approaches, but those causes and approaches did not always jibe. Underlying differences in (to cite just a few examples) the aims of resource management, attitudes toward hunting, appreciation of wilderness, and the role of political activism in solving environmental problems divided these audiences. Importantly, however, Leopold also served as a bridge across the generations. All were reading from the same book, a fact that would prove highly significant in the long run.

Leopold and the Re-integration of Conservation

By the 1980s, another demographic shift began to play out. Within the conservation professions, elders from the post-World War II generation began to approach their retirement years; older baby boomers rose through the professional ranks; and younger baby boomers, trained in the post-Earth Day era, entered those ranks. Meanwhile, non-professional readers of *A Sand County Almanac* went about their lives in their communities, the paperbacks still residing on their bookshelves, the words still working their quiet influence.

By the late 1970s and early 1980s, changes in society, in politics, and in the environment itself cast Leopold's words in new light. Systemic environmental problems—increasingly vitriolic disputes over national forest management policy, groundwater pollution problems due to intensified agricultural practices, climate change, global-scale threats to biological diversity, incessant suburban sprawl, and on down the list of modern conservation dilemmas—demanded more systemic solutions. Such solutions came to be explored under many names, including *ecosystem management, conservation biology, ecological economics, community-based conservation,* and *sustainable agriculture.* New terms—*biodiversity* and *sustainability* prominent among them—were invoked to broaden the conceptual ground on which conservation stood.[21] These responses, while novel in name, often returned for grounding to the fundamentals of integrated conservation, as outlined by Leopold and his contemporaries. As a result, Leopold's intellectual stock continued to rise through the 1980s and 1990s.

As we are still working within this most recent phase, we are unable to read it with clarity. But as the waves of passion in the conservation and environmental movements have swelled and subsided, Leopold's legacy has ridden through them all, and remained robust. Why and how? It has to do in part, of course, with the historic record of his accomplishments and the quality of his writing and thinking. But it has also to do with the welter of forces that keep Leopold relevant, that bring us invariably back to him, more sober but more ready perhaps to consider the subtleties of his work. These forces might include the following:

• **The fact of continuing environmental degradation, and the need for more integrated responses that are informed by ethics.** For those who see our fragmented approach to landscapes, their biota, and their human communities as a primary cause of environmental degradation, the search for solutions leads back to the integrated view that Leopold articulated finally in "The Land Ethic." Leopold's declaration of the ethical underpinnings of conservation has continued to gain attention and to have substantial impacts on national policy (through, for example, the shift toward ecosystem management in the land management agencies and in many conservation organizations).[22] Leopold regarded the lack of attention from philosophy and religion as "proof that conservation [had] not yet touched [the] foundations of conduct"; the consolidation of environmental ethics and the greening of religion may now be regarded as proof that it has at least begun to touch those foundations.[23]

• **The anti-environmental "wise use" movement.** As forces of opposition to conservation and environmentalism assumed greater power in the 1980s and 1990s, many younger environmentalists were compelled to revisit their roots and to learn (often for the first time) their connections to the older conservation movement. Likewise, more conservative conservationists were also led to examine their political loyalties. Even staunch conservatives began to rethink their priorities when Ronald Reagan named James Watt his Secretary of the Interior. For many in this period, Aldo Leopold stood out as one who did not place his politics before his conservation commitments. The relationship between political conviction and conservation action has always been complex. In his writing Leopold does not come across as an ideologue, and in life he was not. He has remained a relevant and flexible voice during a period of intense politicization of conservation.

• **The erosion of community.** During these same years many have sensed and tried to define the changes that are transforming our human communities.[24] Somewhere between the shoals of unwarranted nostalgia and uncritical economic optimism lies (we may hope) safe passage, but the route is difficult to discern. Renewed attention to communitarian values is an important part of contemporary social criticism. A parallel expression has emerged from within conservation, emphasizing the need to *re-place* communities, to see them in terms of the biophysical environments in which they are embedded. "Community" was a key word in Leopold's lexicon, and the "extension" of community that Leopold advocated in "The Land Ethic" has accordingly assumed increased importance.

• **The interdisciplinary imperative.** This pertains particularly to academia, where hyperspecialization and reductionism move on apace, opportunities for "thinking time" shrink, and the selective pressures on success continue to intensify. Such trends tend to overwhelm efforts to maintain connections among the sciences, arts, and letters. Leopold's characteristic interdisciplinary approach carries authority here. He stands as an example and reminder of a time before the need to specialize was ratcheted up several additional notches, and a greater share of rewards still accrued to those whose training, teaching, and work were broad and diverse.

These forces—and no doubt many others—have allowed Leopold's readers to see him in a new light, as one who identified tendencies that would increasingly characterize American society and the American landscape through the twentieth century. The implicit messages in Leopold's essays, spoken amid the bugling of cranes and the songs of wild rivers, have become more explicit. Yet, new readers can still respond to the faith Leopold felt down to his very marrow: that the future of the human enterprise on this (and any other) continent is tied fundamentally, if not always clearly, to the future of our wild co-inhabitants and landscapes.

A Taxonomy of Responses

Since *A Sand County Almanac* was published, most of its readers have remained unaware of the life that gave it shape, responding not so much to Aldo Leopold the historical personage as to "The Author of *A Sand County Almanac.*" For the general reader, this may be of small consequence; a good book stands on its own, and its quality endures regardless. (Does it matter that we know so little of the author of the Book of Job? That Shakespeare's life remains opaque to us? We know the author through the words and the story.)

It is the duty, however, of the historian and literary biographer to fill in the facts, to weigh the text against the life, and to provide the book with a sort of narrative *habitat.* Such scrutiny enriches our understanding of the creature itself—robbing it perhaps of some of its immediate mystery, but providing a richer appreciation of its existence. With such perspective, we may see in our prior responses and images a little less of Leopold and a little more of ourselves. What do we see when we reexamine "The Author of *A Sand County Almanac*"?

Leopold the Prophet

We encounter first, of course, Leopold the environmental "prophet." Leopold's daughter Nina Leopold Bradley, when asked to speak of her father's conservation philosophy, has sometimes referred to "that poor old land ethic." It is a great deal to ask one essay, or book, or person, to bear the weight of society's need to transform its relationship with the natural world. Over the decades, a disproportionate amount of that weight has fallen upon Aldo Leopold.

Among Leopold's contemporaries were several who recognized the full depth of Leopold's conservationist critique and first employed the all-but-inevitable tag of "prophet." Roberts Mann, a Leopold friend and superintendent of the Cook County (Illinois) Forest Preserve District, published an article in 1954 entitled "Aldo Leopold, Priest and Prophet."[25] Ernie Swift, another friend and colleague who led Wisconsin's Conservation Department, followed in 1961 with "Aldo Leopold, Wisconsin's Conservation Prophet."[26] Historian Roderick Nash, in his classic 1967 book *Wilderness and the American Mind,* called his chapter on Leopold simply "Aldo Leopold, Prophet."[27] The trope has endured. Wallace Stegner, not one given to hyperbole, regarded *A Sand County Almanac* as "the utterance of an American Isaiah. . . almost a holy book in conservation circles."[28] *A Sand County Almanac* continues to be referred to regularly as the "Bible" or "scripture" of the environmental movement.

This "prophet" tradition, whether one regards it as appropriate invocation or unnecessary overstatement, is instructive. Aldo Leopold has reflected a strong social need. Any social movement (especially in its emergent phase) requires a prophetic voice to give itself coherence and direction. Martin Luther King was the pre-eminent prophetic voice of the modern civil rights movement. For complex reasons, there was no equivalent iconic figure in the environmental movement. But environmental reformers could and did look back to find not only Leopold, but John Muir, Henry David Thoreau, and, among contemporaries, Rachel Carson and David Brower, Sigurd Olson and Barry Commoner, Edward Abbey and Gary Snyder. They became the movement's "prophets." As conservation itself continued to evolve at the turn of the twenty-first century, Leopold (among these others) continued to fulfill the prophet function.

Leopold the All-purpose Hero

One key factor set Leopold apart even within the pantheon of environmental prophets: he coupled the inspiration of his prose, thought, and activism with the authority of his experience. Leopold, unlike the others, wrote from a varied professional background in on-the-ground forestry, range management, wildlife management, wilderness protection, and restoration work. He was a respected figure in each of these fields and could speak to all his professional colleagues in their own languages. And so Leopold served another posthumous function: as an all-around, acceptable and accessible "conservation hero," able to appeal to a broad range of conservation factions—at least as long as the deeper tensions within conservation lay dormant.

One of the more interesting variations on this image of Leopold involved an unlikely source. The February 18, 1956, edition of the *Saturday Evening Post* featured a realistic sketch of Leopold in a full-page advertisement for the Weyerhauser company. The ad depicted Leopold, on bended knee with a fawn under his protective watch, against a clear-cut mountainside in the background. Aldo Leopold by this time was apparently seen as a reasonable conservationist who could support, as the text of the ad put it, "*true conservation* through the wise use and perpetuation of industrial forest uses" [emphasis in original].[29]

This Leopold-as-conservation-hero motif reflected conservation's growing mainstream constituency. By 1956 conservation, however vague, fuzzy, and pliable its definition, had become acceptable across a broad demographic spectrum. As long as Leopold represented the kindly and constructive school of *reasonable* conservation, even a major industrial force such as Weyerhauser could present his image in one of their prominent advertisements. It could, for the time being, ignore the fact that Leopold was a dedicated activist, a critical scientist, politically involved and often courageous, and not one to shrink from unseemly controversies involving conservation policy.

Leopold the Radical Environmentalist

If Leopold's work and words had helped to build a broader, more popular, better funded, more respectable, more mainstream environmental movement, it also inspired the counter-response. As environmentalism became more acceptable, it became, in the view of others, more diluted. And so we find another reading of Leopold's legacy in ascendance: Leopold as radical environmentalist and deep ecologist.

The most prominent example of this "redeployment" of Leopold came through the actions of the 1980s Earth First! movement. When Dave Foreman, Edward Abbey, and their compatriots launched the movement, they drew heavily upon Leopold in raising high the bar of compromise in conservation politics. Leopold's powerful image of the faltering "green fire" in the eyes of the dying wolf of "Thinking Like a Mountain" came to symbolize for this new generation of wilderness activists the loss of the North American wilds. "A militant minority of wilderness-minded citizens," they read in Leopold's essay "Wilderness, "must be on watch throughout the nation and available for action in a pinch."[30] At the same time, their philosophical standard-bearers in the deep ecology movement could point to "The Land Ethic" as a foundational document.[31]

Of course, counter-responses ensued. Hence the disgruntled forester, who groused in the *Journal of Forestry* that Leopold was merely a "starry eyed. . . pipe-smoking academician." Another suggested that the pipe held more sinister substances, noting that he [the reader] had "seen nothing that Aldo Leopold had to say that does not make me think that he was anything but the original pot-head."[32]

What do we learn from Leopold the Deep and Radical Ecologist? He reflected the increasingly polarity within the environmental movement as its influence rose through the 1970s and 1980s. During these years, the ranks of environmental professionals and bureaucrats burgeoned. Prior to that, if one were engaged in environmental work, one was likely an amateur—poorly paid (if paid at all) and engaged primarily out of a sense of public duty. By the mid-1970s, the scene was changing. Membership in the major environmental organizations was on the rise. As paid staffs expanded, professional expertise began to overshadow grassroots activism. Passion was nice, but a master's degree got you the job and respect. As the environmental professional class grew, however, the grassroots activists, driven by powerful social, political, and spiritual motives, hardly went away. The result, in a sense, was a splitting of the Leopold legacy. Suited professionals could see Leopold as a sort of master diplomat and spokesman, able to speak to all sides on environmental issues. Activists could see Leopold as a committed and deeply honest radical, whose message provided intellectual armor.

Leopold the Naïve Interloper

This category encompasses an entire suite of images. It refers to the response evoked as Leopold's interdisciplinary influence has come to be felt in fields not his own. This response may be traced in any number of fields; it will suffice here to examine it in philosophy, politics, and conservation itself.

As J. Baird Callicott has pointed out, that Leopold in fact *made* any contribution to philosophy is not a view that all philosophers have shared.[33] Consider the following statements. H. J. McCloskey, an Australian philosopher, suggested that "there is a real problem in attributing a coherent meaning to Leopold's statements, one that exhibits his 'Land Ethic' as representing a major advance in ethics rather than a retrogression to a morality of a kind held by various primitive peoples." Far from an advance in ethics, then, Leopold offered only retrogression. Another regarded Leopold the philosopher as "something of a disaster, and I dread the thought of the student whose concept of philosophy is modeled principally on these extracts from Leopold's writings." Another reviewer saw "The Land Ethic" as "dangerous nonsense."[34] In short, for a few of the more formally trained philosophers, Aldo Leopold's forays in this field are hardly worthy of serious consideration.

How does Leopold fare among politicians and political theorists? Somewhat better, actually, especially in recent years. Because Leopold's conservation politics defied conventional ideological pigeonholing, those searching for deeper political lessons have found his work in this arena especially instructive.[35] The same maverick quality, however, has also left Leopold open to easy criticism. Such criticism has come, on the one hand, from those who have preferred a more direct political approach to environmental issues. Thus, in 1974, still in the wake of the high wave of the environmental movement, we find an article entitled "The Inadequate Politics of Aldo Leopold." The author found Leopold's politics to be "wholly conventional, some would say naïve. From one point of view the wonder is not that he accomplished so much as a political operator, but that he accomplished so little. . . . One reason for Leopold's frustration was his own inability to face the likelihood that so fundamental a change in people's attitudes as he advocated would involve concomitant changes in the economic system and probably in the political superstructure. Again and again in his writing he seemed on the verge of some sort of ideological breakthrough, but appeared to draw back from the brink of discovery. In the political and administrative sector. . . this inexperienced administrator had little to offer for implementation of his 'land ethic' beyond a very traditional reliance on high-minded moral persuasion."[36]

If some saw Leopold's politics as naïve and inadequate in the highly politicized context of 1970s environmental activism, others would see his approach in a new light as that context continued to change. A decade later, Leopold's biographer (i.e., this author) could receive inquiries from a conservative journal interested in an article on Aldo Leopold, because they felt he was "an environmentalist we could live with." This is not as surprising as it may seem. Conservatives and libertarians can find much to agree with in "The Land Ethic." A core component of "The Land Ethic" is in fact Leopold's belief that individuals had to assume greater responsibility for the health of the land; that absent such responsibility, governments would inevitably need to step in, and governments simply could not assume or carry out all necessary conservation functions. The editors evidently saw here an opportunity to explore these "conservative" elements of "The Land Ethic."[37]

Aldo Leopold's politics were not naïve. As Susan Flader has shown, Leopold's sense of citizenship and civic responsibility was keen and evolved along with the changing currents in the conservation movement.[38] That we can read his politics as conservative and progressive, naïve and sophisticated, personal and public, again tells us as much about ourselves as it does about Leopold. It says, perhaps, that we have yet to evolve a politics that can respond in a healthy and democratic fashion to complex conservation dilemmas; that we are still struggling to find ways to protect, in Leopold's words, "the public interest in private land"[39]; that we continue to paw among our traditional political ideologies in search of solutions and find it very difficult to imagine where constructive alternatives may lie. For those deeply involved in the struggle to forge new relationships on and with the land and among the people who inhabit it, Leopold's politics, far from being naïve, remain instructive and encouraging. (And, yes, inspiring.)

The Leopold-as-naïve-interloper view has occasionally found currency within the conservation world as well. Many of Leopold's precepts of conservation were beyond the pale in his own day, and many remain so. More specifically, the breadth of perspective he brought to conservation was highly unusual, so that those who inhabited one portion of the conservation spectrum could not always appreciate his comprehensive view. (The story is told, for example, of the joke that went around the hallways of Wisconsin's state Conservation Department, about how to spell this word "aesthetic" that the Professor was always using).

Leopold was both a specialist (in several fields) and a generalist. But as the conservation professions specialized further in the years following his death, it became very easy for some to look back and regard Leopold as a dilettante in their increasingly insular fields. Hence, for example, latter day foresters could ignore Leopold's credentials in the field and claim in effect that he wasn't much of a forester after all.

Another "sub-heading" in this particular category involves the problematic (for some) fact that Aldo Leopold was also a life-long hunter. For this, Leopold has received his share of criticism from at least some anti-hunters, activists, and environmental ethicists. Conversely, he has been held high by conscientious hunters as a premier example of the ethically sophisticated and environmentally committed sportsman.

Leopold confronted the chasm in attitudes toward hunting directly and regularly in his own lifetime. The chasm grew only deeper in the years that followed. No less a figure than Rachel Carson, for example, had an outright disdain for the only Leopold, apparently, that she knew: the one of *Round River,* the collection of Leopold's hunting journal entries first published in 1953.[40] Carson's conservation ethic, of course, was more closely aligned with Albert Schweitzer's "reverence for life" philosophy than with a Leopoldian land ethic. *Round River's* portrait of Leopold the hunter was more than she could tolerate. The same response can be found, again, in the recent *Journal of For-*

estry critique, where we find the following lambaste: "Leopold preached the extension of ethics to all fellow members of the land community, and he practiced killing them until the end of his life."[41] Suffice it to say that this critic chose the bluntest of rhetoric to address one of the most sensitive issues in conservation and one of the most complex of human behaviors—one, it is safe to say, that Leopold pondered carefully and consciously on a daily basis for decades.

These dismissals of Leopold by selected philosophers, political activists, and even conservationists again track broad trends in society. In them we can read the impact of increased specialization and politicization in conservation. Divided into areas of special knowledge and special interest, conservation like other fields struggles to find coherent connections between the present and the past, the abstract and the actual, the sciences and the arts, philosophy and practice. By contrast, Leopold's written record reveals a mind at ease with complexity, open to mystery as well as to new data, and resistant to reductive tendencies in both science and politics.

He was, by all but unanimous consent of historical sources, a decent and delightful person to know and to work with, an inspiration to those working in conservation, tolerant of human foibles, and lacking in hidden demons. Ironically, such qualities may account for the challenge some have in "handling" Leopold. Modern readers, accustomed to irony and alienation and sensitive to political subtexts, may find Leopold's personality an increasingly difficult kind to get a hold on. In our contemporary attempts to resolve postmodern dilemmas, we may project them onto Leopold.

Several illustrations may serve to make the point. For years, a portrait of Leopold has hung on the walls of the Department of Wildlife Ecology at the University of Wisconsin in Madison. The artist chose to depict Leopold with cigarette in hand (an intermittent smoker, he preferred his pipe to cigarettes). Graduate students—if not the genuflectors—have appreciated the humanity in that particular icon. Then there was the survey question in *Sierra* magazine. The editors asked readers to respond to the query, "Can you eat meat and consider yourself an environmentalist?" Among the responses: "Remember: Aldo Leopold ate meat, Adolph Hitler did not."[42] The past calls out to us. . . from the far side of the postmodern minefield.

Leopold the Eco-fascist

More extreme examples of the above may be found on the far fringes. Because Aldo Leopold is a focal point for discussion of environmental ideas and strategies, he is occasionally criticized as an advocate of oppressive social and governmental actions to safeguard the environment. The reasoning is this: Leopold in "The Land Ethic" places the good of the collective, the community, the whole, the ecosystem, above the good of the constituent parts; he, therefore, would have the whole impose its will on the constituent members of that whole. (The irony, of course, is easily lost on many such critics, i.e., that Leopold saw individual responsibility, as articulated in "The Land Ethic," as the only sure antidote to such eventualities).

Many of these criticisms arise out of reasoned consideration of the difficult questions that Leopold's work—indeed, that conservation generally—poses. These arguments, well developed and thoughtful, appear in our academic journals and conference proceedings. So do effective counter-arguments.[43] Not all such exchanges, however, are so rational. One of the strangest, a 1993 letter to the editor of *Iowa State Daily,* criticized the mission of Iowa State University's Leopold Center for Sustainable Agriculture. Not content to question the institution, the letter-writer attacked Leopold as "racist," stating that "He believed in the superiority of the Nordic race. He believed that population growth has to be stopped; he rejected the sanctity of life and he scorned human beings so much that he believed the population of a country could be managed like an animal reservation."[44] However bizarre such rantings may seem, they are not to be dismissed lightly. We read into Leopold (however undeserving) not only our hopes and concerns, but our uneasiness and our fears.

There are, no doubt, other "Leopolds" that bear consideration. As the taxonomy fills out, we can begin to identify the several basic tendencies that mark much Leopold commentary and criticism. The most common, noted above, is to assume that Aldo Leopold existed only as "The Author of *A Sand County Almanac*"; that it is unnecessary to take into account other aspects of his conservation career; that the historical and personal context of the *Almanac,* however interesting, is of incidental importance. One may find this view among Leopold's devotees as well as his detractors.

A second common tendency is to divorce Leopold's publications from his practice. Leopold was a man of action as well as words, and the dynamic between these two spheres of his life may be the most significant of his many contributions. He tried to define a workable standard for conservation to follow and work toward. But he also worked toward it himself, and thereby humanized it.

A third common tendency is to read only that part of Leopold with which one feels most comfortable or conversant and to avoid confronting the entirety of the person, his expertise, and his record. Hence we find the critic who attends only to one of the several disciplines Leopold worked in, or one of the professions he practiced. Evidence of this tendency can be found in many the fields to which Leopold contributed, from wildlife ecology and agriculture to economics and philosophy.

Finally, another common tendency is to consider Leopold's work only up to a certain point in time. Hence, for example, the occasional wildlife manager who will read *Game Management* and appreciate it as the profession's founding volume, while ignoring or slighting the epic progression from *Game Management* (1933) to *A Sand County Almanac* (1949). Again, evidence of this tendency is widely distributed.

Leopold, in short, has been a mirror to our environmental responses. We see in him a succession of reflections over the decades since his death. In the years immediately following World War II, awareness of widespread environmental problems increased, and our fears grew apace. Leopold offered a way of understanding the human dimensions of these problems, and of imagining possible solutions. He cast warnings, as did others of the time, but tempered the warnings with wonder and wry humor, humility and poetry. In one essay after another, he leavened his conservation message not only through his expressions of love for "things natural, wild, and free," but also through his understanding of the human condition and of human shortcomings (including, of course, his own).

As the environmental movement coalesced in the 1960s and early 1970s, many found inspiration in Leopold's words. Leopold recognized clearly the harsh realities of environmental degradation, but provided a positive response to those realities.

In the academic and policy arenas, he showed how the sciences, literature, history, and philosophy not only could be, but *had* to be, brought together to address problems and suggest solutions. He contributed to the foundations upon which new, more integrated environmental policies and programs could be built.

Into the 1970s and 1980s, Leopold's words provided guidance not only for far-reaching policy changes, but in a sense for their complement: a well tempered understanding that conservation problems could not merely be legislated or administered away, but had to be addressed from within—within our selves, communities, cultures, agencies, businesses, organizations, and institutions. A sense of the limits of purely technical or political solutions gained ground. Stated another way, Leopold's land ethic was now read not just as a rationale for short-term technical fixes or policy initiatives, but as a guide to necessary longer-term social and cultural changes.

Finally, it seems of late that readers are responding increasingly to the degree of personal commitment that they find in Leopold. Leopold, although profoundly aware of harsh conservation realities, avoided the mire of despair. One of his most notable character traits was his capacity to face squarely and honestly a difficult conservation dilemma and to address it in a constructive manner despite overwhelming odds. This trait marked his literary endeavors as well, and never more so than in completing "The Land Ethic." Despite serious health problems and other difficult personal circumstances, he found the internal resources to pull together "The Land Ethic" as he completed his collection of essays in the summer of 1947. That strength of character rests between every line of *A Sand County Almanac.*

Whither Leopold's Legacy?

How will future generations respond to the Leopold legacy? What will they look for there, and what will they find? How will Leopold's work and thought reflect back upon them? Those questions are of course unanswerable, but we may speculate around the fringes.

The various disciplines and professions to which Leopold contributed are still struggling to gain historical self-awareness. Few foresters are taught the history of forestry. Few wildlife managers are taught the history of wildlife management. Ecologists are sometimes taught the history of ecology. Most professionals have a strong curiosity about their professional past, and seek it out, but only recently have more formal opportunities to understand this past arisen. Many still find Leopold's *A Sand County Almanac* a better history text than anything they receive through their formal training. Environmental history has emerged to fill in some of these gaps, but we still lack comprehensive treatments of the development of conservation through the nineteenth and twentieth centuries. This situation, if nothing else, will ensure that attention will continue to focus on Leopold, for the simple reason that his life provides a unique medium through which to address recurring issues, debates, developments, and trends in conservation. His life story will continue to offer critical insights into not only the past, but the future.

An inescapable dilemma will need to be taken into account. As noted above, Leopold's legacy is likely to become even more important with time, even as the immediate connections to that legacy inexorably fade. Conservationists will continue to examine that legacy, but Leopold's insights cannot serve if they are regarded as inert museum specimens. Leopold's legacy, if it is to remain vital, must be able to grow and evolve, to tolerate dissent, resist dogma, and welcome criticism.

Leopold's legacy already comes with built-in defenses. He was in many ways his own sharpest critic and anticipated many of the forces that might have led to the fossilization of his ideas. Many a critic will yet discover that Leopold was often there first and had already taken his own weakest points into account. Moreover, Leopold was not alone in his prescient views. He was, to borrow his words from "The Land Ethic," part of a "thinking community" that struggled to meet the conservation challenges of its day. We build upon the work, not simply of Leopold, but of a generation whose achievements and frustrations he articulated.

Students of Leopold's work are fortunate to have the testimony of primary sources, many of whom in the year 2000 are still with us. They have as well a generous inheritance of recorded impressions of Aldo Leopold upon which to draw. Alfred Etter, who studied with Leopold, penned in 1948 one of the more sensitive accounts. It appeared as an obituary, and described a day afield with Leopold. Etter's account captured well the enduring personal qualities of Leopold. At the family's shack, wrote Etter, "[Leopold] tried to piece together answers to the questions which Nature so often tempted him to solve. From pads of moss or patches of quack grass he learned a piece of history. From a tangle of ash logs a suggestion of some principle dawned upon him. From a broken pine a brief diagram of the balance of the forces in the environment was devised. Above all, this farm was a place where his children could learn the meaning of life and gain confidence in their ability to investigate small problems and discover things which no one knew."[45]

For those who consult the historic record, this understanding of Leopold's way of thinking and observing and conducting himself offers resistance to distortion. Paul Errington, another contemporary, also spoke to this, again in a 1948 obituary: "Let no one do [Leopold] the disservice of fostering Leopoldian legends or Leopoldian dogmas. Knowing him as I have, I can say that he would not wish these to arise from his having lived. I can imagine his gentle scorn at the thought of anything like elaborate statuary in his memory, while despoliation and wastage of the land and its biota continue as usual."[46]

Readers returning to Leopold will no doubt continue to find their own growth reflected in his words. Not uncommonly, readers who first encountered Leopold through *A Sand County Almanac* in their idealistic youth return years later to its pages to find the earlier inspiration now enriched by more subtle wisdom. For many, Leopold has become the proverbial parent who has "grown *so much wiser* since *I* was young."

A fine example of this can be found in a 1988 essay published in the *North Dakota Quarterly*. The author, Patrick Nunnally, recalled that he had first read *A Sand County Almanac* in the politically charged 1970s, when he was involved in wilderness protection battles in the southern Appalachians. He later moved to Iowa, where he found himself interacting more regularly with farmers. He also found himself asking what Leopold had to offer under those different circumstances. Nunnally recalls returning to the *Almanac*, only to find a broader appreciation of its value:

> [Leopold] establishes a grounding, a framework for conversation, without foreclosing much in the way of intelligent reflection and inquiry. It seems to me that I formerly used

> Leopold to end conversations: "This is what Leopold says, and that is the final word." Instead, I look to him now to keep me focused and to keep me reminded of the larger conversation and stakes of which individual land protection discussions are a part. His principles provide a steady foundation that guides my discussions with individual farmers about the possibilities for conservation tillage and that grounds abstract philosophizing about the need to overthrow the Western world view for an ecologically-just society. He still has value as a source for quotations—he writes better on this subject than nearly anyone else who has tried, and his particular phrases ring better than any of my own. But it is more important to me now that he provides exemplary inquiry to complicated problems, with more than one viable position but only one best position. What formerly I cited as received dogma, now, I hope, I can use as wisdom of a thinker who has preceded me in the land conservation debate.[47]

This is the more measured and better-balanced view of Leopold that we can anticipate and work toward. Finally, five decades after Leopold's death, we may appreciate his continuing influence without having to make him over into a deity or a devil, a hero or a threat, without having to regard him as naïve, radical, old-fashioned, or prophetic. This is the kind of critical attitude that pays due honor to Leopold by reflecting not merely our desires or our fears, but our *growth.*

Notes

1. Boris Zeide, "Another Look at Leopold's 'Land Ethic,'" *Journal of Forestry* 96,1 (January 1998), 13-19.
2. J. Baird Callicott, "A Critical Examination of 'Another Look at Leopold's "Land Ethic,"'" *Journal of Forestry* 96, 1 (January 1998), 20-26. The April 1998 issue of the *Journal of Forestry* featured eight further commentaries. These articles were reprinted by the Society for American Foresters in a Forestry Forum publication, *The Land Ethic: Meeting Human Needs for the Land and Its Resources* (Bethesda, Md.: SAF, 1998).
3. For a compilation of Leopold's writings, with commentary, in these diverse fields, see Curt Meine and Richard L. Knight, *The Essential Aldo Leopold: Quotations and Commentaries* (Madison, Wisc.: University of Wisconsin Press, 1999).
4. For biographical treatments of Leopold, see Susan L. Flader, *Thinking Like a Mountain: Aldo Leopold and the Evolution of an Ecological Attitude Toward Deer, Mountains, and Forests* (Columbia: University of Missouri Press, 1974; reprinted by the University of Wisconsin Press, 1994); Curt Meine, *Aldo Leopold: His Life and Work* (Madison, Wisc.: University of Wisconsin Press, 1988); Marybeth Lorbiecki, *Aldo Leopold: A Fierce Green Fire* (Helena and Billings, Mont.: Falcon Publishing Co., 1996).
5. Aldo Leopold, *Game Management* (New York, Charles Scribner's Sons, 1933; reprinted by the University of Wisconsin Press, 1986).
6. See Dennis Ribbens, "The Making of *A Sand County Almanac*," pp. 91-109 in J. Baird Callicott, ed., *Companion to* A Sand County Almanac: *Interpretive & Critical Essays* (Madison, Wisc.: University of Wisconsin Press, 1987); Curt Meine, "Moving Mountains: Aldo Leopold & *A Sand County Almanac,*" *Wildlife Society Bulletin* 26:4 (1998), 697-706.
7. Aldo Leopold, "The Thick-billed Parrot in Chihuahua," *The Condor* 39:1 (January-February 1937), 9-10; Leopold, "Marshland Elegy," *American Forests* 43:10 (October 1937), 472-474; Leopold, "Song of the Gavilan," *Journal of Wildlife Management* 4:3 (July 1940), 329-332; Leopold, "Escudilla," *American Forests* 46:12 (December 1940), 539-540. The *Wisconsin Agriculturist and Farmer* essays can be found in J. Baird Callicott and Eric T. Freyfogle, eds., *For the*

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37. At the time, I was a busy graduate student, and had no time to take on the article. As I remember, my response at the time was: "I'll tell you what. I'll write the article, and if you can get *The Progressive* to publish it simultaneously, I'll do it." Nothing came of the suggestion.

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Presettlement Wildlife in Northwest Wisconsin Pine Barrens

Abstract *Archeological and historical records were used to document wildlife found in Wisconsin's Northwest Pine Barrens during the two hundred-year period from European discovery (1650) to European settlement (1850). The Northwest Pine Barrens, a relatively narrow strip of xeric sandy soils, is a fire-dominated ecotonal community between western prairies and eastern forests. Archeological records of wildlife exist along the St. Croix River and its major tributary, the Namekagon River, and at the site of two fur trading posts on the Yellow River. Historical wildlife records exist in the journals of French explorers, French and English fur traders, and American traders, missionaries, and government officials. The open pine barrens supported a wildlife community not unlike that of today with the exception of large ungulates including the buffalo, moose, elk, some furbearers like the marten, and a few birds like the passenger pigeon.*

Knowledge of the species composition, population sizes, and range distribution of Wisconsin's wildlife prior to European settlement is important. Environmental conditions that existed at the time of exploration and settlement are generally accepted as desired future states by the emerging discipline of restoration biology. Agreement on common ground such as presettlement vegetation or wildlife is needed by the many varied interest groups involved in developing increasingly important ecosystem management plans (Kay 1994, Neumann 1995). Finally, accounts of early wildlife misinterpreted either in error or by a conscious effort to revise history need to be identified and corrected.

The objectives of this article are to document presence and distribution of some wildlife species that existed in the Wisconsin's Northwest Pine Barrens during the two hundred-year period from European discovery and exploration (1650) to European settlement (1850).

The Barrens

A pine barrens is a transitional ecosystem, an ecotone between forest and prairie, born of fire and maintained by fire. Pine barrens are savannas which were described by Curtis (1959) as

> a peculiar combination of grassland and forest, in which the bulk of the land was occupied by grasses and a few shrubs, but which also had widely spaced tall trees, frequently of a given species at a given place.

The Northwest Pine Barrens is an area of sandy soils approximately 12–15 miles wide and 125 miles long from the Sterling Barrens in Polk County in the southwest to the Moquah Barrens in Bayfield County to the northeast (Figure 1).

The northwest pine barrens have been described in detail by Curtis (1959), Vogl (1970), Mossman et al. (1991), Niemuth (1995), and Radeloff et al. 1999. Murphy (1931) described the "barrens" as "where coniferous forests and open expanses of sweet fern and grassy barrens dwarf into insignificance the few evidences of man's present occupancy and use of the land." He further stated, "The grassy and sweet fern barrens . . . are desolate open tracts where only a charred stump, a cluster of jack pines, or a scrub oak bush breaks the monotonous sweep of the rolling, thinly clad ground surface." Originally there were about 2.3 million acres of pine barrens in Wisconsin, but today only a few percent of the ecosystem's early seral stages remains (Curtis 1959, Shively 1994), a victim of wildfire control, forest succession, and tree plantations.

Sources of Records

In order to discuss presettlement wildlife and habitat we must examine available wildlife records. One source is the oral history of Native Americans or Indians in the region. Another source is prehistoric evidence gathered by archeologists. A third source is the historical record left in the form of letters, journals, and books written by early European discoverers and explorers.

Oral History

Oral history of present Native Americans, despite romantic appeal, is subject to doubt. Indians passed their largely spiritual history from generation to generation through story telling. This tradition was severely damaged by the federal government in misguided attempts to force these people into the dominant white culture. Indian children were taken from their families and placed into boarding schools where they were punished for participating in any part of their native culture including using their native language and story telling (Edgar Oerichbauer, Burnett County Historical Society, personal communication 1993). The oral chain of history was damaged and perhaps broken in many cases. The most reliable information we have about presettlement indigenous cultures and their relationships to wildlife is from materials written by Europeans, despite the possibility of non-Indian biases.

Archeological Records

Archeological records are not abundant in this region of Wisconsin. Both prehistoric man and early historic man traveled along and lived near water. It is in this shoreline habitat that limited archeological material is found.

After the St. Croix National Scenic Riverway (SCNSR) was created, the U.S. National Park Service initiated archeological investigations of the property (Perry 1986). A series of sites from the lower St. Croix River to the upper or its major tribu-

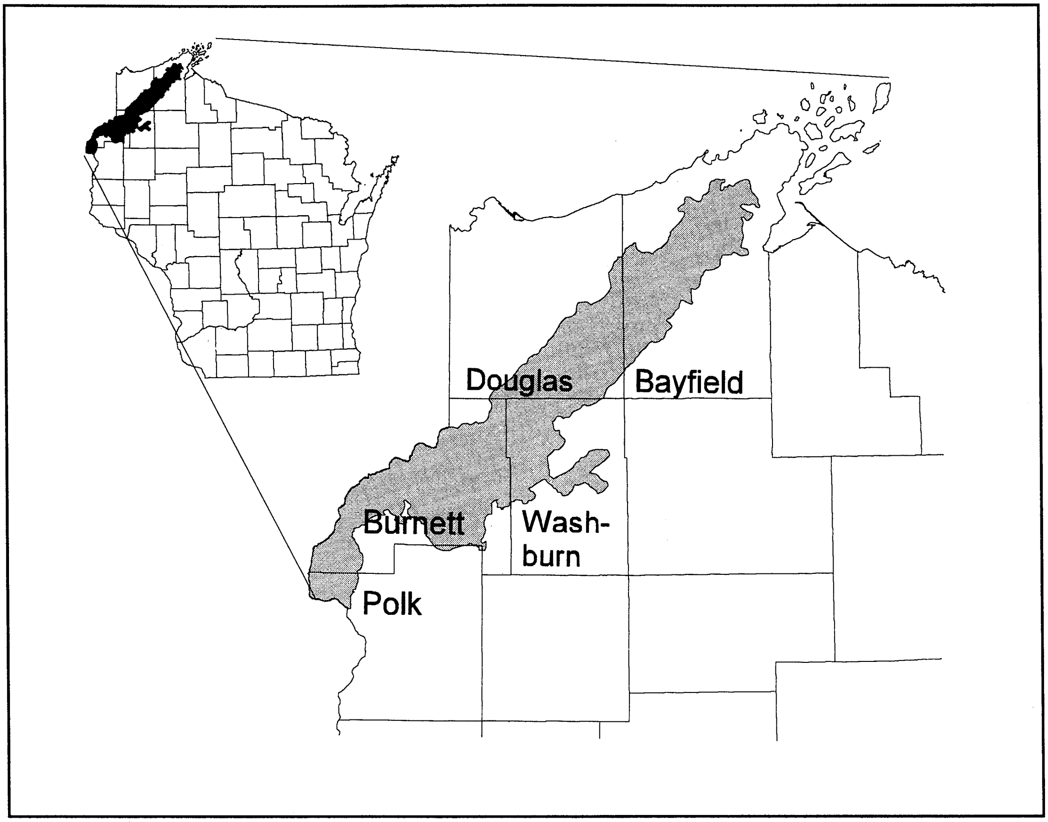

Figure 1. Northwest Wisconsin Pine Barrens (from Radeloff et al. 1999).

tary, the Namekagon River, were excavated from 1976 to 1982. Most of the upper SCNSR sites appeared to have been inhabited by humans for varying lengths of time during the Woodland Period (200 BC–1650 AD). Mammalian bones were the predominant (95%) artifacts found. This does not necessarily imply that mammals made up a large part of the aboriginal diet since fish and bird bones are more fragile and less apt to survive the ravages of time than mammalian bones.

The prehistoric fauna suggested by the specimens recovered from the sites does not differ noticeably from the modern fauna of the area with the exception of several specimens of elk or wapiti (Table 1). White-tailed deer was the dominant species. Other identifiable mammals included the dog or wild canids, beaver, muskrat, raccoon, striped skunk, snowshoe hare/white-tailed jackrabbit, eastern cottontail, woodchuck, porcupine, and pocket gopher. Pocket gopher remains were thought to be natural intrusions in the sites where encountered, not cultural artifacts. Although bird bones were found, none were identifiable. Reptile remains included the Blanding's turtle, snapping turtle, box/water turtle, and map/false map turtle. Fish identified at upper riverway sites included the northern pike, walleye, white bass, and catfish. Along the lower river, mussels are found at the sites along with greater number of fish remains.

Table 1. Wildlife records obtained from archeological and historical sources in Wisconsin's Northwest Pine Barrens.

Species	*Source*[a]
Birds	
Swans (*Cygnus* spp.)	6
Canada Goose *(Branta canadensis)*	4-5
Mallard *(Anas platyrhynchos)*	4
Northern pintail *(Anas acuta)*	4
Blue-winged teal *(Anas discors)*	4
Redhead duck *(Aythya americana)*	4
Merganser (*Mergus* spp.)	7
Wild turkey *(Meleagris gallopavo)*	4-7-10
Crane (*Grus* spp.)	5
Plover *(Charadriidae)*	9
Passenger pigeon *(Ectopistes migratorius)*	9
Belted kingfisher *(Ceryle alcyon)*	9
Red-headed woodpecker *(Melanerpes erythrocephalus)*	9
Yellow-shafted flicker *(Colaptes auratus)*	9
Eastern kingbird *(Tyrannus tyrannus)*	9
Gray catbird *(Dumetella carolinensis)*	9
American robin *(Turdus migratorius)*	9
Blackbird *(Icteridae)*	9
Mammals	
Snowshoe hare/white-tailed jackrabbit *(Leporidae)*	1
Eastern Cottontail rabbit *(Sylvilagus floridanus)*	1
Woodchuck *(Marmota monax)*	1
Thirteen-lined ground squirrel *(Citellus tridecemlineatus)*	9
Pocket gopher *(Geomys busarius)*	1
Beaver *(Castor canadensis)*	1-4-5-6
Muskrat *(Ondatra zibethicus)*	1-4-5
Porcupine *(Erethizon dorsatum)*	1-8
Wild canids *(Canidae)*	1
Timber wolf *(Canis lupus)*	5
Black Bear *(Ursus americanus)*	2-4-5-6-8
Raccoon *(Procyon lotor)*	1-4
Marten *(Martes americana)*	4-5
Fisher *(Martes pennanti)*	4-5
Weasels (*Mustela* spp.)	5
Mink *(Mustela vison)*	4-5
Badger *(Taxidea taxus)*	4
Striped skunk *(Mephitis mephitis)*	1
River otter *(Lutra canadensis)*	4-5-6
Mountain lion *(Felis concolor)*	2-4
Lynx/bobcat (*Lynx* spp.)	4-5
Elk *(Cervus canadensis)*	1-2-4-5-11
White-tailed deer *(Odocoileus virginianus)*	1-2-5-6-8
Moose *(Alces alces)*	2-5-8-9-12
Caribou *(Rangifer caribou)*	2
Buffalo *(Bison bison)*	2-3

Table 1, continued.

Species	*Source*[a]
Turtles	
Snapping turtle *(Chelydra serpentina)*	1
Blanding's turtle *(Emydoidea blandingii)*	1
Painted turtle *(Chrysemys picta)*	4
Map/false map turtle (*Graptemys* sp.)	1
Box/water turtle *(Emydidae)*	1
Snakes	
Fox snake *(Elaphe vulpina)*	9
Fish	
Sturgeon *(Acipenser fulvescens)*	5-6
Whitefish *(Coregoninae)*	5
Northern pike/muskellunge (*Esox* sp.)	1-4-5-6
Buffalo (*Ictiobus* sp.)	4-6
Redhorse *(Moxostoma erythrurum)*	4-6
White sucker *(Catostomus commersoni)*	4-6
Other suckers *(Catostomidae)*	4-5
Catfish *(Ictalurus)*	1-4-5
White bass *(Morone chrysops)*	1
Walleye *(Stizostedion vitreum)*	1-4-5-6
Invertebrates	
Mussels *(Unionidae)*	1

[a]1 – Perry 1986; 2 – Adams 1961; 3 – Schorger 1937; 4 – Ewen 1983; 5 – Thwaites 1911; 6 – Nelson 1947; 7 – Birk and White 1979; 8 – Ely 1835; 9 – Mossman 1994; 10 – Schorger 1942a; 11 – Schorger 1954; and 12 – Schorger 1956.

Mammal remains found at the sites are from forest-dwelling species with the exception of elk and possibly white-tailed jackrabbit and pocket gopher, which are more typically creatures of grasslands and savannas.

Another significant source of information about early wildlife resources in the area was an archeological excavation of the historic NW and XY Company fur trading forts on the Yellow River, just downstream of Little Yellow Lake, Burnett County. These adjacent posts, rediscovered in 1969 and named Forts Folle Avoine, were occupied during the winters of 1802–03 and 1803–04 (Oerichbauer and Mueller 1988).

Refuse pits at the Forts Folle Avoine yielded the remains of 13 mammal, 6 bird, 1 turtle and 7 fish species (Ewen 1983).

White-tailed deer again dominated the number of specimens recovered followed by the beaver, black bear, otter, raccoon, muskrat, fisher, badger, lynx/bobcat, marten, and mink (Table 1). In addition, there were possible elk or wapiti and mountain lion remains found at the site. Birds identified included the Canada goose and four duck species: the mallard, pintail, blue-winged teal, and redhead. In addition, a wild turkey bone was tentatively identified. The painted turtle was the only reptile found. Fish species included the northern pike/muskellunge, walleye, buffalo, white sucker, redhorse sucker, other suckers, and catfish. Wild rice *(Zizania aquatica)* and corn *(Zea mays)* were also found at the site.

Historical Records

Historical records begin in the 1620s when the Frenchman Etienne Brule explored the south shore of Lake Superior, possibly reaching Chequamegon Bay (Holzhueter 1986). Brule was followed by Radisson, who explored and traded furs with the Indians of northwest Wisconsin during 1658–62 (Adams 1961). The Frenchman, in their wanderings from Madeline Island in Chequamegon Bay of Lake Superior to Lac Court Orielles to the Mississippi River, reported killing *stagg* [elk], *boeuf* [buffalo], *oriniack* and *elan* [moose], *fallow does and bucks* [white-tailed deer], *carribouck* [caribou], *bear* [black bear], and *mountain lions* (Table 1).

Radisson mentioned that "Buffs [buffalo] . . . come to the upper lake [Lake Superior] but by chance." Schorger (1937), in an examination of Radisson's journal, concluded that Radisson probably first encountered buffalo near the Brule-St. Croix waterway [in the pine barrens], ranging east of the St. Croix River. Schorger lists Burnett and Polk counties in the southern part of the northwest pine barrens as being within the range of the buffalo.

Radisson also mentioned that the *Sault* [Ojibwa or Chippewa] Indians were at war with the *Nation* [Sioux} Indians at that time. In 1680, the French *coureur de bois,* Daniel Greysolon, *Sieur Du Llut* [Duluth], traveled up the Bois Brule River from Lake Superior and down the St. Croix River to the Mississippi River (Turner 1970). Duluth established Fort St. Croix at the portage between the Brule River and the St. Croix River. The French named a river that entered the St. Croix River just south of the outlet of St. Croix Lake, *river au boeuf* [ox or buffalo River]. The French fur traders traveled the waterways, trading with the Chippewa Indians centered in La Pointe on Madeline Island in Chequamegon Bay and the Sioux Indians centered in the region of the Upper Mississippi River. The two tribes had been at war until Duluth negotiated peace between them to facilitate trading.

Indian life had an annual cycle. Turner (1970) stated:

> The Indians, returning from the [winter] hunting grounds to their [permanent] villages in the spring, set the squaws to making maple sugar, planting corn, watermelons, potatoes, squashes, etc., and a little hunting was carried on. The summer was given over to enjoyment, and in the early period to wars. In the autumn they collected their wild rice, or their corn, and again were ready to start for the hunting grounds, sometimes 300 miles distant.
>
> The Chippeways had an institution called by them by a term signifying "to enter one another's lodge." whereby a truce was made between them and the Sioux at the winter hunting season.

In 1763, the English gained control of the fur trade in northwest Wisconsin as a result of their victory over the French in the French and Indian War (Turner 1970). With the French gone, warfare between the Chippewa and Sioux resumed.

According to Hickerson (1988), a "contested" or "debatable" zone up to 200 miles wide from northwest Wisconsin to northwest Minnesota (Figure 2) developed between the two tribes by 1780 and continued until 1850. No permanent villages were found in this buffer zone located in the ecotone between the forest to the north and the prairie to the south. Both Chippewa and Sioux ventured into the zone only to make war and

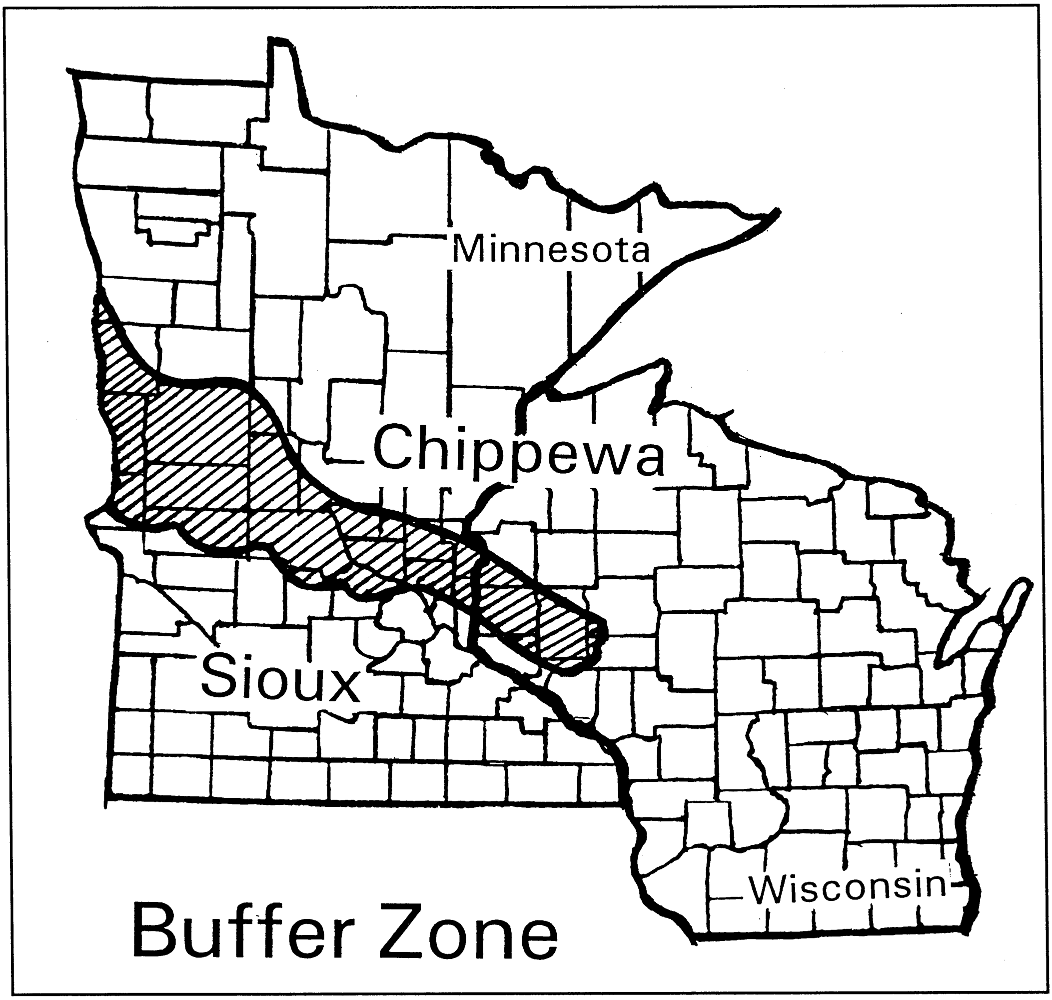

Figure 2. Buffer zone of Hickerson (1988).

hunt at the risk of their lives. The effect of this buffer zone on wildlife was dramatic.

Hickerson (1988) stated:

> Warfare between members of the two tribes had the effect of preventing hunters from occupying the best game region intensively enough to deplete the [game] supply. . . . In the one instance in which a lengthy truce was maintained between certain Chippewa and Sioux, the buffer, in effect a protective zone for the deer, was destroyed, and famine ensued.

Hickerson's conclusions were based upon reports by Carver in 1767, Perrault in 1785–86, Pike in 1805–06, Johnson in 1809, Cass and Doty in 1820, and Schoolcraft in 1824 and 1831. Irving (1835) reported a similar intertribal buffer zone containing an abundance of wildlife in present-day Oklahoma, and Jackson (1993) reported another intertribal battle zone with abundant wildlife in the Bear Valley of Idaho. Kentucky, probably the Kentucky Barrens (Schorger 1943), was also an early game-rich battleground of the tribes east of the Mississippi (Jackson 1993).

The existence of several journals maintained by fur traders stationed at the Forts Folle Avoine and the Connor Post, a contemporary fur trading site on the Snake River, a tributary of the St. Croix River in Minnesota 28 miles west of Yellow Lake, provides a rare opportunity to compare historic records with archeological evidence. All trade was with the Chippewa Indians for both furs and food (Ewen 1983).

While the traders did some of their own hunting, their subsistence depended upon the Indian hunters. Journal entries from both forts (Thwaites 1911, Gates 1965) indicated that hunters took their game within 20–30 miles of the trading posts.

The best records were kept by Michael Curot at Forts Folle Avoine from September 16, 1803, to May 9, 1804 (Thwaites 1911). Curot, a clerk for the XY Company, recorded the pelts and meat he traded for to feed himself and his co-workers. Furs and hides were from approximately 247 beaver, 88 muskrats, 68 deer, 42 lynxes (includes bobcats), 23 otter, 15 bear, 13 fisher, 6 weasels, 4 moose, 3 marten, 2 mink, and 1 possible elk or "red deer" (Table 1). The beaver pelts were shipped to Grand Portage, Minnesota in 3 packs weighing approximately 90 pounds each. He also shipped 6 packs of other fur. The adjacent NW post shipped 21 packs of pelts including 6 beaver packs. Curot also recorded the presence of wolves in the area.

Curot traded for the meat of 41 deer, 4 elk or "machichinse," 3 bear, 22 ducks, 9 geese, and 1 crane. He also acquired fawn skins filled with wild rice, cakes of fat, and maple (*Acer* spp.) sugar. In addition, the trader and his hunters netted and speared nearly 700 fish including sturgeon, pike, walleyes, suckers, catfish, and whitefish during the nearly eight month period.

The lack of grouse traded for food was explained by Schorger (1942b):

> Game-birds, though numerous, were seldom molested since the [relatively-expensive lead] ball [for a black-powder muzzle- loading rifle] required to secure a sharp-tailed grouse *[Tympanuchas phasianellus]* could fell a deer as readily.

George Nelson, a fur trader for the XY Company, who spent the previous winter of 1802–03 at the same post wrote of his experience some years later (Nelson 1947). His sketchy records describe the area surrounding the fort in somewhat more detail than Curot. He stated:

> The Indian name is "Yellow water lake" [Yellow Lake] from the yellow sand in the bottom. . . . At the S.E. side it is flat & miry; & an immense quantity of rice grows there; and in their Season, ducks of various Sorts [20 species], Geese & Swans in multitudes. There is also plenty of fish, Carp of several sorts, some of monstrous size, pickeral, pike &c.
>
> In the morning Early I would steal out after taking a careful survey of the coast [for Sioux Indians, mortal enemies of the Chippewa and possibly white men trading and living with the Chippewa], go to the river & firing one or two shots killing 3 or 4 ducks.
>
> Deer in great numbers & bears of every colour from deep black to a light brown, nearly yellow . . . Beaver & raccoons & porcupine. . . . Beaver and otter . . . no troute nor catfish (Barbotte), Carp [probably suckers] of several varieties & good, one sort particularly, very large, almost enormous, & very fat. Pickeral & Pike a variety of Pike, some of which are very large and excellent. Sturgeon . . . eels . . . turtle, some of 18 ins. diameter.

Both Nelson and Curot worried about the presence of Sioux Indians, enemies of the

Chippewa, since the location of their trading posts were just north of the buffer zone described by Hickerson (1988).

The Snake River, Minnesota, post was occupied during the winter of 1804–05 (Gates 1965). John Sayer was the clerk stationed at that post and was assisted by trader Thomas Connor. Sayer kept a detailed journal (Birk and White 1979), much like that of Curot.

The wildlife pelts and meat obtained in trade with the Chippewa Indians were similar to that of Curot. Exceptions include "shelldrakes" or mergansers and a "Outarde" or wild turkey (Evrard 1993). The Minnesota fur traders apparently included more deer and ducks and fewer fish in their diets compared to the more diverse diet of the Wisconsin traders.

In 1816, the Americans took control of the fur trade from the English as a result of the War of 1812. In 1835, the Protestant missionary Edmund Ely recorded the hunting results of 5 Chippewa men from the Yellow Lake area of present-day Burnett County. From November 15 until January 15, they killed 13 moose, 9 bears, and 2 deer (Ely 1835). In addition, the Indian hunters also harvested porcupines, rabbits, grouse, and "furred game."

Henry Schoolcraft made several trips through northwest Wisconsin during 1831–34 and reported extensively on the vegetation of the area in addition to the wildlife (Schoolcraft 1834 and 1851, Mossman 1994). He stated:

> The country [the lower Namekagon River] as we decend assumes more the appearance of upland prairie, from the repeated burnings of the forest. The effect is, nearly all the small trees have been consumed, and grass has taken their place. One result of this is, the deer are drawn up from the more open lands of the Mississippi, to follow the advance of the prairie and open lands towards Lake Superior.
>
> The moose is also an inhabitant of the Namekagun. The Chippewas, at a hunting camp we passed yesterday, said they had been on the tracks of a moose, but lost them [the tracks] in high brush. Ducks and pigeons [the now-extinct Passenger pigeon] appear common.
>
> Among smaller birds are the blackbird [probably the red-winged blackbird *(Agelaius phoeniceus)* or Brewer's blackbird *(Euphagus cyanocephalus)*], robin *(Turdus migratorius),* catbird *(Dumetella carolinensis),* red-headed woodpecker *(Melanerpes erythrocephalus),* kingfisher *(Ceryle alcyon),* kingbird *(Tyrannus t.),* plover [probably killdeer *(Charadrius vociferos)* or upland sandpiper *(Bartramia longicauda),* but possibly also spotted sandpiper *(Actitus macularia)* or migrant shorebirds] and yellowhammer [possibly the yellow-shafted flicker *(Colaptes auratus)*].
>
> The copper head snake [probably fox snake *(Elaphe vulpina)*] is found at the Yellow River [in Burnett and/or Washburn counties]; also the thirteen striped squirrel *(Citellus tricemlineatus)*. . . . Its [Yellow River] banks afford much of the open ground [barrens] which are favorable the thirteen-striped or prairie squirrel.

Schoolcraft also discussed vegetation in the Northwest Pine Barrens. He remarked on the abundance of the *whortleberry* [blueberry or *Vaccinium* spp.] along the Namekagon River.

> Both banks of the river are literally covered with the ripe whortleberry — it is large and delicious. The Indians feast on it. Thousands and thousands of bushels of this fruit could be gathered with very little labor.

Schoolcraft mentioned a "plain" that existed in 1832 near present-day Gordon. He also discussed the impact of fire on the landscape to the east of the pine barrens region. On the Sawyer/Washburn County line just south of the present city of Hayward, he stated:

> Just after passing the middle pause [on the portage from the Namekagon River to Lac Court Orielles], the path mounts and is carried along a considerable ridge, from which there is a good view of the country. It is open as far as the eye can reach. Sometimes there is a fine range of large pines: in by far the largest space ancient fires appear to have spread, destroying the forest and giving rise to a young growth of pines (*Pinus* spp.), aspen (*Populus* spp.), shadbush (*Amelanchier* sp.), and bramble (*Rubus* spp.).

It is obvious from the description of the vegetation of the Northwest Pine Barrens that the character of the landscape was open and the wildlife species found there reflected that openness.

Other records during this period reinforce the concept. Schorger (1942a) mentions "John Lewis Peyton . . . in 1848 . . . saw some wild turkeys while crossing a plain between La Pointe and the St. Croix River." In another work, Schorger (1954) reported that a Reverend Brunson traveled by horse and wagon from Prairie du Chien to La Pointe in 1843 before any roads existed, an indication of the openness of the country.

The open landscape and its wildlife inhabitants were a function of climate, soils, topography, and the Native American use of fire. Indians used fire extensively for warmth and to prepare and preserve food, to stimulate food production such as blueberries, to simplify wood collecting, to reduce insect pests, to clear land, to drive and attract game, and to harass and attack their enemies (McKinney 1959, Muir 1913, Murphy 1931, Schroger 1937 and 1943, Appleman 1975, Dorney and Dorney 1989. Simms 1992, Stolzenburg 1994, Ashworth 1995, MacCleery 1995, Mills 1995, Pyne 1995, Quaife 1995, Mirk 1997, Schneider 1997, and Loope and Anderton 1998).

As a result of a series of treaties ending in 1842, the Chippewa and Sioux Indians made peace with each other, ceded their lands to the U.S. Government, and were confined to reservations in northern Wisconsin and Minnesota. This opened the area to European settlement. Scandinavian settlers first arrived in Burnett County in the 1850s and became the first permanent white residents in the pine barrens. Cessation of Indian burning and uncontrolled subsistence hunting, farming, and logging activities of the settlers were largely responsible for changes in the wildlife community inhabiting northwest Wisconsin in the late nineteenth century.

Buffalo disappeared from the region by 1830 (Schorger 1937) before the arrival of European settlers, elk by 1860 (Schorger 1954), and the moose by 1890 (Schorger 1956). Deer remained in good numbers until 1890 (Schorger 1953). Birds, especially waterfowl and grouse prospered in the early part of the twentieth century (Schorger 1943 and 1945) then declined, setting the stage for the rise of the modern-day conservation movement.

Conclusions

The northwest Wisconsin pine barrens during the 200 years from discovery (1650) to European settlement (1850) was a mosiac of grassland, brushland, and forest. This fire community owed its existence to xeric, sandy soils that were warmed and dried by prevailing southwest winds, allowing frequent fires, set by lightning and Indians, to sweep its length.

The openness of the Northwest Pine Barrens vegetation was reflected by the wildlife community inhabiting the region. The high grass component of the ecosystem provided forage for large ungulates including the buffalo in the southern part of the barrens and the elk throughout the barrens. Other grass- and brushland wildlife reported in the barrens included the white-tailed deer, thirteen-lined ground squirrel, pocket gopher, red-winged and/or Brewer's blackbird, catbird, kingbird, red-headed woodpecker, yellow-shafted flicker, Blanding's turtle, and fox snake.

Some wildlife species such as the buffalo, caribou, and passenger pigeon disappeared. The passenger pigeon is extinct, and the caribou was a creature of Wisconsin's boreal forest and bogs, not the barrens. Most species including the white-tailed deer, black bear, and sandhill crane, were reduced to low numbers but have recovered spectacularly in the last 50 years. Some extirpated species returned, either with human help (fisher, Canada goose, trumpeter swan *(Cygnus buccinator),* and wild turkey) or with our relatively newly acquired tolerance of wildlife (moose and timber wolf). Several species such as the elk and marten have been successfully reintroduced elsewhere in Wisconsin but have not yet recolonized the northwest pine barrens. In addition, there are unconfirmed observations of mountain lions roaming the barrens again and the reintroduction of the whooping crane *(Grus americana)* is now being contemplated.

If the habitat base of the Northwest Pine Barrens ecosystem can be preserved in the face of increasing human development pressures, the wildlife community we know today should remain with us into the foreseeable future.

Acknowledgments

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James O. Evrard

Birds and Amphibians of Selected Pine Barrens Wetlands

Abstract *Wildlife inhabiting the wetlands of the pitted outwash section of Wisconsin's northwest pine barrens are little known. Six small and relatively infertile wetlands located in and adjacent to the Namekagon Barrens Wildlife Area were surveyed in 1996 and 1997 to determine the distribution and abundance of birds and amphibians. Three frog and two bird surveys were conducted in each wetland. Pitfall traps associated with drift fences adjacent to three of the wetlands were also used to capture amphibians. Incidental wildlife observations were recorded. Nine frog species, two salamander species, and twenty-five bird species were observed in, over, and immediately adjacent to the six wetlands. The value of the pine barrens wetlands for some wildlife species probably has been underestimated based upon the perceived infertility of the wetlands. These wetlands should continue to provide secure habitat for a wide range of wildlife due to little human development and large-block public and private forest ownership.*

The northwest Wisconsin pine barrens is an area of sandy soils approximately 12–15 miles wide and 125 miles long extending from the junction of Wolf Creek and the St. Croix River in Polk County in the southwest to Bayfield County about 12 miles south of Lake Superior in the northeast (Strong 1880) (Figure 1).

The "barrens," an ecosystem born in fire and maintained by frequent wild fires, was described by Murphy (1931) as "where coniferous forests and open expanses of sweet fern and grassy barrens dwarf into insignificance the few evidences of man's present occupancy and use of the land." He further stated, "The grassy and sweet fern barrens . . . are desolate open tracts where only a charred stump, a cluster of jack pines, or a scrub oak bush breaks the monotonous sweep of the rolling, thinly clad ground surface."

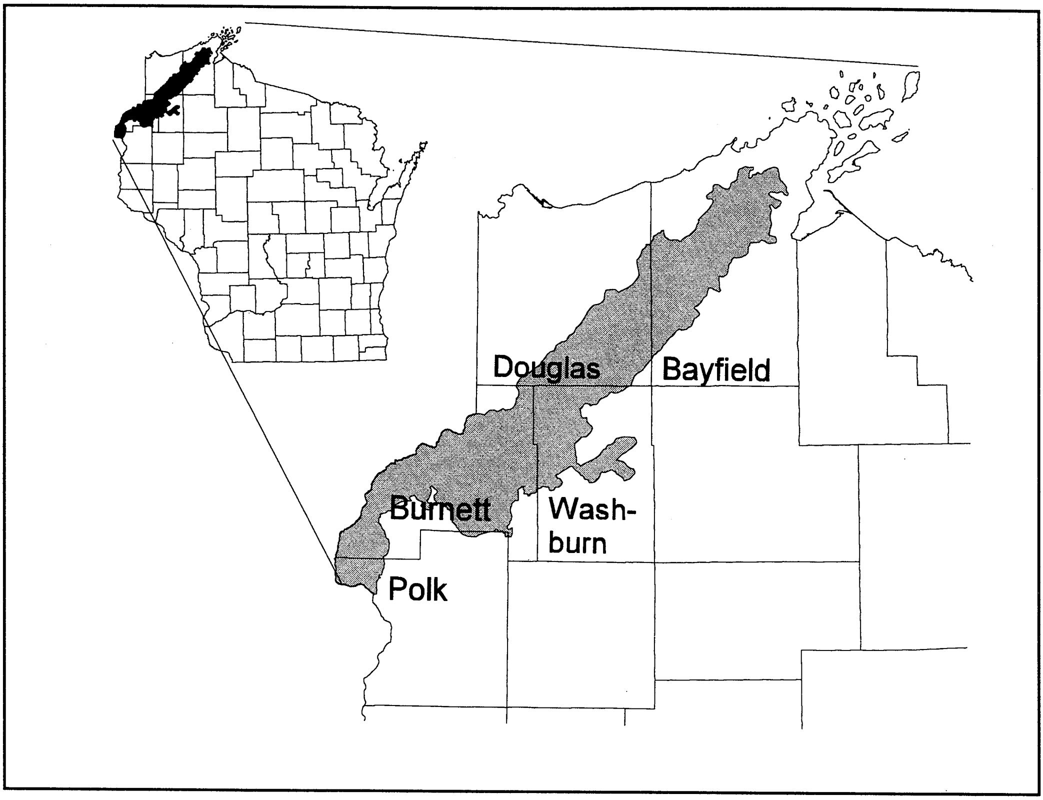

Figure 1. Wisconsin's northwest pine barrens (from Radeloff et al. 1998).

Originally, there were about 2.3 million acres of pine barrens in Wisconsin, but today only about 1% of the ecosystem's early seral stages remains (Curtis 1959), a victim of wild fire control, forest succession, and tree plantations. Much of the land is still wild, being in large-block public and private land ownership dominated by forestry activities (Riegler 1995).

Murphy (1931) divided the northwest pine barrens into three geographic sections: the northeastern hill section, the pitted sand plain section, and the southwestern marsh section. The northeastern hill section was earlier termed the Kettle Range by Sweet (1880). Mossman et al. (1991) devoted only part of one paragraph of their lengthy paper on the birds of Wisconsin's pine and oak barrens to birds observed in pine barrens wetlands. Faanes (1981) failed to discuss wetland birds in the northwest pine barrens other than those inhabiting the large sedge meadows in the vicinity of Grantsburg in the southwestern section.

Wildlife inhabiting these extensive marshes are relatively well known. A bibliography developed by Evrard (1997) lists over 25 citations dealing specifically with birds inhabiting the large wetlands in western Burnett County.

In contrast, wildlife inhabiting the lakes and wetlands in the pitted sand plain and northeastern hill or Kettle Range sections of the northwest pine barrens are little known. Jahn and Hunt (1964) discussed the limited value to waterfowl of two types of naturally occurring wetlands in this pitted sand plain subsection, the "soft-water bog lakes and sand-lined kettle lakes."

Similarly, the amphibians inhabiting these kettle wetlands are not well known. Hay (1995) stated that little was known about the abundance, health, or effects of habitat management on herptile populations in the barrens ecosystem. Vogt (1981), later updated by Casper (1996), summarized what little was known of amphibians occurring in the Wisconsin's northern pine barrens wetlands.

The objective of this study was to determine the species and relative abundances of the birds and amphibians inhabiting six selected wetlands located in and adjacent to the Namekagon Barrens Wildlife Area in the northwest Wisconsin pine barrens.

Study Area

The pitted sand plain consists of drift material originating from receding glaciers. The pits or depressions were formed by melting blocks of ice left imbedded in the sand and gravel drift. Many of the depressions are occupied by lakes and marshes, while others are dry. Some depressions are relatively shallow, and some exceed 30 m in depth (Strong 1880). Some have sloping sides, but many have characteristic abrupt banks from wetland margins to the nearly uniform plain.

The Namekagon Barrens Wildlife Area is located within the pitted sand plain near the junction of the Namekagon and St. Croix rivers in Burnett County. The Namekagon Barrens Wildlife Area is owned by Burnett County but is leased by the Wisconsin Department of Natural Resources and managed primarily for sharp-tailed grouse *(Tympanuchus phasianellus)* using prescribed burning (Vogl 1970).

Six wetlands were studied within or adjacent to the NBWA including four unnamed wetlands in Section 12 and two wetlands (Richart and Bradley lakes), in Section 24, T42N, R14W, Town of Blaine, Burnett County (Figure 2). Aquatic vegetation of each wetland was mapped and sampled in mid-summer of 1996 using the line intercept method (Greig-Smith 1964). Two lines, perpendicular to the shoreline in each wetland, beginning at the high water mark and extending 30 m into the wetland, were used to identify and quantify aquatic vegetation. Wetland A was a 4.1-ha semi-permanent marsh with 95% of its surface area covered by emergent aquatic vegetation dominated primarily by slender sedge *(Carex lasiocarpa)* and blue-joint grass *(Calamagrostis canadensis)* with several "islands" of cranberry *(Vaccinium oxycoccos)* and Sphagnum moss (*Sphagnum* sp.). Wetland B was a 7.5-ha permanent pond with 50% of its surface covered by floating and emergent vegetation. Emergent aquatics were dominated by slender sedge, blue-joint grass, and three-way sedge *(Dulichium arundinaceum).* Floating vegetation was dominated by spatterdock *(Nuphar variegatum).* Wetlands A and B were surrounded by fire-managed "brush prairie," first named by Strong (1880).

Wetland C was a semi-permanent marsh, 4.1 ha in size, and was surrounded by recently clear-cut and burned jack pine *(Pinus banksiana)* and oak *(Quercus ellipsoidalis)* vegetation. Its surface is totally covered by aquatic vegetation dominated by slender sedge and manna grass *(Glyceria canadensis).* Wetland D was a smaller (2.6-ha) shallow semi-permanent marsh with 100% of its surface area covered by emergent vegetation. This wetland was more bog-like with emergent vegetation dominated by slender sedge, cranberry, and sphagnum moss.

The northern lobe of Richart Lake (Wet-

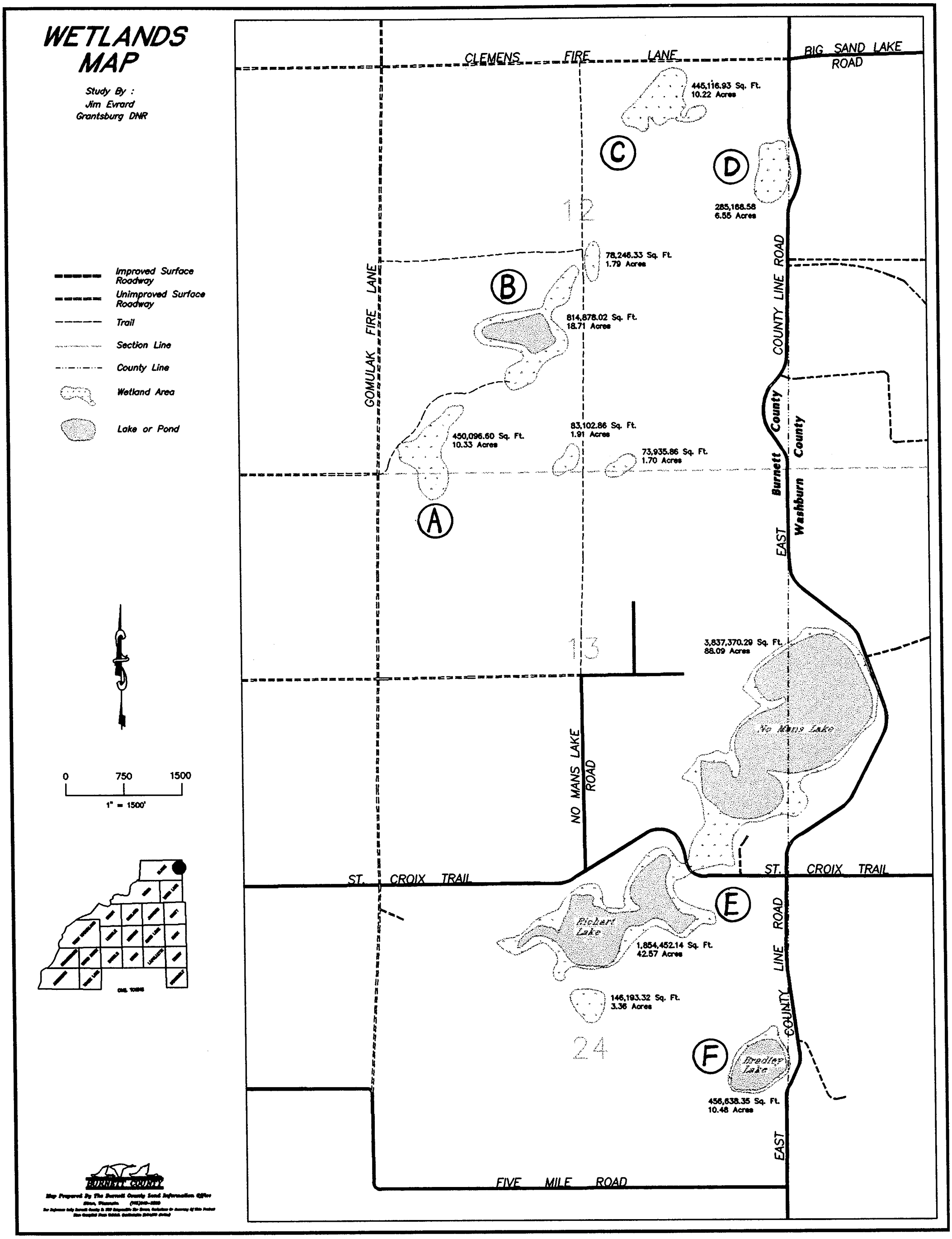

Figure 2. Study area wetlands.

land E), about 25% of the 17-ha permanent wetland, was included in this study. About 35% of the surface of the lobe was covered by floating-leaf and emergent vegetation, mostly water smartweed *(Polygonum amphibium)* and soft-stem bulrush *(Scirpus validus)*. The smaller (4.2 ha) but deeper Bradley Lake (Wetland F) had concentric bands of aquatic vegetation extending out from its shores to a mean distance of 25 m. Dominant plant species included water lily *(Nymphaea odorata)*, manna grass, and slender sedge. Both Rickart and Bradley Lakes were surrounded by jack pine/oak forest.

There was no difference in the water chemistry of Wetlands A, B, and D when tested in June 1997—slightly acidic with a pH of 6.0 and with a methyl orange total alkalinity of 18 ppm (Water Ecology Kit Model AL-36B, Hach Company, P.O. Box 389, Loveland, CO 80539). The waters of Wetland C and Richart Lake, however, were less acid (6.5 pH), but with the same total alkalinity (18 ppm). The water in Bradley Lake was neutral (7.0 pH) and had higher total alkalinity (36 ppm) than the other five wetlands. Total alkalinity less than 40 ppm is considered low, and aquatic vegetation, plankton, and fish populations in such water are normally sparse (Moyle 1956).

Methods

Frog and bird surveys were conducted in cooperation with the Marsh Monitoring Program of Environment Canada and the Long Point Bird Observatory (Anonymous 1996). Three frog surveys (early and late May and early June, 1996–97) were conducted after 10 p.m. Three minutes were spent at each station or wetland, recording and mapping frog species by call level and the number of individuals calling within a 180° semi-circle facing towards the wetland away from the station marker, a 2-m high steel fence post.

Amphibians also were captured in pitfall and funnel traps associated with drift fences (Vogt and Hine 1982). The drift fences were operated for 6-day periods in late April, early and late May, and early June 1996–97. Traps were opened after a major precipitation event, beginning with snow melt in late April, and checked every second day during the four periods. All captured amphibians were released after being identified.

One drift fence was installed immediately adjacent to each of Wetlands B, C, and D. Eleven pitfall traps and five funnel traps were spaced along the 15-m-long, 46-cm-high metal sides of each T-shaped drift fence. Pitfall traps were made of 19-l plastic pails buried flush with the ground surface. At least 3 cm of water was maintained in each trap to prevent desiccation and death of captured amphibians. Triangular funnel traps (60 x 30 cm) were made of welded wire mesh lined with aluminum screening (after Immler 1945). Both ends of the funnel trap were fitted with an inverted aluminum screen cone having a 5 x 8-cm elliptical opening.

The study wetlands were surveyed for birds twice each year, once in late May and again in mid-June 1996–97, beginning after 6 p.m. A playback audio tape was played on a cassette player for 5 minutes followed by 5 minutes of silent listening at each station. The playback tape consisted of 30 seconds each of calls of the Virginia rail *(Rallus limicola)*, sora rail *(Porzana carolina)*, least bittern *(Ixobrychus exilis)*, pied-billed grebe *(Podilymbus podiceps)*, and combination common moor hen *(Gallinula chloropus)*/American coot *(Fulica americana)*, followed by 30 seconds of silent listening between each species. All adult birds seen and heard within a 100-m radius semi-circle centered on the station marker were recorded and mapped. The area surveyed in each wetland was 1.57 ha. Birds recorded included territorial birds and aerial foragers and birds associated with aquatic habitat that were seen flying through the sampled area. In addition, observations of birds and amphibians in the wetlands made incidental to other study activities were recorded.

Results

Amphibians

Eight frog species were recorded during the thrice-yearly auditory censuses during 1996–97 (Table 1). Incidental observations added a ninth species, the mink frog *(Rana septentrionalis).* The number of species heard per wetland ranged from five to eight, but only three species, the gray treefrog *(Hyla versicolor),* northern spring peeper *(Pseudacris c. crucifer),* and chorus frog *(P. triseriata)* were heard in all six wetlands. Cope's gray treefrog *(Hyla chrysoscelis)* was found in five of the six wetlands, not being recorded in Richart Lake.

Wetland B had the most species of the six wetlands, including the mink frog heard in mid-July 1997. Eastern American toads *(Bufo a. americanus)* also were heard incidentally in Wetland C in 1996 but were not recorded during the formal auditory surveys.

Bullfrogs *(Rana catesbeiana)* were recorded in Wetlands E and F, but only in 1997. Green frogs *(R. clamitans malanota)* were much more numerous in 1997 than in 1996. Northern leopard frogs *(R. pipiens)* were heard in only three of the six wetlands.

Only five amphibian species were captured in the pitfall traps associated with drift fences adjacent to Wetlands B, C, and D (Table 2). These species included two salamanders, the blue-spotted salamander *(Ambystoma laterale)* and the eastern tiger salamander *(A. t. tigrinum),* and three frogs, the eastern American toad, chorus frog, and northern spring peeper. The blue-spotted salamander was by far the most numerous amphibian captured in the pitfall traps. Only one tiger salamander was captured in two years.

Birds

Eighteen bird species were recorded during the twice-yearly bird censuses during 1996–97 (Table 3). Only three species, the mallard *(Anas platyrhynchos),* tree swallow *(Tachycineta bicolor),* and red-winged blackbird *(Agelaius phoeniceus)* were recorded on all six wetlands. Wetlands A and B were richer (more species observed) and more productive (more individual birds counted) than the other wetlands.

Ten bird species were recorded in Wetland A during the surveys in 1996 and 1997. The Virginia rail was recorded only in Wetland A and only in 1997, once during a formal survey and once incidentally. Miscellaneous observations added to the number of species and individuals using the wetland. There was a possible breeding pair of Canada geese *(Branta canadensis)* in the wetland, along with breeding pairs of mallards, ring-necked ducks *(Aythya collaris),* and pied-billed grebes. In addition, the northern harrier *(Circus cyaneus),* belted-kingfisher *(Ceryle alcyon),* eastern kingbird *(Tryannus tryannus),* barn swallow *(Hirundo rustica),* yellow warbler *(Dendroica petechia),* and common yellowthroat *(Geothlypis trichas)* were seen in the wetland. A brood of pied-billed grebes was recorded in July 1997.

Wetland B was similar to Wetland A in terms of number of species and individuals recorded (Table 3). A single common loon *(Gavia immer)* was recorded in the wetland in addition to breeding pairs of mallards, ring-necked ducks, pied-billed grebes, and up to four male wood ducks *(Aix sponsa).*

Table 1. Numbers of frogs recorded in audio surveys in selected northwest Wisconsin pine barrens wetlands, 1996–97.

	Wetland											
	A		*B*		*C*		*D*		*E*		*F*	
Species	*96*	*97*	*96*	*97*	*96*	*97*	*96*	*97*	*96*	*97*	*96*	*97*
Eastern American toad	1	1	1				2	2				
Chorus frog	4	2	1	1	2	2	1	3	1		3	4
Northern spring peeper	*	11	*	8	11	*	*	*	*	4	*	*
Cope's gray treefrog	4	4	9	1	2	3	3	3			2	4
Eastern gray treefrog	2	2	2	1	1	3	3	3		1	2	3
Bullfrog										4		2
Green frog				6		2		3	1	10	1	2
Northern leopard frog	2	1	1	1		1						

*Too many frogs calling to count individuals.

Table 2. Numbers of amphibians captured in pitfall and funnel traps associated with drift fences adjacent to selected northwest Wisconsin pine barrens wetlands, 1996–97.

	Wetland					
	B		*C*		*D*	
	1996[a]	*1997*[b]	*1996*	*1997*	*1996*	*1997*
Blue-spotted salamander	11	6	18	6	84	23
Tiger salamander		1				
American toad	1					4
Chorus frog	1	1	6	1	2	1
Spring peeper		1	3		3	5

[a] Four trapping periods (4/22-28, 5/6-12, 5/26-31, 6/17-24).

[b] Four trapping periods (4/18-24, 5/12-20, 5/28-6/4, 6/16-21).

Incidental observations of other species in Wetland B included a red-necked grebe *(Podiceps grisegena)* and a pair of green-winged teal *(Anas crecca)*, both considered visitors, and migrant bufflehead *(Bucephala albeola)* and lesser yellowlegs *(Tringa flavipes)*. In addition, a breeding pair of common loons was confirmed, along with breeding pairs of Canada geese, hooded mergansers *(Lophodytes cucullatus)*, blue-winged teal *(Anas discors)*, and northern harriers. A brood of ring-necked ducks was seen in 1997. A sora rail also was heard in the wetland.

Wetland C had only six bird species recorded during surveys (Table 3). Incidental observations added only one additional species, migrant lesser yellowlegs, in the two years. The 1996 surveys failed to detect breeding mallards, sora rails, and eastern kingbirds, which were seen incidental to other work.

Wetland D was similar to Wetland C, with only seven species recorded during surveys. Incidental observations added species (breeding pairs of Canada geese and mallards, common snipe *[Gallinago g.]*, killdeer *[Charadrius vociferus]*, and migrant lesser yellowlegs).

Few species or individual birds were surveyed in Wetlands E (Richart Lake) and F (Bradley Lake). The only observation of a

Table 3. Birds recorded in 1.57-ha samples of selected northwest Wisconsin pine barrens wetlands, 1996–97.

	Wetland											
	A		*B*		*C*		*D*		*E*		*F*	
Species	*96*	*97*	*96*	*97*	*96*	*97*	*96*	*97*	*96*	*97*	*96*	*97*
Common loon			1	2						1	1	
Pied-billed grebe		1		3								
Great blue heron										1		
Canada goose	1	1										*
Mallard		2	2	1		3		2	*			*
Green-winged teal				2								
Ring-necked duck		2	3						2			
Hooded merganser	*											
Virginia rail		1										
Sora rail	2	2				2	1	1				
Common snipe								*				
Belted kingfisher										1		
Eastern kingbird			1	1		1	1	2				
Tree swallow	6	1	3	3	2			1	2	2		1
Barn swallow				1								
Yellow warbler		*		*		1		1				
Common yellowthroat			1	*								1
Red-winged blackbird	4	5	4	2	3	2	4	5	1			1
Total	**13**	**15**	**15**	**16**	**5**	**9**	**6**	**12**	**5**	**5**	**1**	**3**

*Flew over wetland, not recorded in wetland.

great blue heron *(Ardea herodias)* was made on Richart Lake. Incidental observations added only increased numbers of ring-necked ducks and mallards in Richart Lake in 1996 and confirmed a pair of breeding loons using Bradley Lake in 1997.

Discussion

Northern spring peepers, chorus frogs, and treefrogs were the most frequently recorded frogs in the study area wetlands despite the green frog and eastern American toad being considered common and ubiquitous in Wisconsin (Vogt 1981, Casper 1996).

A possible reason for the relatively low frequency of green frogs recorded in this study could be the cool spring of 1996. Green and bullfrogs are among the last frog species to begin calling in the spring (Vogt 1981), with night-time temperatures influencing the initiation and intensity of calling (Anonymous 1996). Cooler weather could also be the reason bullfrogs were not recorded in 1996 but were heard calling in the warmer spring of 1997, the first record for this species in Burnett County (Casper 1996). The bullfrog has a patchy distribution in Wisconsin due to human introductions and overexploitation for bait and food (Vogt 1981, Casper 1996).

Spring peepers have been reported to have declined in Wisconsin during the past decade (Mossman and Hine 1984, 1985) but appear to be abundant in the study area wetlands. The Cope's gray treefrog is a savanna species (Jaslow and Vogt 1977, Vogt 1981) and apparently the northwest pine barrens are suitable habitat, judging by the numbers recorded in this study.

The northern leopard frog was formerly widespread and common in Wisconsin (Vogt 1981), but the population crashed in the 1970s (Hine et al. 1981) and has not recovered (Casper 1996). This decline could be the reason for the low numbers and limited distribution in the study wetlands. The relatively low volume of their calls and the brief annual calling period might also have contributed to the low frequency of calls recorded.

The boreal mink frog is at its southern range limit in Burnett County (Casper 1996), which could explain the single record in two years of surveys. Finally, no wood frogs *(Rana sylvanica)* were found in the study area wetlands, despite the species being common and widespread in Wisconsin (Casper 1996). Their apparent absence could be explained by the audio censuses being conducted too late in the spring for the very early calling species and by their preference for wooded habitat (Vogt 1981).

There were more blue-spotted salamanders captured adjacent to study area wetlands in 1996 than in 1997. This difference may be due to the cooler and moister spring of 1996, which are conditions that promote salamander movements (Anonymous 1996). The blue-spotted salamander is the most abundant salamander in Wisconsin (Casper 1996) and in the study wetlands. This species is often found in areas with very sandy soil (Vogt 1981).

Despite the tiger salamander being considered a savanna species inhabiting prairie ponds, marshes, and kettle potholes (Vogt 1981), only one individual was captured in my study, perhaps a reflection of the methods used to detect this species rather than its abundance.

All the bird species recorded incidentally and during the formal surveys were known to nest in northwest Wisconsin, with the exception of the bufflehead and lesser yellowlegs (Robbins 1991).

The common loon used the larger wetlands (B, E, F) consistently and was suspected to nest in the area, although no nests or young were observed. Loons are known to feed and nest in wetlands as small as 5 and 6 ha in the southwest marsh area of the northwest Wisconsin pine barrens (Evrard 1995) and may nest in the larger study area wetlands in the future. The presence of successfully nesting pied-billed grebes in the wetlands indicates that aquatic food resources are probably adequate for this species.

The red-necked grebe, which is endangered in Wisconsin (Anonymous 1997), was seen once in April 1996 in Wetland B and must be considered a visitor, although the species presently nests 37 air miles southwest in the large pine barrens marshes near Grantsburg (Gieck 1988, James Hoefler, Wisconsin Department of Natural Resources, personal communication, 1997)

Waterfowl use of study area wetlands was greater than anticipated given the relative infertility of the wetlands. Breeding pairs of mallard were recorded on all but Wetland F. Ring-necked duck breeding pairs were found on Wetlands A, B, and E, and a female with a brood was seen on Wetland B. Breeding Canada geese were found in Wetland A in 1996 and 1997 and were suspected of nesting. A Canada goose pair with a brood was observed on Wetland E but outside of the area studied. Pairs of green-winged and blue-winged teal, lone hooded mergansers, and molting male wood ducks were recorded in the wetlands, indicating breeding birds in the region (Jahn and Hunt 1964, March et al. 1973) but not necessarily nesting in or near the wetlands studied. Because waterfowl are not very vocal compared to other groups of birds and their presence was mostly detected by sight rather than sound, the dense emergent aquatic vegetation in some of the wetlands may have allowed some birds to go undetected.

The value of pine barrens wetlands for breeding mallards and ring-necked ducks may have been underestimated. Ring-necked ducks historically nested throughout Wisconsin but retreated to the northern third of state by the 1950s because of habitat destruction and human disturbance (Jahn and Hunt 1964). In the 1950s, the ringneck represented 4–19% of the breeding ducks in Wisconsin and by the late 1960s had declined to only 1–4% of the total breeding community (March et al. 1973).

Sora rails were found in Wetlands A, C, and D, which had 95–100% of their surface area covered by emergent aquatic vegetation. The Virginia rail was heard on two occasions in Wetland A. The surface area of Wetlands B, E, and F may have been too open to provide suitable habitat for the rails.

The northern harrier was observed hunting over the grassy and shrubby margins of Wetlands A and B, habitat of the yellow warbler and common yellowthroat. Eastern kingbirds and many tree swallows were seen flying over the surface of the wetlands, feeding on insects.

The red-winged blackbird was the most numerous species in the wetlands studied, and it is the most common summer bird in Wisconsin (Robbins 1991). Based on the area censused, there was a mean of 1.7 territorial males/ha in the six wetlands studied in 1996 and 1.6/ha in 1997. Densities ranged from a low of 0.6 males/ha in Wetlands E and F in 1996 and 1997 to a high of 3.2/ha in Wetlands A and D in 1997, a five-fold difference. The low densities in Wetlands E and F are due to a scarcity of nesting habitat (tall grasses and low shrubs) along the wetland margins.

Conclusions

The little-known wetlands in the pitted outwash plain section of Wisconsin's northwest pine barrens support a surprising variety and number of amphibians and birds. While these wetlands are not as productive as the more fertile southern wetlands, they have been less affected by man. The value of these wetlands may have been underestimated and may contribute significantly to statewide populations of certain wildlife species. The lack of human development and the large-block public and private industrial forest ownership increases the importance of these wetlands as wildlife habitat now and in the future.

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Blanding's Turtles in the Crex Meadows Wildlife Area

Abstract *Little is known about the Blanding's turtle* (Emydoidea blandingii), *a threatened species in Wisconsin. The study's objective was to determine the status of the species in the extensive wetlands of the Crex Meadows, Wisconsin's largest wildlife management area. From 10 June to 17 July 1997, 51 Blanding's turtles were captured, measured, marked, and released to determine sex and age and estimate the population size. Eleven Blanding's turtles were recaptured, providing population estimates for Crex Meadows that ranged from 107 to 161 turtles. The sex ratio was highly skewed towards females, which was probably an artifact of the sampling methods used. Because 95% of the turtles captured were adult females, the population estimate provided only an estimate of the numbers of female, not male, Blanding's turtles. The age ratio was highly skewed towards adults. This again could be sampling bias or could be due to high nest and juvenile mortality. The many deep and permanent marshes and open brush prairie uplands of the Crex Meadows Wildlife Area apparently provide good habitat for the Blanding's turtle.*

The Wisconsin Natural Heritage Inventory lists the pine barrens as rare globally (G3) and imperiled in the state (S2) (Temple 1995), with only 1% of the original 2.3 million acres of pine barrens remaining in Wisconsin (Curtis 1959). These remnants are fragmented and isolated (Shively 1994), potentially endangering the continued existence of plant and animal species, including the Blanding's turtle.

The State of Wisconsin lists the Blanding's turtle as a threatened species (NR 27.03, effective October 1979). The Blanding's turtle is a long-lived species, not reaching sexual maturity until 15 to 20 years of age (Ross 1989, Rowe 1992, Congdon et al. 1993, McGown 1999). Long-lived species need high juvenile survival or large numbers of offspring to maintain a stable population. Recent declines in nest survival, measured by low recaptures of juvenile turtles and attributed to increases in mammalian and avian predators (Congdon et al. 1993, McGown 1999), have caused concern for the species. Despite its wide geographical distribution in the state (Casper 1996), the status of the species in Wisconsin is poorly known. Only one study of the Blanding's turtle has been completed in Wisconsin, and that was conducted in the central part of the state (Ross 1985). Little is known about the Blanding's turtle in the northwest pine barrens (Hay 1993).

This study attempted to determine the status of the Blanding's turtle inhabiting the extensive wetlands and pine barrens of the Crex Meadows Wildlife Area in northwest Wisconsin.

Study Area

Crex Meadows is the largest state-owned wildlife management area in Wisconsin and the largest restored pine barrens in the state. Crex Meadows Wildlife Area is a 10,800-ha brush prairie-wetland complex managed by the Wisconsin Department of Natural Resources (Vogl 1964, Zicus 1964). It is an area of many large deep marshes, numerous small shallow wetlands, and an extensive system of all-weather roads. The slightly rolling uplands surrounding the wetlands consist of brush prairie (Strong 1880), maintained by intensive prescribed burning, and young jack pine *(Pinus banksiana),* Hill's oak *(Quercus ellipsoidalis),* and aspen *(Populus tremuloides)* forests.

Methods

Blanding's turtles were captured by hand by slowly driving on roads in June and July 1997, looking for turtles on or adjacent to the roads. Turtles were also captured in hoop-net traps (Lagler 1943, Legler 1960) and seine nets from 10 June to 16 July 1997 in roadside wetlands where turtles were observed.

Turtles were aged by counting plastral annuli (Sexton 1959). Annuli develop by periods of rapid growth (summer), followed by periods of slow growth (winter). However, the annuli of older turtles are worn and difficult or impossible to count. Annuli lengths were measured to the nearest mm using dial calipers. Plastron and carapace lengths were measured to the nearest mm using outside calipers.

The sex of the turtles was determined by plastron and tail characteristics (Graham and Doyle 1977), with males having concave plastrons and females having flat plastrons and an anal opening on the tail anterior to the carapacial margin.

Turtles were weighed to the nearest 0.1 g on a spring scale, marked with notches in the carapace (Cagle 1939), and released at the capture site. Recapture of marked turtles provided population estimates using the marked/recapture methods developed by Schnabel (1938) and Schumacher and Eschmeyer (1943). Recaptures, especially in the future, could provide information about recruitment, survival, and habitat use.

Results and Discussion

Sixty-two Blanding's turtles were captured, of which 51 individuals were first-time captures and 11 were recaptures of turtles previously marked in this study. In addition, two mortalities were recorded. One unmarked turtle was found dead in a cultivated field, and a marked turtle was found killed by a vehicle on a road.

The locations of the 62 captures and recaptures were as follows: 54 on road, 5 in hoop nets, 2 in hand nets, and 1 in a seine net.

The first turtle was marked on 10 June 1998 and the last turtle on 17 July, a period of 41 days. Eighty-four percent of the turtles were captured and marked during the first 10 days of the sampling period. Peak capture success occurred from 15 to 20 June when an average of eight turtles was captured per day.

Marked/recapture estimates of the population size of Blanding's turtles in Crex Meadows ranged from 107.3 (Schnabel 1936) to 161.3 (Schumacher and Eschmeyer 1943) turtles (Canfield and Evrard 1997). Because these estimates don't agree, their validity is questionable. Koper and Brooks (1998) recently compared mark-recapture population estimates with known population sizes of painted turtles *(Chrysemys picta)* and found that almost all the estimates were far below the true population sizes. Based on their findings, our highly variable population estimates of Blanding's turtles in the Crex Meadows Wildlife Area should probably be considered a minimum estimate.

Because the population estimate of 107–161 turtles was based upon a sample of animals that was 95% female, the population size is more correctly an estimate of the number of nesting female Blanding's turtles rather than the total population inhabiting Crex Meadows.

In our study, the sample of turtles captured was skewed heavily towards adult females (48 females vs. 3 males or 16:1). Other studies (Congdon and van Loben Sels 1991, Piepgras et al. 1998) have reported sex ratios favoring female Blanding's turtles, but none were as skewed as in this study. This skewed ratio is understandable since female turtles select sandy road edges for nesting, and 44 of the 54 turtles captured on roads were female. All 3 males and 4 females were captured in the water. The sex ratio for those turtles captured in the water was less skewed (1.3:1) and similar to that range reported in earlier research (Joyal 1996).

Mean carapace lengths and widths were similar between 47 female and 3 male Blanding's turtles, although the male sample size was limited (Table 1). This

Table 1. Measurements of Blanding's turtles captured in the Crex Meadows Wildlife Area, Wisconsin, 1997.

		Carapace Length[a]		*Carapace Width*[a]		*Plastron Length*[a]		*Weight*[b]	
Sex - Age	*Number*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Female	47	234.2	10.6	157.6	6.6	186.1	9.7	1942.0	253.4
Male	3	234.3	20.8	158.0	13.4	173.7	16.9	1866.7	365.3
<u>Annuli</u>									
4	1	105.0	0.0	81.0	0.0	80.0	0.0	200.0	0.0
10	2	231.0	60.0	154.5	36.0	182.0	49.0	1850.0	825.0
11	11	228.5	11.6	154.4	7.5	181.5	13.3	1859.1	251.7
12	7	228.0	10.1	155.3	7.7	181.2	10.0	1804.2	224.4
13	6	234.2	12.0	156.0	7.3	188.3	9.9	1937.5	236.2
14	7	232.9	9.6	159.3	7.6	182.4	7.2	1885.7	219.9
15	5	234.0	3.6	158.6	3.6	184.2	3.9	1920.0	119.8
16	3	236.3	0.9	160.0	2.4	187.3	1.9	2000.0	204.1

[a]millimeters
[b]grams

similarity agrees with previous work done by Rowe (1987), Congdon and van Loben Sels (1991), Rowe (1992), and Joyal (1996).

However, there appear to be differences in Blanding's turtle sizes from one geographic area to another (Joyal 1996). For 47 female Blanding's turtles in our study, the mean carapace length was 234 mm, the mean carapace width was 158 mm, and the mean plastron length was 186 mm (Table 1). Sizes of Blanding's turtles in adjacent Minnesota were similar—mean carapace length for 37 adult females was 237 mm (Piepgras et al. 1998) and 245 mm for 42 adult females (Sajwaj et al. 1998).

However, mean carapace lengths for 11 adult females in southern Maine and for 20 adult females in Nebraska were 206 mm and 185 mm respectively (Joyal 1996, Germano et al. 1998). Differences also apparently existed between mean measurements for males from northwest Wisconsin and from southern Maine. However, this comparison is questionable due to small male sample sizes in our study.

Age structure and/or food quality and availability could possibly be responsible for these size differences (Quinn and Christiansen 1972, Graham and Doyle 1977).

The age structure, determined by counting plastron annuli, indicated that the Blanding's turtle population inhabiting Crex Meadows apparently has many adults but very few young. Another explanation might be that capture techniques used in this study could be unsuitable for sampling young turtles.

Male Blanding's turtles reach sexual maturity at approximately 12 years of age (Graham and Doyle 1977) and females at 14–20 years (Petokas 1977, Ross 1989, Congdon and van Loben Sels 1991). Twenty-seven or 66% of the turtles captured were breeding adults (≥12 years of age), 13 or 32% were subadults (10 and 11 years old), and only 1 or 2% was a juvenile (4 years old).

Other Blanding's turtle studies have reported finding very few young animals (Gibbons 1968, Graham and Doyle 1977, Congdon et al. 1983, Kofron and Schreiber 1985, Petokas 1987, Ross 1989, Joyal 1996, Standing et al. 1997, Germano et al. 1998, Piepgras et al. 1998, Sajwaj et al. 1998). Either nest success is very low and/or survival of young turtles is low due to predation, or juvenile turtles' behavior or habitat (Ross 1989, Pappas and Brecke 1992, Congdon et al. 1993, Herman et al. 1998, McMaster and Herman 1998, Morrison et al. 1998) is considerably different than that used by adult turtles (Sexton 1995).

The limited information gathered in this study did not permit determining habitat preferences of Blanding's turtles. However, in general, the deep, large, permanent marshes interspersed with upland brush prairie of the Crex Meadows Wildlife Area apparently were preferred compared to nearby heavily wooded river valleys. In an extensive two-year survey of turtles on the nearby St. Croix River, Donner-Wright (1997) found only one Blanding's turtle.

Joyal (1996) in southern Maine found that Blanding's turtles preferred permanent, deep marshes in large wetland complexes in areas sufficiently open for abundant sunlight to reach the wetlands. She also found that the turtles needed open uplands for nesting, short-term basking, long-term estivation, and travel between wetlands. Linck and Moriarity (1998) found that recently burned upland prairies are important nesting habitat in Minnesota. Crex Meadows provides the appropriate wetland and upland habitat, but the many roads may provide barriers and danger to migratory turtles (McGown 1999).

Recommendations

The apparent absence of young Blanding's turtles in this study and other studies (Standing et al. 1997), whether a reflection of actual numbers or inadequate sampling techniques, might be a factor limiting the population of this threatened species. Small radio transmitters attached to newly hatched turtles (Herman et al. 1998, McMaster and Herman 1998, Morrison et al. 1998, Tanck and Thiel 1998, McGown 1999) as they emerge from their nests might help determine juvenile turtle survival and habitat preferences or reveal potential techniques to increase their capture. Transmitters attached to adults of both sexes could also reveal habitat preferences and mortality patterns. This knowledge could ensure the continued survival of the Blanding's turtle in Crex Meadows.

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D. Timothy Gerber

Floating-leafed and Submersed Aquatic Macrophyte Distribution and Abundance, With Emphasis on Eurasian Watermilfoil *(Myriophyllum spicatum)* in Forest Lake, Fond Du Lac County, Wisconsin

Abstract *Exotic species invasions play an important role in reducing native biodiversity. Tracking the spread, distribution, and abundance of the exotic submersed aquatic macrophyte eurasian watermilfoil* (Myriophyllum spicatum) *in Wisconsin and cataloging native biodiversity within the lakes it invades is of interest to state aquatic biologists, lake managers, and lake property owners. The purpose of this paper is to assess, through the use of a nondestructive sampling method, both the spread and distribution of this exotic species and the distribution of native aquatic flora in Forest Lake, Fond du Lac County, Wisconsin. I found twenty-two species of aquatic macrophytes, including eurasion watermilfoil, within the lake. Some significant differences in abundance and depth distribution were found for six of the most dominant aquatic species. Although eurasion watermilfoil was not listed in previous plant surveys of Forest Lake, it has become well established. An additional exotic emergent aquatic species, purple loosestrife* (Lythrum salicaria), *was also found, and its distribution was determined.*

Exotic species invasions have historically played an important role in reducing native biodiversity (Devine 1998). Since the early 1960s, invasion of the exotic Eurasian watermilfoil (*Myriophyllum spicatum*, hereafter EWM) in southern Wisconsin (Engel 1993) has negatively affected native aquatic macrophyte communities and thus has had an impact on many organisms that interact with these plants. Tracking the spread, distribution, and abundance of EWM in

Wisconsin and cataloging native biodiversity within the lakes it invades is therefore of interest to aquatic biologists, lake managers, and lake users.

Forest Lake (T13N, R19E, sec. 12, Hydrologic unit 04040003, Fond du Lac County, WI) is a 20.4-ha kettle lake located in the terminal moraine of the Green Bay glacier. This single basin lake receives no permanent surface water inflow and has no stream outlet (Wisconsin Department of Natural Resources 1970, U.S. Geological Survey 1994). With a mean depth of 3.3 m, Forest Lake supports a diverse assemblage of rooted, floating-leafed and submersed aquatic plant species that cover much of the lake's bottom. The 47.6-ha watershed surrounding Forest Lake is moderately to steeply sloped with a loam soil that supports primarily woody vegetation (47 ha). The remaining area (0.6 ha) is marsh and shrub wetland (Wisconsin Department of Natural Resources 1970). The watershed has been extensively developed on the northern and eastern sides (private homes and cottages) where shoreline disturbance (sand beach development) is greatest. During the 1960s, dredging at the northern end of the lake caused additional disturbance to the native aquatic plant community.

As of 1968 (Wisconsin Department of Natural Resources 1970), EWM was not found in Forest Lake; however, since then this exotic species has become a problem. Because of interest in exotic species distribution and control in Wisconsin, a systematic survey of Forest Lake's aquatic macrophyte community was conducted to determine the extent of the EWM invasion. The purpose of this paper is to (1) quantitatively and qualitatively document the native aquatic macrophytes and EWM in Forest Lake, (2) describe the within-lake distribution of native macrophytes and EWM at present, (3) assess if changes in macrophyte distribution have occurred since the 1968 survey, (4) determine if other exotic species occur, and (5) determine sediment characteristics within disturbed areas of the lake.

Methods

Data Collection

A qualitative and quantitative aquatic vegetation survey was conducted during July 1993. To minimize disturbance to aquatic plant beds, a nondestructive sampling technique (Titus 1993) was used. Twenty evenly spaced (approximately 107 m between) transects were established perpendicular to the shoreline to assess species composition, frequency, and abundance (Figure 1). Four 0.25-m^2 sample sites were located along each transect, one site at each depth interval (0.5, 1, 2, and 3 m) for a total of 80 sample sites. The maximum depth interval was set at 3 m because aquatic plant growth was limited to 3.7 m (Wisconsin Department of Natural Resources 1970). Each transect was assessed visually for the presence or absence of plants and percent cover of each species using snorkel or SCUBA equipment. An abundance score was determined for each site based on the percent cover for each species (see below). Voucher specimens of each species were deposited in the University of Wisconsin-Milwaukee herbarium.

To determine the range of sediment characteristics under which EWM grows within the most disturbed extreme northern region of Forest Lake, six 200-g samples of sediment were randomly collected within EWM beds at 1-2 m depth during September 1993. Each sample was dried and sent to the University of Wisconsin-Extension Soil and Plant Analysis Lab (5711 Mineral Point Road, Madison, WI) for analysis of pH, organic matter (percent organic matter

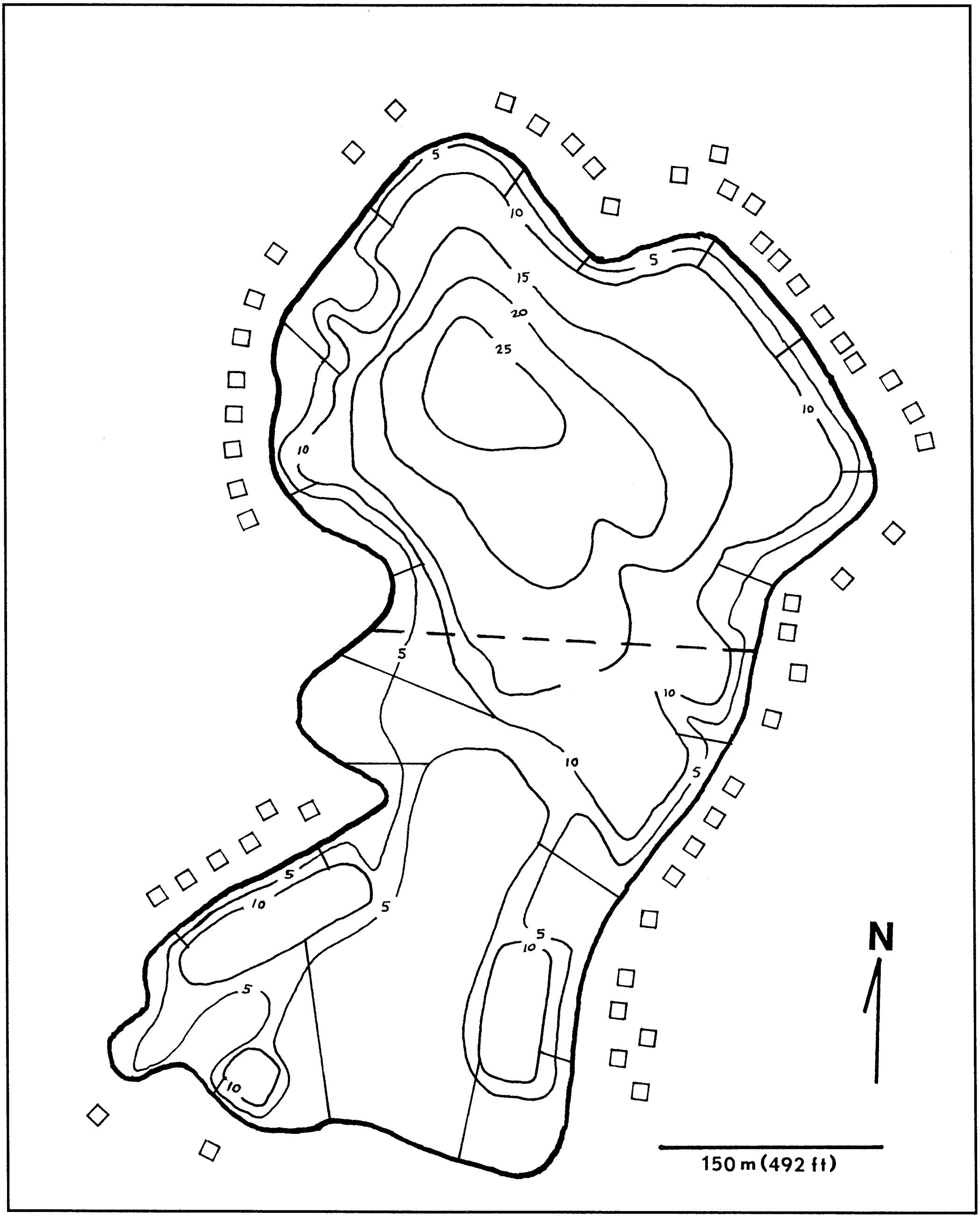

Figure 1. Locations of the 20 transects (lines perpendicular to shore) used for the vegetation survey of Forest Lake. Squares represent private homes or cottages on the lake. The dotted line separates the lake into northern and southern regions. Contour lines are drawn at 5 ft (1.5 m) intervals.

by titration), texture (percent silt, percent sand, percent clay), and mineral content.

Analyses

In a 1968 Department of Natural Resources aquatic plant survey (Wisconsin Department of Natural Resources 1970), differences were found between the northern and southern regions of Forest Lake; therefore, the lake was again divided into northern and southern regions for this study. Abundance, relative abundance, frequency, and relative frequency were calculated using an abundance score (modification of Titus 1993) to determine how common each species was in the northern versus southern regions and within the whole lake. For each sample site, an abundance score was determined in the field for each species using the following designations: 0 (Absent); 1 (Present) = single plant to plants covering $\leq$ 1% of 0.25-m^2 sampling area; 2 (Abundant) = plants covering 1-50% of sampling area; 3 (Common) = plants covering > 50% of sampling area. Mann-Whitney U tests were performed on the most abundant species to determine if significant differences exist for abundance between northern and southern regions. Abundance differences were also determined for the most dominant species at two depth levels for the entire lake: shallow (0.5 m and 1 m depths combined) and deep (2 m and 3 m depths combined). Wilcoxon's Signed Ranks tests were performed on depth distribution (shallow vs. deep) within the entire lake.

Results

Twenty-two aquatic macrophyte species were found within Forest Lake (Table 1). Three native emergent species (*Sagittaria* sp.,

Table 1. Aquatic macrophyte species in Forest Lake, Fond du Lac County, Wisconsin (taxonomy follows Gleason and Cronquist 1991) by region. N = northern, S = southern.

Scientific Name	*Common Name*	*Region*
Ceratophyllum demersum L.	Coontail	N, S
Chara sp.	Muskgrass	N, S
Eleocharis acicularis (L.) Roemer & Schultes.	Spike Rush	N, S
Lythrum salicaria L.	Purple Loosestrife	N, S
Myriophyllum sibericum Komarov	Northern Watermilfoil	N, S
Myriophyllum spicatum L.	Eurasian Watermilfoil	N, S
Najas flexilis (Willd.) Rostk. & Schmidt	Bushy Pondweed	N, S
Nuphar variegata Durand	Yellow Water Lily	N
Nymphaea oderata Aiton	White Water Lily	S
Polygonum amphibium L.	Water Smartweed	S
Potamogeton amplifolius Tuckerman	Large-leafed Pondweed	N, S
Potamogeton foliosus Raf.	Leafy Pondweed	N
Potamogeton gramineus L.	Variable-leaf Pondweed	N, S
Potamogeton natans L.	Floating-leaf Pondweed	S
Potamogeton pectinatus L.	Sago Pondweed	N, S
Potamogeton pusillus L.	Slender Pondweed	N, S
Potamogeton zosteriformis Fern.	Flat-stemmed Pondweed	N, S
Sagittaria sp.	Arrowhead	N, S
Scirpus validus Vahl	Soft-stem Bulrush	N, S
Typha sp.	Cattail	S
Vallisneria americana L.	Water-celery	N, S
Zosterella dubia (Jacq.) Small.	Water star-grass	N, S

Scirpus validus, and *Typha* sp.) and one exotic emergent species (purple loosestrife, *Lythrum salicaria*) were excluded from abundance and frequency analyses. The native floating-leafed *Nuphar variegata,* found in the lake but not within any sampling sites, was also excluded from analyses. Only the seventeen true aquatic species (i.e., floating-leafed and submersed) found within sampling sites were considered for abundance and frequency analyses. The number of species at individual sampling sites ranged from zero (8 sites) to six (1 site).

Six dominant species (RA_W > 10% or RF_W > 10%; Tables 2 and 3) were found within Forest Lake: *Chara* sp., *Najas flexilis, Myriophyllum sibiricum, Myriophyllum spicatum* (EWM), *Potamogeton pusillus,* and *Vallisneria americana.* Significant differences ($P \leq 0.05$) in abundance among these six species existed between the northern and southern halves of Forest Lake. EWM (P = 0.004) was significantly more abundant in the northern region, whereas *Najas flexilis* (P = 0.002) and *Potamogeton pusillus* (P = 0.001) were more abundant in the south. No significant differences in abundance between northern and southern regions were found for *Myriophyllum sibiricum* (P = 0.971), *Chara* sp. (P = 0.684), and *Vallisneria americana* (P = 0.529). Of aquatic macrophytes other than the six dominant species, *Potamogeton foliosus* was present in the northern region but absent in the southern region. *Nymphaea odorata, Polygonum amphibium,* and *Potamogeton natans* were present in the southern region but not the northern region.

Species abundance differs at different depths in Forest Lake. Within the entire lake, *Myriophyllum sibiricum* (P = 0.015), *Chara* sp. (P = 0.017), and *Potamogeton pusillus* (P = 0.023) were found in higher abundance in deep water. No significant differences in abundance for depth were found for *Najas flexilis* (P = 0.134), EWM (P = 0.279), and *Vallisneria americana* (P = 0.209).

Purple loosestrife, an exotic emergent aquatic species, was found growing in sparse patches within the lake and in dense patches in surrounding wetlands. A visual inspection of the wetlands was made to determine distribution of this species. Because of the interest in exotic species control, distributions for both EWM and purple loosestrife were mapped (Figure 2).

Sediments found within EWM plant beds at the extreme northern end of Forest Lake were assigned a designation of sand to sand-loamy. Sediment texture composition ranged from 95–85% sand, 14–6% silt, and <1% clay. Organic matter content was low (4.24–0.97%). This was probably due to human disturbance along the northern lake shore, where property owners use sand to maintain beaches. Sediment pH values ranged from 7.2–6.7. Sediment mineral ranges are given in Table 4. Water mineral ranges are taken from U.S. Geological Survey (1994) data and Wisconsin Department of Natural Resources (1970) data (Table 4).

Discussion

Within the last 30 years, EWM has become well established in Forest Lake, and purple loosestrife has become well established in the surrounding wetlands. Neither exotic species was found during the 1968 Wisconsin Department of Natural Resources survey (1970), but EWM has now become the most dominant true aquatic macrophyte species within the northern region of Forest Lake and the fifth most abundant species within the entire lake. EWM distribution within the lake is not uniform, however; its greatest concentration was at the 2-m depth

Table 2. Abundance (A = sums of abundance scores) and relative abundance (RA) of floating-leafed and submersed species of the northern region (N), southern region (S), and whole lake (W) for Forest Lake, Fond du Lac County, Wisconsin. A_W = 0 (absence), 1 (present), 2 (abundant), or 3 (common) for each occurrence in a 0.25 m^2 area and $\%RA_W = (A/A_{Total})*100$ for 80 sample sites; A_N, A_S, $\%RA_N$ and $\%RA_S$ are calculated similarly for 40 sample sites each.

Species	A_N	$\%RA_N$	A_S	$\%RA_S$	A_W	$\%RA_W$
Ceratophyllum demersum	3	2.2	3	1.8	6	2.0
Chara sp.	25	18.7	20	12.1	45	15.1
Eleocharis acicularis	1	0.7	2	1.2	3	1.0
Myriophyllum sibericum	26	19.4	24	14.5	50	16.7
Myriophyllum spicatum	35	26.1	2	1.2	37	12.4
Najas flexilis	14	10.4	43	26.1	57	19.1
Nymphaea oderata	0	0	5	3.0	5	1.7
Polygonum amphibium	0	0	2	1.2	2	0.7
Potamogeton amplifolius	2	1.5	3	1.8	5	1.7
Potamogeton foliosus	1	0.7	0	0	1	0.3
Potamogeton gramineus	4	3.0	4	2.4	8	2.7
Potamogeton natans	0	0	3	1.8	3	1.0
Potamogeton pectinatus	1	0.7	4	2.4	5	1.7
Potamogeton pusillus	4	3.0	36	21.8	40	13.4
Potamogeton zosteriformis	3	2.2	4	2.4	7	2.3
Vallisneria americana	14	10.4	9	5.5	23	7.7
Zosterella dubia	1	0.7	1	0.6	2	0.7
Total	**134**	**100**	**165**	**100**	**299**	**100**

Table 3. Frequency (F) and relative frequency (RF) of floating-leafed and submersed species of the northern region (N), southern region (S), and whole lake (W) for Forest Lake, Fond du Lac County, WI. F_W = no. of occurrences/80 sample sites; $\%RF_W = (F/F_{Total})*100$; F_N, F_S, $\%RF_N$ and $\%RF_S$ were calculated similarly for 40 sample sites each.

Species	F_N	$\%RF_N$	F_S	$\%RF_S$	F_W	$\%RF_W$
Ceratophyllum demersum	3.8	3.4	2.5	1.9	6.3	2.6
Chara sp.	17.5	15.8	10.0	7.7	27.5	11.5
Eleocharis acicularis	1.3	1.2	1.3	1.0	2.6	1.1
Myriophyllum sibericum	17.5	15.8	16.3	12.6	33.8	14.1
Myriophyllum spicatum	23.8	21.5	2.5	1.9	26.3	11.0
Najas flexilis	13.8	12.5	33.8	26.2	47.6	19.9
Nymphaea oderata	0	0	6.3	4.9	6.3	2.6
Polygonum amphibium	0	0	2.5	1.9	2.5	1.0
Potamogeton amplifolius	2.5	2.3	3.8	2.9	6.3	2.6
Potamogeton foliosus	1.3	1.2	0	0	1.3	0.5
Potamogeton gramineus	5.0	4.5	5.0	3.9	10.0	4.2
Potamogeton natans	0	0	3.8	2.9	3.8	1.6
Potamogeton pectinatus	1.3	1.2	5.0	3.9	6.3	2.6
Potamogeton pusillus	3.8	3.4	18.8	14.6	22.6	9.4
Potamogeton zosteriformis	3.8	3.4	5.0	3.9	8.8	3.7
Vallisneria americana	13.8	12.5	11.3	8.7	25.1	10.5
Zosterella dubia	1.3	1.2	1.3	1.0	2.6	1.1
Total	**110.5**	**100**	**129.2**	**100**	**239.7**	**100**

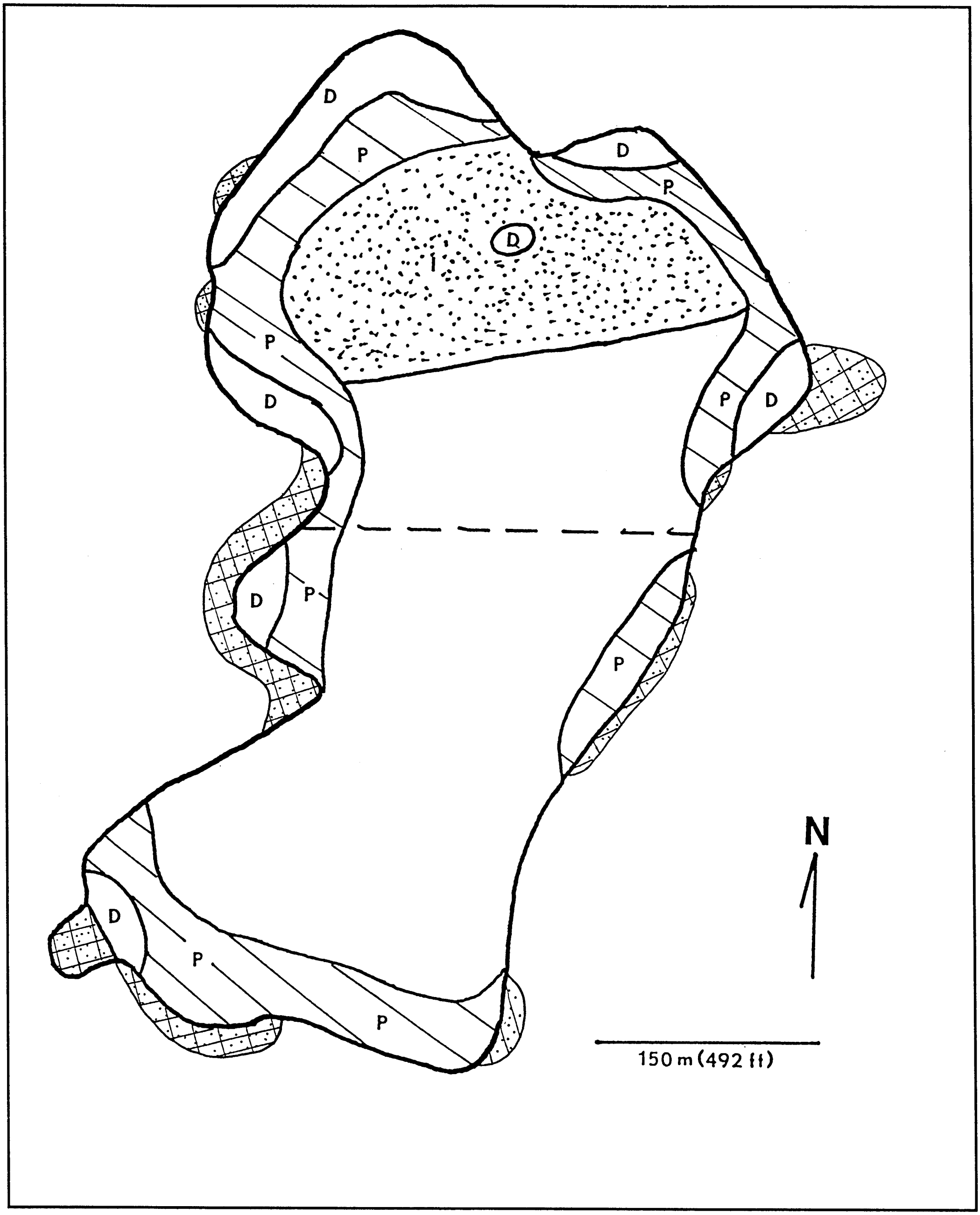

Figure 2. Distributions of EWM and purple loosestrife within and surrounding Forest Lake. Areas with dense (D) or patchy (P) stands of EWM are shown. The stippled deep water area contains patches of dense EWM stands that reach the surface later in the growing season. The cross-hatched, stippled areas identify loosestrife stands.

Table 4. Range of sediment (see collection site information in text, N = 6) and water mineral characteristics (N = 2, one shallow and one deep water sample, unless otherwise indicated; taken on May 3 [USGS 1994]) at the north end of lake; and mean water mineral characteristics (N = 1) on April 1968 (modified from WDNR 1970) of Forest Lake, Fond du Lac County, Wisconsin.

		Water, dissolved (ppm)	
Characteristic	*Sediment (ppm)*	*1994*	*1968*
Calcium	94,800 – 81,400	26	10.8
Magnesium	59,300 – 50,100	15	18.3
Iron	5,000 – 2,800	<50	0.01
Aluminum	3,800 – 2,000	—	—
Sulfur	501 – 103	4–5 (sulfate)	17.0
Potassium	468 – 128	<1	1.7
Phosphorus	247 – 155	<1 (total P; N = 8)	0.12
Sodium	231 – 173	2.4	8.7
Manganese	106 – 76	<40	—
Zinc	51 – 29	—	—
Copper	9 – 5	—	—
Boron	5 – 3	—	—

interval, which is consistent with other reports for this species (Nichols 1992, Deppe and Lathrop 1993, Lillie 1996). Purple loosestrife is restricted to shallow areas, and a visual inspection of surrounding wetlands suggests that this species warrants consideration to contain further spread.

As reported for other Wisconsin lakes (Nichols 1988), EWM was found in greatest abundance in the most disturbed areas of Forest Lake. Dense concentrations of EWM, often in pure stands, were found where the greatest number of sand beaches were located and also were growing from the shoreline to a depth of 4 m in previously dredged areas of the lake. Four sampling sites along beach areas had monotypic stands of EWM. *Chara* and *Vallisneria americana* were the only other species found in monotypic stands at one sample site each.

Changes in native aquatic plant distribution and abundance are evident within Forest Lake in the last 30 years. Several notable differences were found when comparing this report with the 1968 survey. *Potamogeton amplifolius,* once common within the northern lake region, is now much less abundant. Although *Chara* is still found along the northern shore, the thick growths of this species previously reported in the 1968 survey were not found in this survey. Within the southern region, *Potamogeton pectinatus* and *Potamogeton zosteriformis* are now found in comparatively low abundance but were previously listed as dominant species. *Najas flexilis,* while common in this report, was not mentioned in the 1968 survey. Interestingly, *Najas flexilis* has also been identified as a species that does well in disturbed areas (Nichols 1988).

While EWM is considerably less abundant in the southern half of the lake, its spread into this region has been noticed within the last several years (personal communication, C. Kendziorski). Previous research (Nichols 1990, Nichols and Buchan 1997) suggests that certain aquatic macrophytes show significant habitat associations with EWM. Three of these "indicator species" (e.g., *Najas flexilis, Myriophyllum* *sibiricum, Potamogeton gramineus)* are dominant in the southern region of Forest Lake. Fish Lake (Dane County, WI), similar to Forest Lake in aquatic macrophyte species composition, has shown a drastic increase in EWM over the last two decades (Nichols 1984, Lillie 1996). Although Fish Lake at present has shown some decline in EWM, it is still by far the most dominant species within the lake (Lillie 1996).

Physical and chemical sediment characteristics influence the distribution of rooted, submersed and floating-leafed aquatic macrophytes (Sculthorpe 1967). EWM has been shown to colonize many different sediment types, from high organic-mucky to low organic-sandy sediments (Nichols 1971, Lillie and Barko 1990, Gerber and Les 1996, Nichols and Rogers 1997). In Forest Lake, the northern shoreline has been disturbed by the development of sandy beach areas with sandy sediments to a depth of >2 m. These sandy sediments are colonized in monotypic or mixed stands by EWM, *Najas flexilis, Chara, Ceratophyllum demersum,* and *Vallisneria americana.* These species, excluding *Chara,* are described by Nichols (1988) as being tolerant of disturbance.

Determination of native and exotic plant abundance, frequency, and distribution are important for understanding plant community dynamics and for developing an aquatic plant management program aimed at slowing EWM spread. Helsel et al. (1996) have shown that when physical and chemical control techniques are used in combination, native plants can recover and reestablish after EWM eradication. However, minimizing lake disturbance and maintaining a healthy native macrophyte standing crop are probably the best preventative measures to keep exotic species from establishing or spreading within a lake. Within Forest Lake, changes in the native species assemblage may be a harbinger of EWM dominance in southern Forest Lake. The southern end of the lake shows fewer signs of disturbance; however, now that EWM has established in the northern end its spread will probably continue.

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Evaluation of Survey Methods for the Karner Blue Butterfly on the Necedah Wildlife Management Area

Abstract *Three Karner blue butterfly (*Lycaeides melissa samuelis *Nabokov) populations were simultaneously monitored using three standard methods. Population estimates resulting from the methods were correlated with the number of butterflies counted while uniformly searching 50 x 50 m plots within the study sites. This deviates from other studies that evaluated survey methods based on correlation with mark-release-recapture surveys. A fundamental flaw of these studies is the assumption that mark-release-recapture estimates are the most accurate. Population estimates from Pollard-Yates surveys showed the highest correlation with the number of individuals found on the 50 x 50 m plots. Population estimates derived from straight-line transects provided the second best correlation followed by mark-release-recapture estimates. With data pooled by date, no significant differences between Pollard-Yates and straight-line transect derived population estimates were detected. Error estimates for mark-release-recapture surveys could be determined for only 59.5% of the population estimates. No significant differences in the variability estimates were detected among survey methods.*

Methods for estimating butterfly numbers are well established (Pollard 1977, Thomas 1983, Pollard and Yates 1993, Brown and Boyce 1998). Validation of monitoring methods has been accomplished for several species by demonstrating strong correlations between survey counts and population estimates derived from mark-release-recapture (MRR) studies (Douwes 1970, 1976; Pollard 1977; Warren 1981; Thomas 1983; Warren et al. 1986; Warren 1987). The underlying assumption of all such studies is that mark-release-recapture population estimates are the most accurate and should be the benchmark by which all other survey methods are gauged. As is the case with many Lepidoptera, MRR has been used extensively for estimating Karner blue butterfly (*Lycaeides melissa samuelis* Nabokov) populations (Schweitzer 1994). The use of MRR has raised concern because it requires many assumptions (Begon 1983) that are difficult to meet and can lead to biased estimates (Gall 1985).

Listing of the Karner blue butterfly as a federally endangered species (Clough 1992) heightened the need for reliable survey methods that are time and cost effective. Currently several methods are used to estimate Karner blue butterfly populations (Andow et al. 1994). The use of different methods in different geographic areas has made inter-site comparisons difficult. Data summary further complicates interpretation because some surveys are summarized by duration and others by transect length (Andow et al. 1994). Demonstrating Karner blue butterfly recovery requires range-wide population evaluations. Without uniform survey methods and data summary, range-wide analysis will be difficult at best. Therefore, recovery of the Karner blue butterfly is directly dependent on researchers and managers developing uniformity in survey protocol.

The goal of this project was to evaluate the accuracy and variability of three standard butterfly survey methods. The efficacy of each method was evaluated based on correlations with an independent, daily population index. Each method was further evaluated based on the spuriousness of the data it produced. The legitimacy of the methods was evaluated by exploring the assumption and limitations implicit to each.

Methods

The study was conducted during July and August 1995 on three different populations on the Necedah Wildlife Management Area in south-central Wisconsin (48°83′N, 90°10′W). All surveys, regardless of method, were conducted between 0800 and 1530. All study sites were staked with a 50 x 50 m grid system. The sites contained 130, 45, and 57 50 x 50 m plots. Each 50 x 50 m cell was searched on most days (70%) with equal effort between 20 July and August 8. The amount of survey effort was dependent on the number of surveyors, which ranged from 5 (9.1 min/plot) to 12 (22.0 min/plot). The order of cell surveys was randomized by population daily. The number of Karner blue butterflies counted while surveying each cell was recorded. The number of butterflies counted was summed for all cells within each population. Therefore, a daily population index (PI) was obtained by tallying the number of butterflies seen among 50 x 50 m cells within a population. The PI requires two assumptions: (1) the butterflies are not attracted to or repulsed by the observer and (2) butterflies counted in one cell are not counted while surveying subsequent cells. To minimize the risk of double-counting, as many as 12 surveyors were used to simultaneously survey two to four adjacent 50 x 50 m plots. By surveying adjacent plots and systematically advancing to new plots in the same direction, the risk of double counting butterflies was further reduced.

Mark-release-recapture activities were conducted on all three populations most days (70%) between 19 July and 11 August regardless of weather conditions. Butterflies were captured with standard aerial butterfly nets and given a unique three digit number with an ultra-fine point felt-tip pen. No mortalities were observed while conducting

MRR methods. Population estimates from MRR surveys (P_{mrr}) were calculated using the Jolly-Seber method with Jolly Software (Pollock et al. 1990). Mark-release-recapture requires three key assumptions: (1) the probability of capture is the same for all individuals, marked and unmarked; (2) the probability of survival is the same for all individuals, including marked individuals; (3) emigration is permanent and thus equal to death (Begon 1983).

Pollard-Yates (PY) surveys (Pollard 1977) and straight-line transect (SLT) surveys were conducted on all three populations. All PY and SLT surveys were conducted between 20 July and 15 August when rain or wind speed (> 15km/h) would not interfere. While conducting PY counts, observers walked a circular route through a subsection of the habitat patch attempting to cover all areas of high nectar/butterfly abundance. Time permitting, additional subsections were surveyed with PY transects, which resulted in more than one PY population estimate per day for some sites. SLTs ran across the entire habitat patch. The first SLT in each unit was randomly placed. Subsequent transects were added at 15 m intervals from the original transect until the habitat patch was saturated. Spacing of 15 m was used because it provided the most thorough coverage while minimizing the risk of counting the same Karner blue butterfly on subsequent transects. SLTs were permanently staked and color-coded to prevent observer deviation while traversing them. Sample size variations for SLTs resulted when all transects could not be surveyed because of logistical constraints. While conducting PY and SLT surveys, observers recorded the perpendicular distance from the transect to each butterfly. Perpendicular distances were recorded in 1/2-m intervals. While conducting PY surveys, a hand-held measuring wheel was used to measure transect length. Population estimates from the SLT and PY surveys were obtained by first determining the effective-strip-width.

Effective-strip-width is the distance from the transect that every butterfly can be assumed to be counted (Buckland et al. 1993). Effective-strip-widths were determined by fitting curves to the distribution of perpendicular distance estimates for each unit using the software "Distance" (Buckland et al. 1993). Karner blue butterflies per hectare were determined as:

$$D = \frac{n}{2^{*}esw^{*}L}$$

where n = number of Karner blue butterflies counted, esw = effective strip width, and L = transect length. Density estimates were then multiplied by the hectares in each unit to give absolute population estimates for PY (P_{PY}) and SLT (P_{slt}) surveys. When estimating abundance with PY and SLT surveys, four assumptions must be made: (1) butterflies are not double counted; (2) perpendicular distance from the transect to the butterfly is estimated accurately; (3) the probability of detecting a butterfly immediately on the transect is 100%; (4) butterflies are not attracted to or repulsed from the surveyor (Buckland et al. 1993). Assumptions 1 and 4 are shared with the PI method.

The risk of double-counting on PY transects was greatly reduced by using circular versus zig-zag routes. Much like the PI surveys, the risk of double-counting on SLT was reduced by having several surveyors simultaneously walking adjacent transects. The sessile nature of Karner blue butterflies also helps reduce the risk of double-counting on PY, SLT, and PI surveys. Although Karner blue butterflies can move several hundred meters on a weekly basis (King 1998), they move little over the course of several minutes (the time between surveys on adjacent plots or transects) (Fried 1987, Packer 1987, Lawrence and Cook 1989, Sferra et al. 1993, Welch 1993, Bidwell 1995). The effects of double-counting on either PY or SLT were further minimized by deriving population estimates from individual transects as opposed to summing the butterflies counted by day and site.

As with other butterflies (Douwes 1970, 1976; Pollard 1977; Warren 1981; Thomas 1983; Warren et al. 1986; Warren 1987), Pearson correlation analysis was used to validate the survey methods. The population estimates, P_{mrr}, P_{PY}, and P_{slt}, were correlated with the PI by population and date to determine which method provided the most accurate estimate. Therefore, accuracy was assumed to equal the precision between the population estimates and the PI. The PI was used as the benchmark because it was independent of the other methods, required the most time observing the populations, had the least assumptions and could therefore be assumed to most accurately reflect true population fluctuations. A Wilcoxon rank-sums test was used to test for differences between the P_{PY} and P_{slt} estimates where n for both was > 1. P_{mrr} could not be included in this analysis as MRR provides only one estimate per population per day. Differences in the perpendicular distance estimates between PY and SLT methods were tested with a Wilcoxon rank-sums test. The coefficients of variation for P_{mrr}, P_{PY}, and P_{slt} were measured as $SE/\bar{x}$. An ANOVA was used to test for differences in the coefficients of variation for the P_{mrr}, P_{PY}, and P_{slt} estimates. When needed to meet test assumptions, data were logarithmically transformed using SAS software. All statistics are reported as $\bar{x} \pm$ SE with significance set at $P \leq 0.05$.

Results

A total of 58 and 878 Karner blue butterflies were counted on 32 PY and 492 SLT surveys respectively. The distribution of the perpendicular distance estimates for both methods approximated a half-normal distribution (Figure 1). Mean perpendicular distance for PY (1.47 ± 0.12) was slightly higher than that for SLT surveys (1.36 ± 0.07) but not significantly ($P > 0.05$). MRR surveys resulted in 1,487 marked individuals with a recapture rate of 27.8% with recaptures pooled by sex and population. Confidence intervals could be determined for only 59.5% of the P_{mrr} estimates because of small sample sizes (Table 1).

Karner blue butterfly abundance (PI) was most strongly correlated ($r = 0.90$; $p = 0.0001$; $n = 15$) with population estimates derived from the Pollard-Yates surveys (P_{PY}) (Table 1). P_{slt} provided the second best correlation ($r = 0.72$; $p = 0.0011$; $n = 17$) with PI, followed by P_{mrr} ($r = 0.66$; $p = 0.0001$; $n = 42$) (Table 1). With data pooled by date, P_{PY} and P_{slt} estimates were not significantly different. P_{mrr} had the highest mean coefficient of variance (0.57 ± 0.31) followed by P_{PY} (0.54 ± 0.09) and P_{slt} (0.50 ± 0.24) although these differences were not significant.

Of the 427 recaptures, 90.5% occurred within seven days of the original capture date (Figure 2). The mean number of days between original capture and final capture dates was 3.59 ± 0.18. One female was recaptured 19 days after her original capture, and two males were recaptured 15 days after their original capture.

Discussion

PY surveys provided the most accurate population estimate based on correlations with PI. Straight-line transect surveys pro-

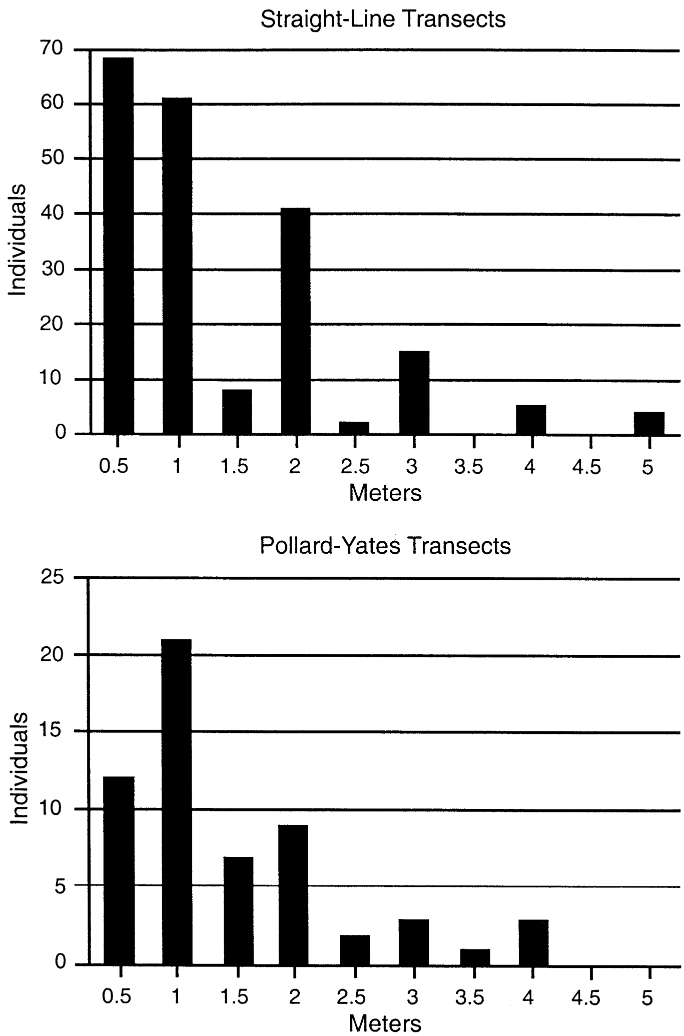

Figure 1. Distribution of perpendicular distance estimates from transect to Karner blue butterflies (*Lycaeides melissa samuelis* Nabokov) on the Necedah Wildlife Management Area, Juneau County, Wisconsin.

vided less accurate and variable estimates but the estimates were not significantly ($P \leq 0.05$) less variable. Mark-release-recapture surveys provided the least accurate population estimates. Further complicating the interpretation of P_{mrr} estimates was the lack of confidence intervals around some of those estimates. Proper testing of MRR data is precluded by the fact that only one population estimate is provided per site and day, which limits comparisons to correlation analysis. Another concern about the use of MRR with Karner blue butterflies is that individuals not only leave populations, they come back fre-

Table 1. Population estimates for three Karner blue butterfly (*Lycaeides melissa samuelis* Nabokov) populations on the Necedah Wildlife Mangagement Area, Juneau County, Wisconsin.

			Method		
Date	*Population*	*Population Index (PI)*	*Straight-line Transects (n)*	*Pollard-Yates Transects (n)*	*Mark-release-recapture*
July 20	NRYN	70	2,174± 339 (15)		195
	SRYN	11	121± 49 (12)	32	30 ± 27
	ERYN	16			16
July 21	NRYN	81			326±108
	SRYN	10	79± 27 (32)	0	169
	ERYN	2	130±130 (43)		2
July 22	SRYN		13±13 (12)	96	
July 23	SRYN		0± 0 (12)	0	
July 24	NRYN	90			464±143
	SRYN	19	40± 29 (12)	32	58± 44
	ERYN	6			6
July 25	NRYN	102			436± 97
	SRYN	28	94± 37 (12)	96	280± 244
	ERYN	15			64
July 26	NRYN	128			540±121
	SRYN	31	27±18 (12)	129	341± 272
	ERYN	9			24± 20
July 27	NRYN	78	1,104± 325 (15)	2,123	617±175
	SRYN	41	134± 74 (12)	161	275±157
	ERYN	14			35± 40
July 28	NRYN	96			922±280
	SRYN	35	252± 63 (20)	306±163 (3)	277±163
	ERYN	10	309± 138 (43)	0± 0 (2)	10
July 31	NRYN	86			826± 250
	SRYN	47			212± 96
	ERYN	8			8
August 1	NRYN	71			552±142
	SRYN	7			128± 96
	ERYN	6			36
August 2	NRYN	56			775± 248
	SRYN	68			225± 86
	ERYN	67			36
August 3	NRYN	77			493± 133
	SRYN	28	27±18 (12)	32	491± 407
	ERYN	3			3
August 4	NRYN	96	830±184 (15)	620	259± 98
	SRYN	32	173± 33 (20)	197± 90 (4)	193± 211
	ERYN	2	139± 72 (43)	0± 0 (2)	2
August 7	NRYN	21			778± 879
	SRYN	13	54± 36 (12)	0	52
	ERYN	1			1
August 8	NRYN	7			16
	SRYN	6	54± 30 (12)	0	6
	ERYN	0			0
August 9	SRYN		67± 24 (12)	161	
August 10	SRYN		94± 42 (12)	161	
August 11	SRYN		36± 13 (32)	73± 46 (4)	
	ERYN		0± 0 (43)		
August 15	NRYN		38± 38 (15)	100	
	SRYN		27± 18 (12)	0	

*Population estimates ± SE. Sample sizes are 1, regardless of method, unless otherwise indicated.

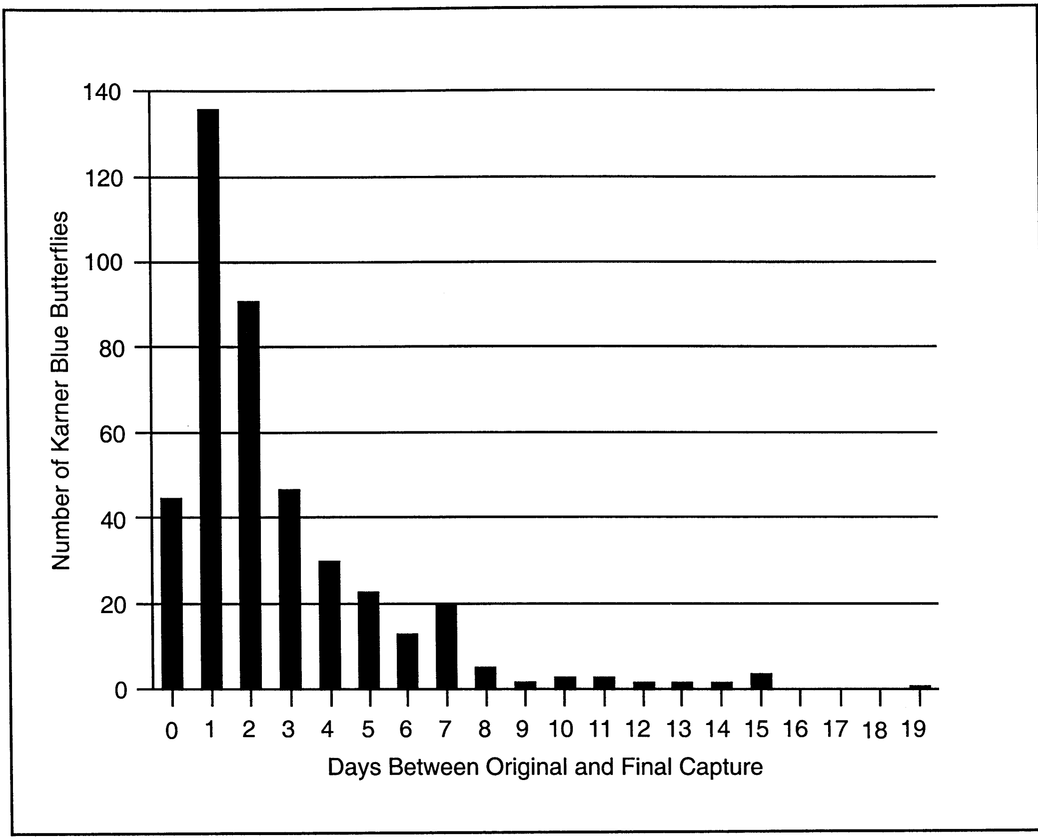

Figure 2. Days between original and final capture dates for Karner blue butterflies (*Lycaeides melissa samuelis* Nabokov) on the Necedah Wildlife Management Area, Juneau County, Wisconsin.

quently (King 1998), which is a violation of one underlying assumption of MRR methodology.

The recapture data indicates that seven-day spacing between counts on the same unit provides relative confidence (90.5%) that the same individuals are not counted on subsequent surveys. This is useful as it provides independence, which allows counts to be summed instead of averaged. The lack of significant differences between PY and SLT perpendicular distance estimates demonstrates the robustness of "Distance" methodology, which helps to validate its use for highly visible Lepidoptera like the Karner blue butterfly. Regardless of the method, population estimates employing "Distance" methodology provided more accurate results than MRR methods. More important, PY and SLT surveys provide the opportunity to independently evaluate the effectiveness and accuracy of population estimates as well as develop confidence limits around those estimates. At best, confidence limits can be established around only some MRR population estimates (< 60% during this study). Even if confidence intervals can be determined, MRR requires that they are derived internally and are therefore suspect (Manly 1971, Roff 1973).

The accuracy and reliability (variability) of PY derived estimates is encouraging for those charged with monitoring Karner blue butterfly populations. As with all endangered species, managers must be aware of the status of all Karner blue butterfly populations they manage. Monitoring dozens of populations across a broad geographic range requires a quick but dependable survey method. Of the methods tested during this study, PY counts required the least time/financial investment followed by SLT and MRR. Although clearly biased toward "optimal" habitat, PY surveys provide a quick but accurate means of monitoring Karner blue butterfly populations. This bias toward "optimal" habitat provides flexibility to reroute transects within sites as nectar sources shift throughout the flight, which is an advantage of the PY method. Data obtained from PY surveys are robust, require less time, and best describe population fluctuations. PY surveys can answer local questions about habitat management or individual population fluctuations but can also answer rangewide, recovery questions that require intersite comparisons (Thomas 1983, Pollard and Yates 1993, Swengel 1996).

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Ecoregions of Wisconsin

Abstract *Ecoregions are geographical areas within which the biotic and abiotic components of terrestrial and aquatic ecosystems exhibit different but relatively homogeneous patterns in comparison to that of other areas. As such these regions serve as a framework for ecosystem management in a holistic sense and allow integration of assessment and management activities across state and federal agencies that may have different responsibilities and missions for the same geographic areas. Most of the spatial frameworks of Wisconsin that are termed ecoregions or have been used for environmental management in the state were designed to address specific aspects of resource management. In a collaborative effort with various state and federal agencies, we have attempted to define a framework to meet broader ecosystem management needs that consider both the terrestrial and aquatic components as well as the human influences and associations with other ecosystem characteristics that affect management potentials for land and water resources. The "Ecoregions of Wisconsin" consist of 27 level IV regions nested within six larger level III regions that also occupy portions of adjoining states. We provide a brief description of the primary distinguishing characteristics (such as soils, vegetation, climate, geology, physiography, water quality, hydrology, and land use) within each level III and IV ecoregion, and discuss the potential applications of the ecoregion map in context of current and future directions of ecosystem management in Wisconsin.*

Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources; they are designed to serve as a spatial framework for the research, assessment, monitoring, and management of ecosystems and ecosystem components. Special purpose maps of characteristics such as plant communities, water quality, soils, and fish distributions are necessary and have long been used for dealing with specific research and management problems. Ecoregions, on the other hand, portray areas within which there is similarity in the mosaic of all biotic and abiotic components of both terrestrial and aquatic ecosystems. Recognition, identification, and delineation of these multipurpose regions are critical for structuring and implementing integrated management strategies across federal, state, tribal, and local governmental agencies that are responsible for different types of resources within the same geographical areas.

Several spatial frameworks that either are termed ecoregions or are used for environmental resource management have been developed for Wisconsin. Most, however, were designed to address specific aspects of resource management rather than ecosystem management in a holistic sense. Others were not refined or subdivided adequately to meet the needs of integrated resource assessment and management across agency and program lines. The purpose of this paper is to present a mapped framework of ecological regions designed to address these broader needs. These regions are intended to complement rather than replace the more specific ecological classifications systems, which may remain more effective for the particular subjects they were designed to address.

Historical Definition and Use of Ecoregions of Wisconsin

Although there is general agreement on the need for an ecoregion-type framework for the research, assessment, and management of environmental resources in Wisconsin, there is considerable disagreement over which framework is the most appropriate. The most popular of the several spatial frameworks that cover Wisconsin are those developed by the U.S. Department of Agriculture (USDA) Forest Service (Bailey et al. 1994, Keys et al. 1995), Albert (1995), and the U.S. Environmental Protection Agency (EPA) (Omernik 1987, 1995a; EPA 1999). The Forest Service and EPA frameworks are national or international in scope and are still undergoing development. Prior to the development of the Forest Service and EPA ecoregion maps, resource managers in Wisconsin used a number of mapping schemes to associate, describe, classify, and otherwise assemble the terrestrial and aquatic resources of Wisconsin into somewhat homogeneous groupings. These included works by Martin (1916) depicting geographical provinces, Finley's (1976) original vegetation cover map, Poff's (1970) hydro-chemical lake regions, and the map of total phosphorus in lakes in Minnesota, Wisconsin, and Michigan (Omernik et al. 1988). The more recently developed map of "natural divisions of Wisconsin" (Hole and Germain 1994) has also been used. These conceptual organizations of Wisconsin's landscape, together with many other special purpose maps (e.g., geology, soils, current vegetation, and land use), were precursors to, and were used in the compilation of, the map presented in this paper.

Titled "Regional landscape ecosystems," the mapped classification by Albert (1995) was based largely on patterns of climate, geology, physiography, and soil, as well as the "natural regions" of Hole and Germain (1994), which were heavily based on potential natural vegetation and soils. The portion of the current Forest Service's National Hierarchy of Ecological Units (Keys et al. 1995) that covers Wisconsin was derived from the work of Albert (1995) and the national classification developed by Bailey

(1976). The Forest Service classification was initiated by Bailey (1976) and was fairly consistent across the country regarding scale, level of detail, and its hierarchical approach. The revised Forest Service framework (Bailey et al. 1994, Keys et al. 1995) was compiled by different regional and/or state groups and reflects spatial inconsistencies because of the different perspectives, approaches, and backgrounds of the different individuals or groups who have conducted the work. For Wisconsin, both Albert's and the Forest Service's classifications are weighted toward terrestrial ecosystems and forest management uses. Consideration of patterns of land use and aquatic characteristics was relatively unimportant in the development of either of these classifications. This apparent lack of attention to land use and water resource characteristics is viewed by some resource managers as a weakness in these frameworks. Conversely, the inclusion of land use and water resource characteristics into the EPA framework is sometimes viewed as a bias by terrestrial resource managers. This difference in perspectives among user groups is the foundation for a continuing debate and emphasizes the need for further dialog and evolution of all frameworks.

The EPA framework, of which the map of Level III and IV Ecoregions of Wisconsin (Figure 1) is a part, is based on the belief that ecological regions can be determined by identifying areas within which there is coincidence in patterns of geographic phenomena, natural and human-related, that reflect spatial differences in ecosystems and their components. This approach also recognizes that the relative importance of each of these phenomena (which include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology) varies from one region to another regardless of scale or hierarchical level. To avoid confusion with other meanings for different hierarchical levels of ecological regions a Roman numeral classification was adopted for the EPA maps and a North American ecological region framework of which they are a part (Commission for Environmental Cooperation [CEC] 1997). As with other similar state and regional mapping efforts, the process used to compile this new map of level III and IV ecoregions of Wisconsin was collaborative, involving numerous individuals representing several government agencies.

The major differences between this map of ecoregions of Wisconsin and those by the Forest Service and Albert lie in their methods of compilation and their intended use. Whereas the focus of the compilation of the maps by the Forest Service and Albert was on depicting regions in the terrestrial landscape that might exist in the absence of humans, the intent of this map is to show patterns of the entire ecosystem, biotic and abiotic, terrestrial and aquatic, with humans being considered as a biotic component. Until only recently, most attempts to define ecological regions did not consider patterns of human use or influence. It is now generally understood that if humans were removed from the planet the mosaic of ecosystem components would not revert to the patterns that existed in the United States before Europeans set foot on the continent or before Native Americans made their impact on the landscape. Too many plants and animals have been removed and introduced, and the land and water have been too drastically modified through activities including mining, urbanization, and channelization. Although the importance of human influence on ecosystems and their patterns is now obvious, the tendency to consider nature as if humans were not part of it seems to have been the norm. Likens (1993) commented that in spite of the fact that humans live in

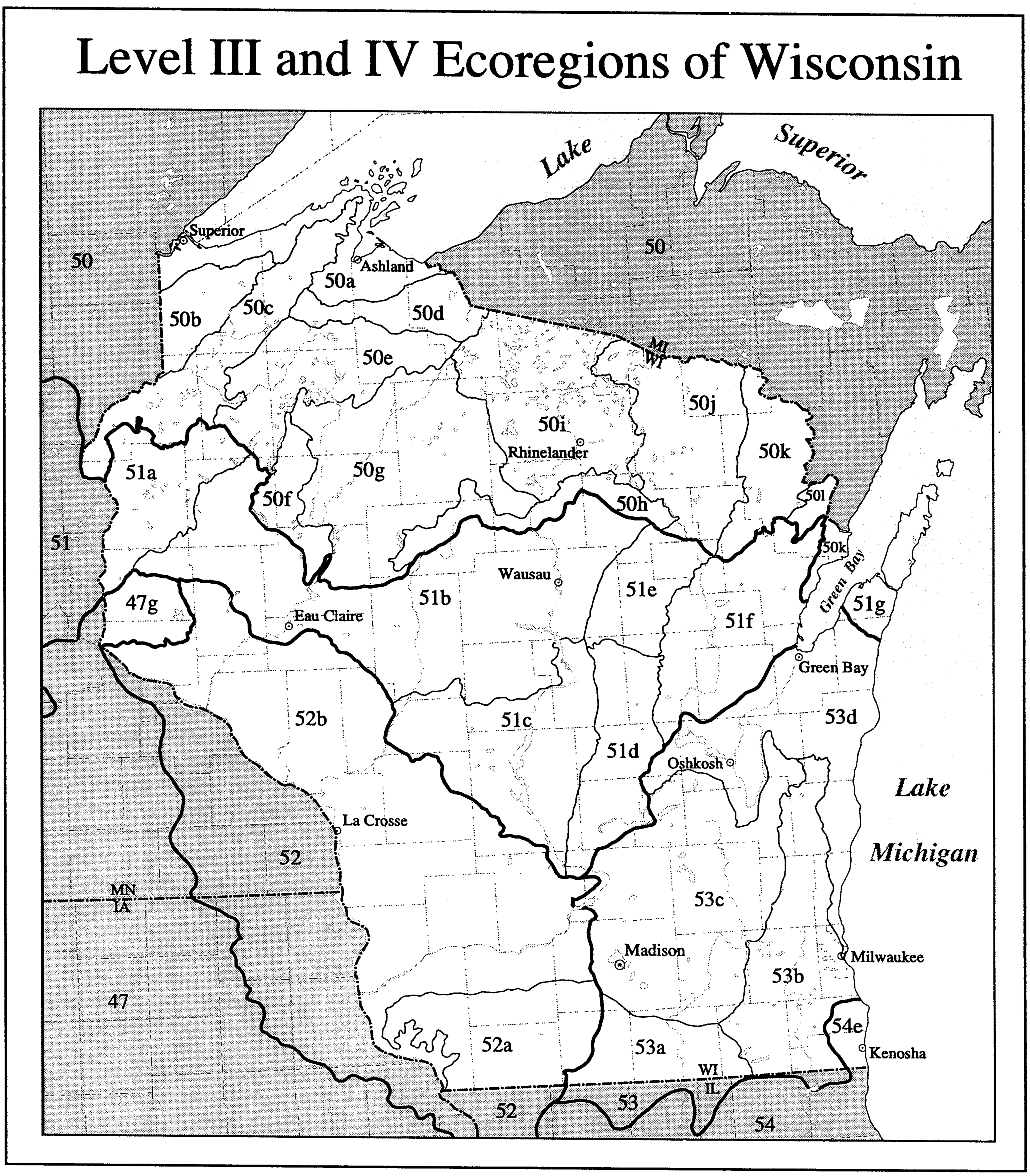
Level III and IV Ecoregions of Wisconsin
Lake Superior
Lake Michigan
Superior
Ashland
Rhinelander
Wausau
Eau Claire
Green Bay
Oshkosh
La Crosse
Madison
Milwaukee
Kenosha
MI
WI
MN
IA
WI
IL
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Figure 1

47 Western Corn Belt Plains
47g Prairie Pothole Region

50 Northern Lakes and Forests
50a Lake Superior Clay Plain
50b Minnesota/Wisconsin Upland Till Plain
50c St. Croix Pine Barrens
50d Ontonagon Lobe Moraines and Gogebic Iron Range
50e Chequamegon Moraine and Outwash Plain
50f Blue Hills
50g Chippewa Lobe Rocky Ground Moraines
50h Perkinstown End Moraine
50i Northern Highlands Lakes Country
50j Brule and Paint River Drumlins
50k Wisconsin/Michigan Pine and Oak Barrens
50l Menominee Ground Moraine

51 North Central Hardwood Forests
51a St. Croix Stagnation Moraines
51b Central Wisconsin Undulating Till Plain
51c Glacial Lake Wisconsin Sand Plain
51d Central Sand Ridges
51e Upper Wolf River Stagnation Moraine
51f Green Bay Till and Lacustrine Plain
51g Door Peninsula

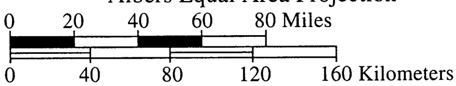
52 Driftless Area
52a Savanna Section
52b Coulee Section

53 Southeastern Wisconsin Till Plains
53a Rock River Drift Plain
53b Kettle Moraines
53c Southeastern Wisconsin Savanna and Till Plain
53d Lake Michigan Lacustrine Clay Plain

54 Central Corn Belt Plains
54e Chiwaukee Prairie Region

Level III Ecoregion
Level IV Ecoregion
State Boundary
County Boundary

Albers Equal Area Projection



Larger scale, color versions of this map can be obtained from Richard Lillie, Wisconsin DNR, Bureau of Integrated Science Services Research, 1350 Femrite Dr., Monona, WI 53716 <lillir@dnr.state.wi.us> or James Omernik, USEPA, 200 SW 35th St., Corvallis, OR 97333 <omernik@mail.cor.epa.gov>. Information on electronic coverages of the map is also available from the authors.

and among ecosystems, ecologists have avoided making detailed and rigorous analyses of the effects of human activities on ecosystems and have sought out pristine or remote areas for their study. Some have stated that, at least for environmental policy, humans should *not* be considered as a biotic component of ecosystems (Udo de Haes and Klijn 1994). However, humans have clearly had an effect on the regional capacities of ecosystems (Holling 1994). As Meeus (1995) has written, "In the course of time each culture leaves behind its own landscape."

It has been argued that the Forest Service map depicts patterns in terrestrial ecosystems and that the EPA maps, including this one of Wisconsin, reflect patterns in aquatic ecosystems, and that there is a need for separate frameworks for both types of systems. We believe that this argument is flawed for at least two reasons. First, a truly holistic approach to ecosystem management should not consider the aquatic and terrestrial ecosystems separately. "An 'ecosystem approach' recognizes that ecosystem components do not function as independent systems, rather they exist only in association with one another" (Omernik and Bailey 1997). Second, the approach used to define the EPA maps, including this one of Wisconsin, was not focused solely on aquatic systems, nor did it only consider patterns in lake density and quality in the map compilation process. Just as patterns of bedrock geology and physiography are of prime importance in defining level IV ecoregions in the Appalachians, surficial geology and soils are key components in Iowa, and elevational banding is critical in the mountains of the western United States, for parts of the country that are covered by high densities of natural lakes, such as in most of Wisconsin, patterns in lake quality are extremely helpful in revealing ecological regions. In order to define meaningful ecoregion boundaries in these types of areas it is important to recognize differences in lake density and quality with differences in many causal and reflective characteristics, including soils, surficial geology, physiography, climate, land use, and vegetation.

The Interagency Ecoregion Mapping Effort

A recent U.S. General Accounting Office (GAO) Report to Congress (GAO 1994) documented the need for agency-wide adoption of an ecosystem approach to resource management and the fact that there is no common spatial ecoregion framework to implement the approach. Although the GAO report was primarily directed toward the need for a common federal interagency framework, the report implied the need to involve state agencies as well and stated that effective ecosystem management "will require collaboration and consensus-building among federal and nonfederal parties within the larger national land and natural resource use framework" (GAO 1994). In response to the need to identify or develop a common framework of ecological regions, a National Interagency Technical Team on ecological mapping formed and was responsible for creating a Memorandum of Understanding entitled "Developing a Spatial Framework of Ecological Units of the United States." This Memorandum of Understanding was signed by the heads of all of the federal resource management agencies in 1996. Reaching the objective of the Memorandum of Understanding requires recognition of the differences in the conceptual approaches and mapping methodologies that have been used to develop the most commonly used existing ecoregion-type frameworks, including those developed by the Forest Service (Bailey et al. 1994), the EPA (Omernik 1987, 1995a), and the USDA Natural Resources Conservation Service (USDA 1981). The first task of the interagency effort is to identify ecological regions common to the three existing frameworks that also have meaning to the holistic objective to depict patterns in the mosaic of all ecosystem components, aquatic and terrestrial, as well as biotic and abiotic. These regions will be roughly at the scale of the Level III ecoregions and original Forest Service sections. While debate continues within the National Interagency Technical Team on the strengths and limitations of the different agency frameworks and the value of rule-based (quantitative) and weight-of-evidence (qualitative) approaches to defining ecoregions, the group has developed a draft map of ecological regions at this general level of detail (McMahon et al. in press).

Important to the work and final product of the interagency effort is the understanding that the common framework of ecological regions is not meant to replace many of the existing frameworks, insofar as their uses for specific applications is concerned. Mapped classifications, such as the USDA map of Major Land Resource Areas that was based on aggregations of map units from state soils maps and was originally intended to reflect patterns in soils properties as they relate to agricultural potential, should continue to be used for their specific applications. Likewise, state and regional maps that focus on terrestrial ecosystems for forest management uses will remain important for those purposes. However, for addressing ecosystem management in an integrated fashion across agencies and special interests, an ecoregional classification that reflects spatial patterns in the mosaic of all ecosystem components will be necessary.

Methods

We have defined ecoregions as areas of relative homogeneity in ecological systems and their components. Factors associated with spatial differences in the quality and quantity of ecosystem components, including soils, vegetation, climate, geology, and physiography, are relatively homogeneous within an ecoregion. The relative importance of each characteristic varies from one ecological region to another regardless of the hierarchical level. Level I and level II divide the North American continent into 15 and 51 regions, respectively (CEC 1997). At level III, the continental United States contains 103 regions (EPA 1999). Level IV is a further subdivision of the level III ecoregions. Wisconsin contains six level III (Figure 2) and twenty-seven level IV ecoregions (Figure 1). The level III descriptions contain some general characteristics of the region, emphasizing the features that make the ecoregion unique from surrounding regions. Level IV descriptions emphasize the important characteristics that make the region different from other ecoregions within the same level III ecoregion.

The approach used to compile this Wisconsin map is based on the premise that ecological regions can be identified through the analysis of the patterns of biotic and abiotic phenomena that reflect differences in ecosystem quality and integrity (Wiken 1986; Omernik, 1987, 1995a). The process of defining the ecological regions involved collaboration with local experts and began with a data collection meeting held in Madison at which time ecoregionalization methods, existing regional frameworks, and other relevant source material were discussed. Based on the approaches outlined in Omernik (1987, 1995a, 1995b) and Gallant et al. (1989, 1995) and the materials

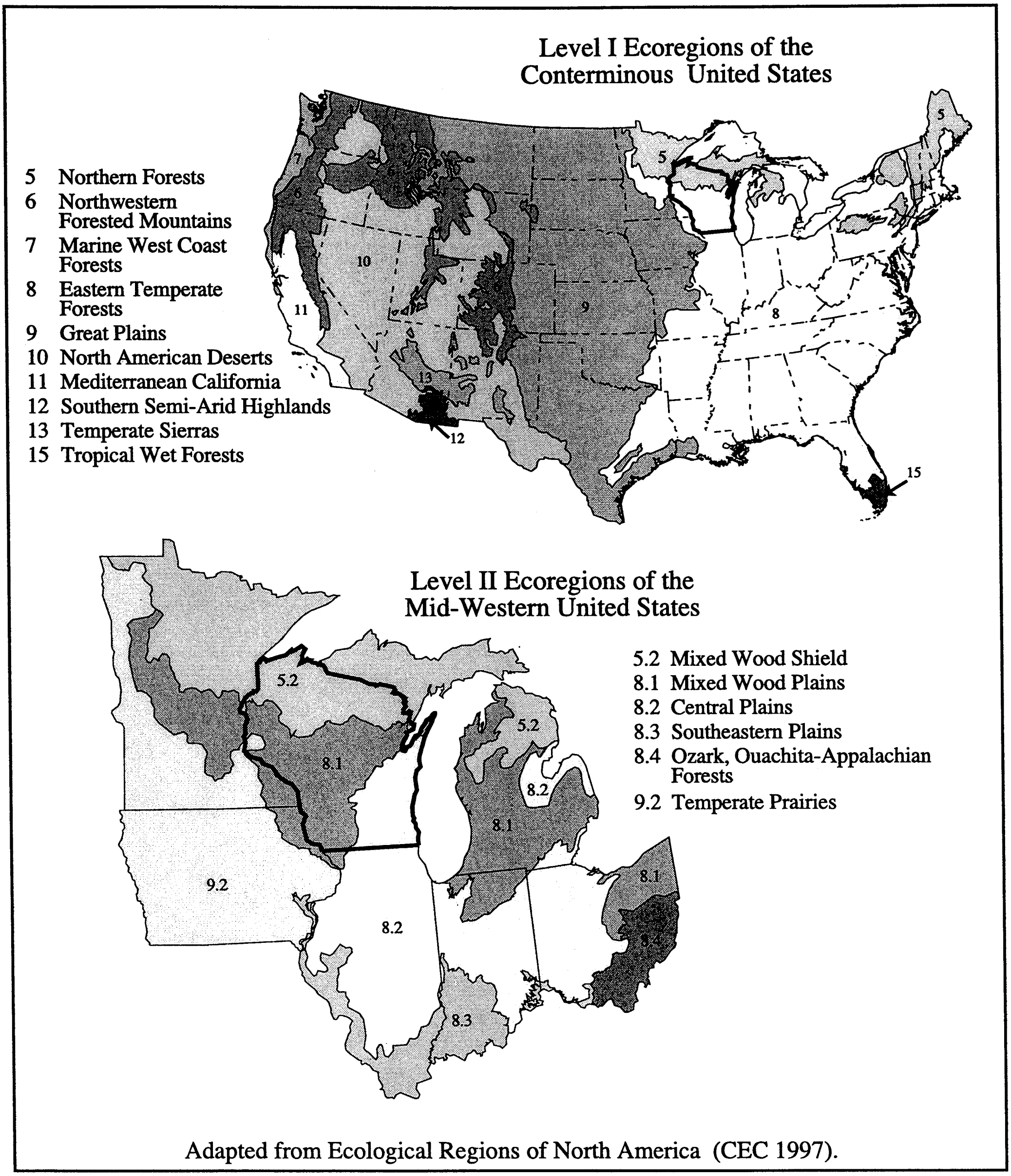

Level I Ecoregions of the Conterminous United States
5 Northern Forests
6 Northwestern Forested Mountains
7 Marine West Coast Forests
8 Eastern Temperate Forests
9 Great Plains
10 North American Deserts
11 Mediterranean California
12 Southern Semi-Arid Highlands
13 Temperate Sierras
15 Tropical Wet Forests
Level II Ecoregions of the Mid-Western United States
5.2 Mixed Wood Shield
8.1 Mixed Wood Plains
8.2 Central Plains
8.3 Southeastern Plains
8.4 Ozark, Ouachita-Appalachian Forests
9.2 Temperate Prairies
Adapted from Ecological Regions of North America (CEC 1997).

Figure 2

and ideas provided by state and local collaborators and other experts, a draft map of level III and IV ecoregions of Wisconsin was developed and circulated among many of the attendees of the first meeting. A second meeting was then held in Central Wisconsin to receive reviewer comments on the draft map and attempt to reach consensus on boundary delineations among the collaborators.

Unlike most of the other similar state and regional efforts to map level III and IV ecoregions, consensus was not reached among those invited to collaborate or confer in this project to map ecoregions of Wisconsin. The reasons for this became clear at the review meeting when the attendees were asked for their comments, suggestions, and concerns regarding the draft map and the method used to compile it. Although 70% or more of these people were comfortable with the product and approach, the remainder were not in agreement, generally for one or more of the following reasons: (1) a concern that the "weight-of-evidence" method used to compile the map was inappropriate and that a quantitative approach should have been used instead; (2) a belief that the map represented aquatic systems and that there should be separate frameworks for terrestrial and aquatic systems; (3) a belief that there should be separate frameworks for aquatic and terrestrial systems and that the aquatic framework should be based on watersheds and/or hydrologic units (see Seaber et al. 1987); (4) a concern that the "tension line" (Curtis 1978) had not been followed in defining the regions; and (5) a concern that patterns of present or past land use should not be used as a tool in defining ecoregions.

The differences in perceptions over how to map ecological regions in Wisconsin as well as at the national level were not surprising given the general lack of agreement on the definitions of ecosystems (Gonzalez 1996) and ecosystem management (Lackey 1998), the disagreement over whether ecosystems are abstract concepts or areas with geographical borders (Rowe and Barnes 1994, Blew 1996, Marin 1997, Rowe 1997), and the history of debate over regionalization and whether quantitative or qualitative techniques are more appropriate for the task (see for example Grigg 1967 and Hart 1982). However, acceptance of the approach used to develop the map of ecological regions of Wisconsin has grown. Consensus has been reached across state and federal agencies in a growing number of states (e.g., Pater et al. 1998, Woods et al. 1999, Chapman et al. in review), and the framework is being used or is being strongly considered for use for many national resource management activities, including the development of biological criteria in surface waters (Davis et al. 1996), the development of nutrient criteria in streams (EPA 1998), and the planning, implementation, and evaluation of bird conservation (USFWS 1999).

We stress that the purpose of this paper is not to tout the advantages of one framework or approach over another, but rather to provide another step in the process of thoughtfully pursuing the debate on and advancement of the definition of ecosystems, the delineation of ecological regions, and ultimately more effective ecosystem management.

Descriptions

The naming of level III and level IV ecoregions was intended to associate place names with a key landscape characteristic descriptive or unique to the region. Consequently, the ecoregion names (and the map) serve an educational purpose by relating public perceptions to the environment, thus playing on the concept of "place" and allowing a connection to be made between ecoregions and the general public.

47. Western Corn Belt Plains

Once covered with tall-grass prairie, over 75% of the Western Corn Belt Plains is now used for cropland agriculture, and much of the remainder is in forage for livestock. A combination of nearly level to gently rolling till plains and hilly loess plains, an average annual precipitation of 63–89 cm, which occurs mainly in the growing season, and fertile, warm, moist soils make this one of the most productive areas of corn and soybeans in the world. Surface and groundwater contamination from fertilizer and pesticide applications as well as livestock concentrations are a major concern for this ecoregion.

The northeastern corner of the Western Corn Belt Plains (47) is a loess-covered till plain and extends into a small area in western Wisconsin and borders the northern boundary of the Driftless Area (52). The fertile prairie soils and gentle topography of this area contributes to more intensive agriculture than in the adjacent North Central Hardwood Forests (51) and Driftless Area (52) ecoregions.

47g. Prairie Pothole Region. The Prairie Pothole Region (47g) is characterized by smooth to undulating topography, productive prairie soils, and loess- and till-capped dolomite bedrock. The potential natural vegetation (PNV) is predominantly tall grass prairie with a gradual transition eastward to more mixed hardwoods, distinguishing 47g from the greater concentration of mixed hardwoods of both 51a to the north and 51b to the east, and the mixed prairie and oak savanna of 52b to the south.

50. Northern Lakes and Forests

The Northern Lakes and Forests (50) is an ecoregion of relatively nutrient poor glacial soils, coniferous and northern hardwoods forests, undulating till plains, morainal hills, broad lacustrine basins, and areas of extensive sandy outwash plains. Soils are formed primarily from sandy and loamy glacial drift material and generally lack the arability of those in adjacent ecoregions to the south. Ecoregion 50 also has lower annual temperatures and a frost-free period that is considerably shorter than other ecoregions in Wisconsin (NOAA 1974, Hole 1976). These conditions generally hinder agriculture; therefore, woodland and forest are the predominant land use/land cover.

The numerous lakes that dot the landscape are clearer, at a lower trophic state (mostly oligotrophic to mesotrophic with few eutrophic lakes), and less productive than those in ecoregions to the south. Streams of ecoregion 50 are mostly perennial, originating in lakes and wetlands; however, stream density is relatively low compared to ecoregions to the south. The Northern Lakes and Forests region is the only ecoregion in Wisconsin where acid sensitive lakes are found. Portions of the southern boundary of ecoregion 50 roughly correspond to the southernmost extent of lakes with alkalinity values less than 400 μeq/l (Omernik and Griffith 1986).

50a. Lake Superior Clay Plain. The Lake Superior Clay Plain (50a) is a flat to undulating lake plain and outwash lowland. The soils of 50a are generally calcareous red clays with organic deposits in swampy areas. A dearth of lakes along with a somewhat milder climate and longer growing season, due to the climate amelioration by Lake Superior, differentiates 50a from surrounding ecoregions. Land use in 50a is predominantly woodland with some limited agriculture of hay, small grains, and apples on Bayfield Peninsula, distinguishing 50a from most other level IV ecoregions in Northern Lakes and Forests (50) where the land use/land cover is predominantly forest and woodland. Ecoregion 50a has a PNV of boreal forest (although somewhat different than boreal forests to the north), unlike the pine barrens and pine forests of 50c, the mosaic of pine and birch in 50b, and the northern mesic forest of 50e.

50b. Minnesota/Wisconsin Upland Till Plain. The Minnesota/Wisconsin Upland Till Plain (50b) is an undulating stagnation and ground moraine plain, with broad areas of hummocky, acid, loamy and sandy till and outwash. Ecoregion 50b has fewer lakes than ecoregions to the east, but a greater lake density than ecoregion 50a to the north. Extensive wetlands—in areas of poorly drained soils, peat over acid sedge and woody peat soils—are scattered throughout the ecoregion and are common in hummocky areas. The till plain of 50b supports a PNV mosaic of red and white pine, conifer swamps, and aspen/white birch/pine forests. Woodland and forest cover the majority of the ecoregion, although there is some limited agriculture with feed-grains and potatoes as the main crops. This region also has one of the lowest densities of roads in the state.

50c. St. Croix Pine Barrens. The St. Croix Pine Barrens (50c) ecoregion is characterized by mostly jack pine, concentrations of red and white pine forests and barrens, well-drained, pink sandy soils. Ecoregion 50c has a greater concentration of lakes, a higher percentage of clear lakes, and lakes with a lower trophic state than in surrounding ecoregions. The sandy soils and pine barren vegetation distinguishes ecoregion 50c from the silty lake plain and boreal forests of 50a and the till plain and more deciduous forest mosaic of 50b.

50d. Ontonagon Lobe Moraines and Gogebic Iron Range. The rolling to hilly, bedrock-controlled and collapsed moraines consisting of loamy till, much of it shallow over igneous and metamorphic rock, distinguish the Ontonagon Lobe Moraines and Gogebic Iron Range (50d) ecoregion from surrounding regions. Rock outcrops increase from very few in the southern portion of this ecoregion to abundant in the north. Likewise, the topography changes from rolling in the southern portion to hilly in the north. Perennial streams are common, and there are fewer lakes than in ecoregions to the south, but more than adjacent ecoregion 50a. The PNV of 50d is a mosaic of hemlock/sugar-maple/pine forests, swamp conifers, and cedar/hemlock forests. This represents a transition from the boreal forests of ecoregion 50a to the mix of hardwoods and conifer forests of ecoregion 50e. Historic mining of iron and copper occurred along the northern and northwestern edge of this region.

50e. Chequamegon Moraine and Outwash Plain. Irregular plains and stagnation moraines, broad areas of hummocky topography, pitted glacial outwash, numerous kettle lakes, and abundant swamps and bogs characterize the Chequamegon Moraine and Outwash Plain (50e) ecoregion. This region has more poorly developed drainage than ecoregions to the west. The soils are coarse, acid, loamy, and sandy-loam mixed—different from the pink sandy soils of ecoregion 50c and the more rocky and silty soils of ecoregion 50g.

50f. Blue Hills. The Blue Hills (50f) ecoregion is characterized by greater relief and a higher concentration of lakes than most surrounding ecoregions, and it contains lakes with generally lower lake trophic states than those of adjacent ecoregions to the east, south, and southwest. End moraines, hummocky hills and depressions, along with areas of Precambrian intrusives are common to 50f as compared to the predominantly rocky ground moraines in 50g to the east. Periodic outcrops of pink quartzite have influenced the topography of the region. Ecoregion 50f supports a PNV of hemlock/sugar maple/yellow birch, white pine and red pine forests, a transition from predominantly hemlock/sugar maple/pine forests of ecoregions in the east to sugar-maple/basswood/oak forests, oak forests, and prairie vegetation of ecoregion 51 to the west.

50g. Chippewa Lobe Rocky Ground Moraines. Much of the Chippewa Lobe Rocky Ground Moraines (50g) ecoregion is comprised of productive but rocky soils, scattered wetlands, extensive eskers and drumlins, and outwash plains. Ecoregion 50g has a considerably lower density of lakes that generally have higher trophic states than 50e, 50f, 50i, and 50h. The rocky soils of 50g are a contrast to the well-drained loamy soils in 50f and the sandy soils in 50i. Ecoregion 50g also supports a PNV mosaic of northern mesic forest (hemlock/sugar maple/yellow birch/white and red pine) and wetland vegetation (swamp conifers/white cedar/black spruce), as compared to the predominantly red and white pine forest of ecoregion 50i and the much lower hemlock component of ecoregions 50f and 50h.

50h. Perkinstown End Moraine. The Perkinstown End Moraine (50h) ecoregion is characterized by hilly to rolling collapsed moraines with outwash sand and gravel and Precambrian intrusives. Relief in this ecoregion is greater than that of the surrounding regions. The soils of 50h are coarse, loamy, and moderate to well drained, over till, in contrast to the more silty, rocky and poorly drained soils of 50g to the south. In addition, ecoregion 50h has fewer lakes than adjacent level IV ecoregions in the Northern Lakes and Forests (50) ecoregion.

50i. Northern Highlands Lakes Country. The Northern Highlands Lakes Country (50i) ecoregion is distinguished from surrounding ecoregions by pitted outwash, extensive glacial lakes (many of which are shallow), and wetlands. In contrast to other ecoregions in the Northern Lakes and Forests (50) ecoregion, Ecoregion 50i contains a much higher density of lakes of generally lower trophic state and lower alkalinity values (hence, greater sensitivity to acidification). The region has soils that are more gravelly, sandy, well to excessively drained, and developed in deep, acid drift. Ecoregion 50i supports a PNV of white and red pine forests, some pine barrens, and jack pine to the south, unlike the predominantly hardwood forests of surrounding ecoregions.

50j. Brule and Paint Rivers Drumlins. The Brule and Paint Rivers Drumlins (50j) ecoregion has extensive eskers and drumlinized ground moraines, pitted and unpitted outwash, wetlands, large glacial lakes, and a lower density of lakes than in adjacent ecoregion 50i. Lake trophic state is very low with a higher percentage of oligotrophic and mesotrophic lakes than most Level IV ecoregions in the Northern Lakes and Forests (50) ecoregion. Soils of the region range from fine to coarse, poor to well drained, and loamy and silty with extensive organic deposits, differing from the sandy, more acid soils in adjacent ecoregions. The PNV is sugar-maple/basswood forest and hemlock/sugar-maple forest, as compared to the more coniferous forests of 50i and the pine and oak barrens of 50k.

50k. Wisconsin/Michigan Pine and Oak Barrens. Irregular outwash plains and moraines, sandy and sandy-loam soils over outwash, sandy and loamy till, and peat deposits in depressions characterize the Wisconsin/Michigan Pine and Oak Barrens (50k) ecoregion. The features are a contrast to the extensive eskers and drumlins, and more loamy and silty soils of adjacent ecoregion 50j. Also, unlike the hardwood forests of ecoregion 50j to the west, 50k supports a PNV of white/red pine forests, jack pine forests, and oak forests and barrens. Land use in 50k is predominantly woodland, although some mixed agriculture is found. More frost-free days occur in 50k than in adjacent eastern ecoregions, due to the ameliorating effect of Lake Michigan and Green Bay, contributing to the greater agricultural component of the land cover/land use. In addition, 50k has more shallow bedrock than surrounding regions, with areas of exposed Precambrian basalt and granite.

50l. Menominee Ground Moraine. The Menominee Ground Moraine (50l) ecoregion is characterized by an undulating ground moraine with drumlins and swamps. The uplands consists of loamy soil over calcareous loamy till (some over dolomite); the lowland areas are muck. The region is dominantly woodland and woodland swamp, but there is a significant agricultural presence. PNV of the region is beech/sugar maple/hemlock and swamp conifer, a contrast to the white/red pine, jack pine, and oak forests of neighboring 50k.

51. North Central Hardwood Forests

The North Central Hardwoods Forests (51) ecoregion is transitional between the predominantly forested Northern Lakes and Forests (50) and the agricultural ecoregions to the south. Nearly level to rolling till plains, lacustrine basins, outwash plains, and rolling to hilly moraines comprise the physiography of this region. The land use/land cover in this ecoregion consists of a mosaic of forests, wetlands and lakes, cropland agriculture, pasture, and dairy operations. The growing season is generally longer and warmer than that of ecoregion 50 to the north, and the soils are more arable and fertile, contributing to the greater agricultural component of the land use. Lake densities are generally lower here than in the Northern Lakes and Forests, and lake trophic states tend to be higher, with higher percentages in eutrophic and hypereutrophic classes. Stream density is highly variable, with some areas having virtually no streams—in wetland and kettle terrain—to others with high densities of perennial streams.

51a. St. Croix Stagnation Moraines. The St. Croix Stagnation Moraines (51a) is a region of ground and stagnation moraines with broad irregular areas of hummocky topography. Soils are silty and loamy, with sandy loamy till commonly underlain by a substratum of acid sand and gravel glacial outwash. There are more lakes in 51a than in ecoregions to the east and south, and lake trophic states, although generally higher than in the region to the north, are lower than in the bordering ecoregion to the southeast. Land use in this region is a mix of agriculture and woodland, in contrast to the mostly woodland and forest land cover of ecoregions to the north, and the greater amounts of agriculture in ecoregions to the southeast. The PNV of 51a ranges from aspen/birch/pine forest, oak-maple forests, and sugar-maple/birch/pine forests and represents a transition from the pines of 50b to the tall grass prairie and oak forests of 47g.

51b. Central Wisconsin Undulating Till Plain. The Central Wisconsin Undulating Till Plain (51b) ecoregion has a greater percentage of agricultural land use than adjacent Ecoregion 51a. The land cover mosaic of woodland and agriculture includes large areas of cropland that produce silage corn, oats, barley, and some apples. Ecoregion 51b has fewer lakes, with higher trophic states, than adjacent level IV ecoregions in ecoregion 51. The undulating to rolling irregular plains of sandy loam till and outwash sands also distinguish this ecoregion from the stagnation moraines of ecoregion 51a to the west and the lacustrine sand plains of ecoregion 51c to the south. This ecoregion ranges from areas in the far east that are underlain with igneous metamorphic rock outcrops to areas in the west and southwest that are underlain by sandstone and shale, which also outcrops with sandstone, comprising roughly 70% of the total area. The region supports a transitional PNV mosaic of oak, hemlock/sugar maple/yellow birch, and white pine/red pine forests in the north, and more sugar maple/basswood/ oak forests to the south.

51c. Glacial Lake Wisconsin Sand Plain. Compared to adjacent ecoregions, the Glacial Lake Wisconsin Sand Plain (51c) is an area of little relief. The droughty outwash, lacustrine, and slope wash sands, sand buttes, and stream bottom and wetland soils support a PNV of jack pine/scrub-oak forests and barrens, along with sedge meadows and conifer swamps, which characterize this flat sandy lake plain. This PNV is in contrast to the predominantly white and black oak vegetation of ecoregion 51d. The region is also distinguished by its more extensive wetlands and a lack of natural lakes. Most of the existing lakes have been constructed for use in cranberry production. Land use in this region consists of woodland and agriculture with crops including mainly cranberries, strawberries, and potatoes.

51d. Central Sand Ridges. The Central Sand Ridges (51d) ecoregion has the highest density of lakes with the lowest trophic states of all level IV ecoregions in the North Central Hardwood Forests (51). Pitted glacial outwash with extensive eskers and drumlins, ice contact deposits, rolling ground moraines, and steep end moraines distinguish this region from the flat lake plain of adjacent ecoregion 51c. The dry, sandy, and loamy till soils of the region support a PNV of oak savanna (white oak, black oak, and bur oak) with areas of sedge meadows, unlike the wetland vegetation and pine or oak barrens of ecoregion 51c and the mosaic of hemlock/beech/maple forests and mixed conifers of northern ecoregion 51e.

51e. Upper Wolf River Stagnation Moraine. The Upper Wolf River Stagnation Moraine (51e) ecoregion is characterized by the hummocky ground and end moraines and pitted outwash, in contrast to the level till plains of ecoregion 51f to the east and the irregular till plain of ecoregion 51b to the west. This region supports a PNV mosaic of hemlock/beech/sugar-maple, wetland vegetation, and mixed conifers, as compared to the predominantly oak forests of 51d to the south. Land use in 51e is mixed agriculture/woodland with a larger area of intact forest than adjacent level IV ecoregions in the North Central Hardwoods Forests (51). This is due to land use practices within the Menominee Indian Reservation; more forest cover is still intact, and agricultural practices are less significant. The lake trophic state in 51e is generally higher than in 51d to the south.

51f. Green Bay Till and Lacustrine Plain. Green Bay Till and Lacustrine Plain (51f) is a transitional ecoregion characterized by wetlands, a mix of outwash and loamy recessional moraines, with many areas of outwash plains in the northwest, lake plains and ground moraines in the south, and ground moraines throughout the rest of the region. The PNV of the region represents a shift from the predominantly northern hardwoods and conifer swamps along the lake shore to the maple/basswood/oak forests and oak savanna to the south. The red sandy, loamy soils of this ecoregion are similar to some southern areas in the northern Wisconsin/Michigan Pine Barrens (50k); however, due to the generally milder climate (because of proximity to Lake Michigan), the growing season is more favorable and much of the area has been cleared of natural vegetation and replaced by agriculture.

51g. Door Peninsula. The Door Peninsula (51g) ecoregion is a lakeshore region with ground moraines. The longer growing season and shallow fertile, calcareous loamy till soils of this ecoregion support a mixed woodland/agriculture land use. Crops in this ecoregion are mostly orchard and fruit crops, including apples and cherries. The bedrock geology of 51g is shallower than other ecoregions in 51 and consists primarily of Silurian bedrock. In recent years this region has become a popular tourism area.

52. Driftless Area

The hilly uplands of the Driftless Area (52) ecoregion easily distinguish it from surrounding ecoregions. Much of the area consists of a loess-capped plateau with deeply dissected streams. Also called the Paleozoic Plateau, because there is evidence of glacial drift in this region, the glacial deposits have done little to affect the landscape compared to the subduing influences in adjacent ecoregions. Livestock and dairy farming are major land uses and have had a major impact on stream quality. In contrast to the adjacent glaciated ecoregions, the Driftless ecoregion has few lakes, most of which are reservoirs with generally high trophic states, and a stream density and flow that is generally greater than regions to the east.

52a. Savanna Section. Topography in the Savanna Section (52a) of the Driftless Area is different than the rest of the level III ecoregion because of its characteristic broad relatively level ridge tops and narrow steep sided valley bottoms. Elsewhere in the dissected Driftless Area the landform mosaic comprises relatively broad, flat valley bottoms with steep sharper crested ridges or a pattern of nearly equal amounts of flatter areas in the valley bottoms and interfluves. The soils are well drained silty loess over residuum, dolostone, limestone, or sandstone. Land use patterns in the Driftless Area also follow spatial differences in slope; hence, 52a is predominantly agriculture on the uplands and some mixed woodland/agriculture in lowland areas. The PNV of the region is a mosaic of oak forests and savannas, large prairie grassland areas, and some sugar maple/basswood/oak forests. The region is also known for past lead and zinc mining.

52b. Coulee Section. Dissected slopes and open hills with most of the gentle slope on the lowland characterize the Coulee Section (52b) ecoregion. Soils are well drained silty loess over residuum, limestone, sandstone or shale, with soils over quartzite in the Baraboo Hills area. Land use in the region is predominantly mixed agriculture/woodland, with most of the agriculture occurring on the lowlands and more level hilltops. The PNV of ecoregion 52b is a mosaic of oak forests, prairie, with larger areas of sugar maple/basswood/oak forests than in 52a.

53. Southeastern Wisconsin Till Plains

The Southeastern Wisconsin Till Plains (53) ecoregion supports a mosaic of vegetation types and represents a transition between the hardwood forests and oak savannas of the ecoregions to the west and the tall-grass prairies of the Central Corn Belt Plains (54) to the south. Like the Corn Belt Plains (54) ecoregion, land use in the Southeastern Wisconsin Till Plains (53) is mostly cropland, but the crops have historically been largely forage and feed grains to support dairy operations, rather than corn and soybeans for cash crops. The ecoregion has a higher plant hardiness value than in ecoregions to the north and west, a different mosaic of soils than western ecoregions, and flatter topography. There are fewer lakes here than in ecoregions to the north, but considerably more than in the western Driftless Area (52) and the southern Central Corn Belt Plain (47). The region also has a relatively high aquatic species diversity.

53a. Rock River Drift Plain. The Rock River Drift Plain (53a) ecoregion has numerous small creeks, a greater stream density and fewer lakes than in ecoregions to the north and east. Glaciation of this region is much older, late Pliocene-early Pleistocene, than in surrounding ecoregions. The drift mantle is thin and deeply weathered with leached soils developed from a silt-loam cap of loess over glacial drift. Steeper topography and broad outwash plains with loamy and sandy soils also characterize this region.

53b. Kettle Moraines. The Kettle Moraines (53b) ecoregion contains a higher concentration of lakes with lower trophic states than in the rest of the level III ecoregions of the Southeastern Wisconsin Till Plains (53). The soils are clayey to the east, especially along the Lake Michigan shore, and more sandy to the west, but generally less clayey than the soils in ecoregion 53d to the north. The region also contains extensive ground and end moraines and pitted outwash with belts of hilly moraines and generally has greater relief than ecoregion 53d to the northeast.

53c. Southeastern Wisconsin Savanna and Till Plain. The till plains of the Southeastern Wisconsin Savanna and Till Plain (53c) ecoregion support a mix of agriculture (cropland and dairy operations) and woodland. Crops include forage crops to support the dairy operations and a wide range of truck and specialty crops. Most of the original vegetation has been cleared with forested areas remaining only on steeper end moraines and poorly drained depressions. Irregular till plains, end moraines, kettles, and drumlins are common, and wetlands are found throughout the region, especially along end morainal ridges. PNV of this region is transitional with a mosaic of sugar maple, basswood, oak to the east, and an increasing amount of white, black, and bur oak, oak savanna, prairie, and sedge meadows toward the west.

53d. Lake Michigan Lacustrine Clay Plain. The Lake Michigan Lacustrine Clay Plain (53d) ecoregion is characterized by red calcareous clay soil, lacustrine and till deposits, and a flat plain. The topography of this ecoregion is much flatter than ecoregions to the south, and there are fewer lakes, but the lakes have generally higher trophic states than in adjacent level IV ecoregions in (50) and (51). Soils are generally silty and loamy over calcareous loamy till, with muck and loamy lacustrine soils in low-lying areas. Ecoregion 53d has prime farmland with a longer growing season and more fertile soils than surrounding ecoregions. Agriculture has a different mosaic of crops, with more fruit and vegetable crops, than that of ecoregion 53c. The PNV of this region is beech/sugar maple/basswood/red and white oak forests with a greater concentration of beech than other ecoregions in 53.

54. Central Corn Belt Plains

Prairie communities were native to the glaciated plains of the Central Corn Belt Plains, and they were a stark contrast to the hardwood forests that grew on the drift plains of ecoregions to the east. Beginning in the nineteenth century, the natural vegetation was gradually replaced by agriculture. Farms are now extensive on the dark, fertile soils of the Central Corn Belt Plains, mainly producing corn and soybeans, cattle, sheep, poultry, and especially hogs, but are not as dominant as in the drier Western Corn Belt Plains to the west. Agriculture has affected stream chemistry, turbidity, and habitat. The extent of the Central Corn Belt Plains (54) ecoregion in Wisconsin is contained within a small area in the southeastern portion of the state. Land use of the ecoregion continues to change, from exclusively agriculture to a pattern with an increasing amount of urban and industrial land.

54e. Chiwaukee Prairie Region. The Chiwaukee Prairie Region (54e) ecoregion is characterized by intensive agriculture, prairie soils, loess capped loamy till, and lacustrine deposits. The soils of ecoregion 54e are fertile and generally more productive than those of ecoregion 53 to the north and west. The PNV of the Chiwaukee Prairie Region is predominantly tall-grass prairie, in contrast to the southern mesic forest and oak savanna of the adjacent region to the north and west. Most of the natural prairie vegetation of ecoregion 54e has been replaced with cropland or urban and industrial land cover.

Applications

The ecoregion framework outlined in this paper will be particularly supportive of the more holistic approaches to natural resources conservation emerging in Wisconsin because it considers elements of the *entire* ecosystem, terrestrial and aquatic, abiotic and biotic, including humans. These contemporary approaches to environmental stewardship, collectively termed ecosystem management by some practitioners, strive to reconcile the conservation of ecological integrity and biological diversity with the availability of economic opportunities and livable communities. The overall goal is sustainable ecological, social, and economic systems. Ecoregions can provide a framework to which pertinent socio-economic and demographic information may be linked using geographic information systems.

The finding of common ground among socio-economic and ecological considerations is increasingly being undertaken through stakeholder partnerships. Participants in these endeavors generally have diverse interests, values, and technical knowledge; therefore, processes and tools— such as ecological classification systems—developed for these new management approaches should consider this circumstance. The ecoregions defined herein are intended to be broadly understandable and acceptable due to their inclusive nature. Furthermore, they are named with consideration for widespread recognition by resource managers and publics alike. Nonetheless, this ecological framework must be considered dynamic and subject to refinement with ongoing use and increased understanding in the spatial nature of ecosystems.

The Wisconsin Department of Natural Resources (WDNR) prepared a report for its resource managers in May 1995 titled "Wisconsin's Biodiversity as a Management Issue" (WDNR 1995). The report recommended (page 31) that WDNR manage at a landscape scale that involves determining both spatial and temporal scales appropriate to the problem or project and then assessing implications at larger and smaller scales. Furthermore, the WDNR biodiversity report proposed that ecoregions be determined for Wisconsin for use in developing management goals. These goals would "meet a wide variety of diverse ecological and socio-economic needs, including the conservation of biodiversity."

In response to the need to define ecoregion boundaries, in 1998 the agency initiated a project to identify Ecological Landscapes of Wisconsin (WDNR 1999). The ecological landscape units defined in the 1998-99 effort followed the USDA Forest Service's National Hierarchy Framework of Ecological Units and were designed primarily to assist regional and statewide efforts for maintaining and restoring natural communities. However, consideration was also given to broader ecosystem planning and communications applications. Ecological, social, and institutional data plus management opportunities were to be assembled for each of the 17 ecological landscape units. The Ecological Landscapes of Wisconsin map has many similarities (e.g., some boundaries lines and units are similar in position and shape) to the level III and IV ecoregion map presented in this paper, leaving the impression that the two maps are redundant. However, while both maps contain similarities, their differences reflect different origins and purposes. The Ecological Landscape map was designed by the WDNR's Land Ecosystem Management Planning Team for the exclusive purpose of defining "areas similar in ecology and management opportunities." The delineation of area boundaries on the Ecological Landscape map was influenced by a tendency to mesh the map units into the hierarchical units defined in the Forest Service's National Hierarchy mapping system. As mentioned previously, the National Hierarchy mapping was directed primarily towards forestry ecosystems and paid little consideration to land use, hydrology, and water quality, which are of critical importance to aquatic ecosystems. Recognizing the emphasis given to terrestrial ecosystems in their National Hierarchy maps, the Forest Service designed a separate framework for aquatic ecosystems (Maxwell et al. 1995).

The ecoregions described in this paper were, on the other hand, developed to facilitate ecosystem management in a more holistic sense and define regions of similar patterns in the mosaic of terrestrial, aquatic, biotic, and abiotic ecosystem components with humans being considered as part of the biota. The intent was to define "general purpose" regions to allow the various state (and federal) agencies and programs with different interests and missions to integrate their assessment, management, and reporting activities. The framework was not intended to replace narrower or special purpose frameworks or maps that may be better suited for addressing specific issues. Also, the level III and IV ecoregion framework described in this paper will augment the set of ecological landscapes by providing counterpart ecoregions that are more broadly defined and linked to the international framework—Ecological Regions of North America (CEC 1997).

The WDNR has also identified administrative areas termed Geographic Management Units (GMUs), which represent a compromise among ecoregions, watershed management units, and jurisdictional/political boundaries. These GMUs cannot serve the same ecological purposes as a strictly ecological framework but likely have advantages for working collaboratively with stakeholder partnerships. Ecoregions as planning entities tend to encourage ecological thinking, which most often must be then transferred to socio-political contexts for implementation. Effective use of these various spatial networks critically depends on the development of "cross-walking" capability using GIS technologies.

The ecoregions described in this paper

can serve research and education purposes as well as management functions. Ecoregions can provide a basis for the collection and organization of biogeophysical data such as that being contemplated under the new WDNR initiative entitled the Aquatic and Terrestrial Resources Inventory. They can also provide a framework for the development of indices of ecological integrity and other parameters that reveal the status of our landscape. Ecoregions can assist habitat suitability analyses and studies of landscape patterns that look at fragmentation and habitat corridor issues. These investigations can be helpful in designating recovery strategies for threatened and endangered species such as the timber wolf.

Ecoregions can serve an educational function by improving awareness of ecosystem spatial scales and their nested hierarchy. Ecological classification per se helps us appreciate the interconnectedness and dependency among ecosystems and also helps us learn more about the elasticity of ecological systems and their responses to natural and human-induced disturbances. Ecoregions provide a suitable context for deliberations of ecosystem opportunities and limitations plus a basis for identifying future desired conditions expressed as ecosystem goals and objectives. Ecoregion frameworks help provide an understanding of the "big picture" for local initiatives and also the converse; they should be viewed not just as an analytical tool but a tool for learning ecological relationships and concepts.

Management actions can be benefited by the use of ecoregions. The protection and preservation of sensitive areas and critical resources can employ ecoregions as a basis for examining the patterns and distributions of these elements across broad suitable landscapes to avoid actions that cause isolation effects but instead encourage connectedness. Some natural communities such as pine-oak barrens and grasslands occurred in widely distributed units in presettlement Wisconsin. An evaluation of current opportunities can benefit from an assessment of potential sites within the context of their respective ecoregions. Although grassland restoration might be considered in several ecoregions (e.g., Prairie Pothole Region, Savanna Section, Rock River Drift Plain, Kettle Moraines, Southeastern Wisconsin Savanna and Till Plain, and Chiwaukee Prairie Region) based on historic presence, an analysis of opportunities and limitations for the various ecoregions may suggest better potential for building a viable (i.e., sustainable) matrix of grasslands within one or two of these regions. This type of analysis is probably improved by the use of ecoregions that consider land use among their determining factors.

Ecoregions can help structure water resource assessment and management programs in Wisconsin. Watersheds, as landscape units, are generally well understood by various publics and are often used as the basis for water resource programs. Watersheds are critical as research units because they help identify areas of influence on water quality relative to a particular point. However, watersheds seldom correspond to areas within which there is similarity in the factors that cause or reflect differences in the quality and quantity of water (Omernik and Bailey 1997, Griffith et al. 1999). In contrast, ecological regions define areas of similarity in mosaics of these factors and hence depict areas of reduced variability in capacities, potentials, and responses to land management activities. A more refined analysis of the characteristics associated with spatial differences in water quality is yielded by consideration of ecological regions within and across watershed boundaries. Here again the incorporation of land use as a component of this ecological classification system is important to its use in exploring non-point source water quality issues, developing reference site data, defining biogeophysical criteria, and setting goals for watersheds, especially larger units such as the Wisconsin and Mississippi River basins.

In 1999, the Forest Service undertook a reassessment of "roadless areas" and road building in national forests. The protection of roadless areas can impact water quality, biological diversity, forest health, and recreational opportunities. Concerns were raised on how management of the Nicolet-Chequamegon Forest in Wisconsin might be altered by the assessment. The Forest was evaluated under a similar study (RARE—Roadless Area Review and Evaluation) in the 1970s (U.S. Forest Service 1979). A contemporary assessment of opportunities for designation of roadless areas or similar management units such as wilderness or natural areas could involve a look at the size and distribution of potential sites across various ownerships by ecoregions.

We believe that the level III and IV ecoregion map presented herein is the most integrated ecological framework developed for Wisconsin. It is nested within an international system and has excellent potential for structuring environmental monitoring and management activities. Because of its widespread development and comprehensive nature, the framework is particularly suited to multidisciplinary, interagency work. The map can enhance collaborative ecosystem research, monitoring, planning, and management. It can also provide a foundation for conducting bioassessments, establishing environmental standards, and reporting such as the 305(b) Wisconsin Water Quality Assessment Report to Congress (a requirement of the Federal Clean Water Act) and the State of the Natural Resources (an annual report produced by the WDNR to the citizens of Wisconsin.) Clearly, this ecoregion framework has many potential applications, but they will not be realized unless the map is added to the tool kit of Wisconsin resource managers and used along with other tools to meet the challenges of contemporary management of natural resources.

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Cathleen Palmini

Across the Unknown Waters to Wisconsin: The Migration Narratives of Four Women Settlers

"When i [sic*] looked into the water and see the little waves that receded back from the boat it seemed that every one was bearing me away from all my friends forever."

—*Orpha Bushnell Ranney, letter of September 1847*

"Sick still. Took nothing the last two days except a little brandy and Laudnum. . . . A fair wind, a great swell on the sea. Ship rolling tremendously."

—*Isabella Mckinnon, diary entry of April 15, 1852*

"All of us, including the sailors thought that this was the end, for we could feel the ship sinking lower and lower. . . . The yelling, the noise, and the panic was terrible."

—*Emilie Schramm Crusius, memoir of 1854 trans-Atlantic voyage*

"What inexpressible joy and relief did I experience when I set my feet on terra firma."

—*Racheline S. Wood, letter of December 1, 1838*

The words of ordinary women in a period of upheaval chronicle homesickness, seasickness, shipwreck, and joy at setting their feet again on firm ground. Compelling glimpses into individual women's lives in the mid-1800s, these words are more compelling for their rarity—few Wisconsin women's writings from the settlement period are accessible which describe the voyage across the Atlantic Ocean and through the Great Lakes to Wisconsin. Held in archives or remaining with family members, the sometimes brief or fragmentary diaries,

*Writings have been transcribed as found with no editorial corrections.

letters, and memoirs of common women have often been viewed as historically insignificant and remain unpublished. The memorable writings of four women of this period, describing travel by water to Wisconsin, humanize the broad sweep of Wisconsin history by focusing on personal accounts of voyages. What does one write when the immediate future is unknown, when the only certainty is what one has left behind? These women express in four unique, feminine voices not only daily experiences while sailing or steaming toward Wisconsin but feelings and attitudes about their lives during this transition.

Who were these women? Isabella Mckinnon, quiet and uncomplaining, crossed the Atlantic in a sailing ship in 1852 and wrote each day in a diary ending with her arrival in Otsego, Wisconsin. In 1854, adventurous, seemingly ever-hungry Emilie Schramm and her mother traveled by steamship from Germany bound for Sauk City. Racheline S. Wood, self-assured but lonely, chronicled in letters her difficult travels of 1838, through the Erie Canal and through the Great Lakes by steamship settling in Plattville. Orpha Bushnell Ranney, although the least-educated, expressed clearly in letters of 1847 her loneliness for loved ones left behind, as she and her husband undertook Great Lakes travel to reach Sun Prairie.

Across the Atlantic

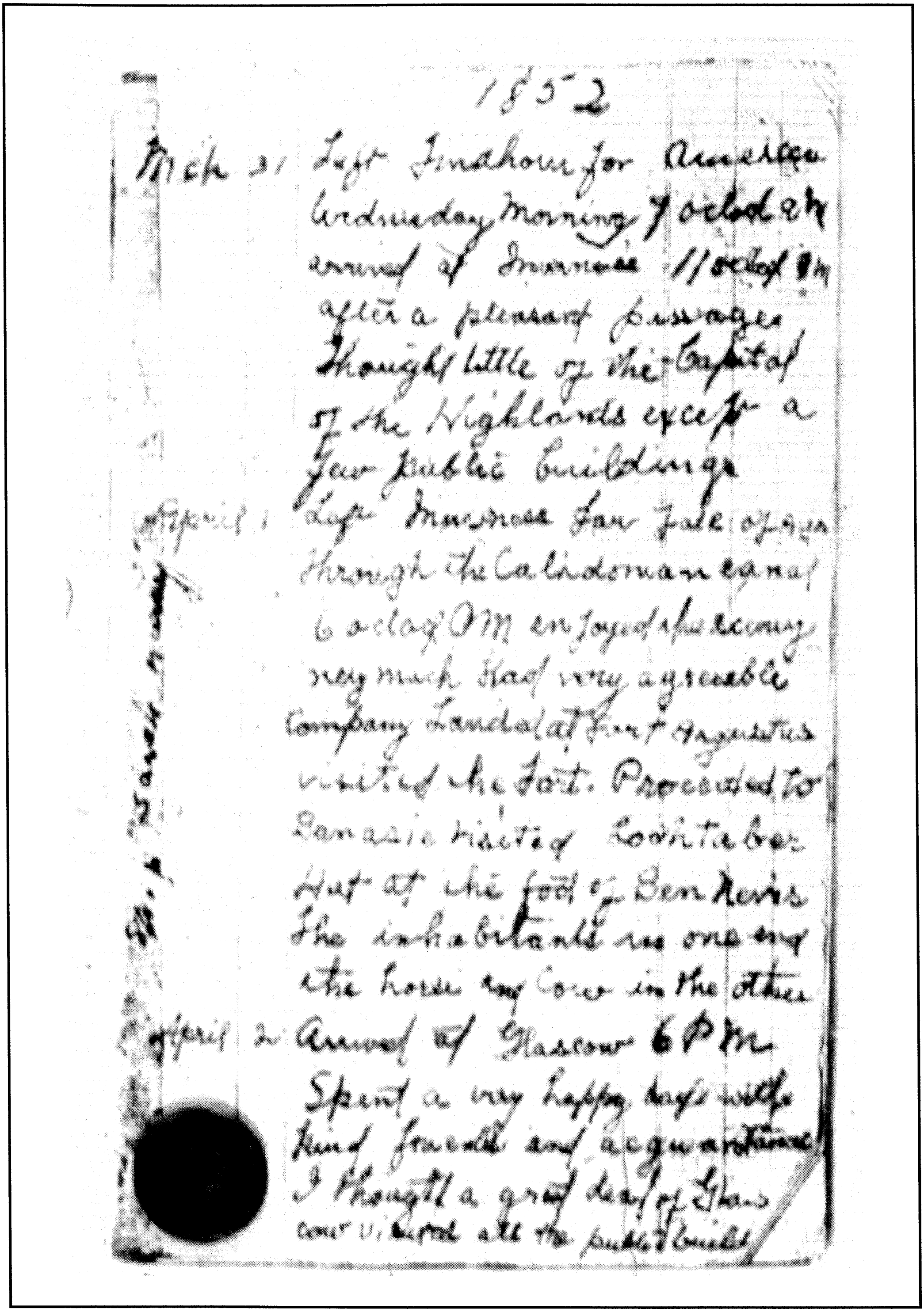
To merely state that the population of Wisconsin grew from 30,945 to 775,881 between 1840 and 1860 is to belie the drama as well as the tedium of the actual journeys of settlers (Smith 466). Immigrants who had crossed the Atlantic by sailing ship or steamer during this period made up approximately half the population of Wisconsin in 1860 (Current 78). The diary of Isabella Mckinnon, written aboard a sailing ship, and the memoir of Emilie Schramm Crusius, describing a steamship voyage, are first-person descriptions of trans-Atlantic immigration to Wisconsin.

Isabella Mckinnon

Nineteen-year-old Isabella Mckinnon, after leaving her village of Findhorn, Scotland, boarded the sailing ship "Sarah Mary" on April 9, 1852, bound for America. In her small four-by-six inch leather journal, Isabella recorded in pencil the notable happenings of each day until June 4, 1852, when she reached her destination—Otsego, Wisconsin. Written in sentence fragments most often without subjects, her diary never reveals whether she made the trip alone or with her family. Isabella's account is notable for her succinctness and calm in describing a voyage that included days of discomfort and dangerous storms as well as days of becalmed seas when the ship made no progress.

The average length of travel to America by sail was six weeks, depending on whether the wind was fair and whether the captain and crew were skilled. Isabella's trip took eight weeks, and she probably traveled as a steerage passenger rather than a higher-paying cabin passenger. The steerage passenger lived in the long 'tween decks—the space between the main deck open to the weather and the lower deck below it. The rows of bunks built there, usually in two tiers, were temporary for the east to west journey. For the trip from America back east, the 'tween decks often carried lumber—a cargo commonly considered more valuable than the steerage passenger (Greenhill 16–17).

Isabella's record did not dwell on the living conditions but briefly described activity on board. Her first entry after boarding the "Sarah Mary" was typical as she matter-of-factly stated "Captain Brown delivered a lec-



1852

Mch 31 Left [illegible] for America
Wednesday Morning 7 oclock AM
arrived at Inverness 11 oclock PM
after a pleasant passage
Thought little of the Capital
of the Highlands except a
few public buildings
April 1 Left Inverness for Fort Augustus
through the Calidonian canal
6 oclock PM enjoyed the scenery
very much Had very agreeable
Company Landed at Fort Augustus
visited the Fort. Proceeded to
[illegible] visited [illegible]
Hut at the foot of Ben Nevis
The inhabitants use one end
the horse and cow in the other
April 2 Arrived at Glasgow 6 PM
Spent a very happy days with
kind friends and acquaintance
I thought a great deal of Glas
gow visited all the public build

Diary of Isabella Mckinnen. State Historical Society of Wisconsin Archives.

ture on board to the passengers from John 6." They remained in the Bay of Greenoch for one day for inspections:

> Passengers examined by the Doctor and Government Inspector. Eight of the passengers rejected. The sugar condemned by the Government Inspector. Superior [sugar] returned. Left the Bay of Greenoch at 5:00 o'clock P.M. Wind unfavorable. Towed out to Sea by a steam tug. One of the passengers a woman, got drunk and disorderly and was put in irons for sometime.

On April 11, she recorded the first of many Sundays, the observance of Sabbath being important enough to her always to merit comment. Of one Sunday, she wrote: "Public worship on the quarter deck. A good attendance, very impressive on the mighty deep." This Sabbath she called unprofitable because the ship was becalmed. To pass the day, the Captain distributed tracts to the passengers, and Isabella spent the greater part of the day reading. The following day the rules of the ship were read.

> April 12: A committee of the passengers formed to keep order and observe cleanliness, one of the rules, to rise at 7:00 A.M. To be in bed at 10:00 P.M. to be rigidly enforced. A fine day, wind favorable. Took the last look of Scotlands hills at 10:00 o'clock A.M. A little sick, soon got better, employed the day in sewing, crocheting and reading. An alarm of fire, nothing serious. A fair wind, all sails set. Going at the rate of 8 knots an hour. A dance, to the music of the Bagpipes, Fiddle and Tambarine, got up amongst the passengers. A beautiful night. On deck all the evening.

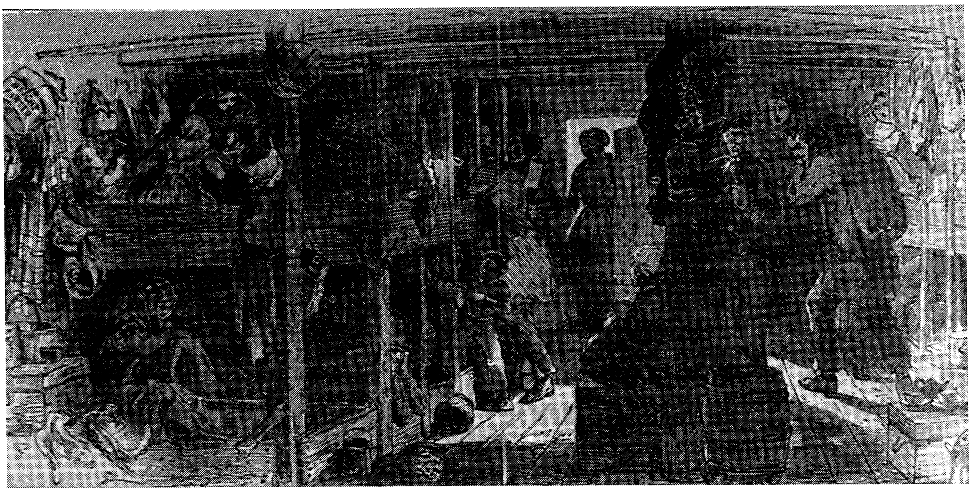
And so Isabella was on her way, and her diary revealed that she did not complain and she did not dramatize happenings. Unused to the motion of the ship, many passengers on sailing ships were seasick as the ship rolled and pitched and tossed. Isabella was seasick for several days and wrote only "A strong fair wind. Sick all day." and the next day "Still continuing a fair wind. Very sick." On the sixth day out, she was still seasick and mentioned the remedy she was trying: "Sick still. Took nothing the last two days except a little brandy and Laudnum." Later that day she reported:

> Went on the quarter deck at 12:00 o'clock. Was much refreshed with the fresh air. A fair wind, a great swell on the sea. Ship going at the rate of 8 1/2 knots an hour. Ship rolling tremendously. Every one more afraid than another. Passed a wreck in the morning.

That seemed to be the end of her seasickness, and she turned to brief descriptions of daily activities. The weather and sailing conditions always merited comment, and during an April storm she did not display her usual calm:

> April 20: A very fine day, calm. The Atlantic like a loch. The wind rose at 3:00 p.m. A strong breeze with rain at 7:00 P.M. Ship going a good rate. On deck at 9:00 o'clock, looking rather stormy. Stayed on the deck an hour with very interesting company.
> April 21: Very stormy all day. High wind with showers of rain and hail, continued very severe all night. Thought we would never see morning. Water rushing into the steerage.
> April 22: Storm somewhat abated, wind contrary.

After this initial storm, even severe weather did not cause her to make worried remarks about their safety. The days seemed to drag on and Isabella's writing dwindled to two or three phrases each day. Noteworthy were two days when fights broke out and the men involved were put in irons for an hour. Passing ships also broke the monotony.



Steerage passengers. *Illustrated London News,* May 5, 1851.

On May 7, about four weeks out, she experienced an event worth recording in more detail:

> Seven ships in sight, fishing for Cod. Passed close by one. Some one with the life boat went and brought some cod, part of which Captain Brown distributed to the passengers gratis. The deck very much resembled a fish market. Every one crowding to get their share. Wind somewhat favorable. 16 miles from Sable Island. 400 from New York.

The passengers' enthusiasm probably reflects the poor quality or at least the sameness of the food provided on board. The food provided for cabin passengers on many sailing ships was adequate to mediocre, and for steerage passengers some ships provided only meager rations with the passengers being expected to cook their own (Greenhill 17).

After several days of misty weather, Long Island, "a very welcome sight," came into view on May 17, and Isabella's daily writing increased. Her first views of America were described with a good-humored tone:

> The tug came along side at 12:00 O'clock. Coming up the River was the finest sight I ever saw. The scenery exceeded everything I have seen. Off Staten Island at 2:00 o'clock. A very pretty place. The doctor came aboard. The passengers all on deck and examined in less than five minutes. The Doctor said he had never examined a more healthy good looking set of passengers. Arrived opposite New York at 3:30 o'clock P.M. The first thing I got belonging to America was a New Testament, which a gentleman came aboard and kindly presented to the passengers. A very amusing sight to see friends meeting friends.

True to form, Isabella did not say who met her. She noted that New York was a very fine city and then detailed her methods of travel across the country. She traveled up the Hudson River and took the Erie Railway for 500 miles to Dunkirk, New York. She took lodging there in a house kept by "very fine people" but was "very much disappointed with the look of the country."

The steamer "Niagara" took her up Lake Erie to Cleveland, a city which she found impressive: "A very fine place and beautiful buildings. Far surpassing any I have yet seen in America. Streets so wide and trees growing on each side." Continuing to Detroit by the steamer "Detroit," Isabella arrived on a Sunday morning in time to visit a Roman Catholic Church. She appreciated the very large, fine building but not the "very strange ceremonies." After staying only a few minutes, she found a Methodist Episcopal Church more to her liking: "Very clean, never saw a more respectable looking congregation."

Continuing on to Chicago by railroad, she found that cholera was spreading in the town. On May 29 she took the "Arctic Steamer" to Milwaukee of which she wrote, "Apparently a fine place." She took lodging in the Wisconsin House, walked around the town, and visited the Congregational Plymouth Church and an "English Church."

On June 1, 1852 she left Milwaukee for Otsego, a distance of 80 miles. Traveling half way the first day, she stayed overnight at "a tavern by the way." Her last three diary entries took her through stormy weather to Otsego:

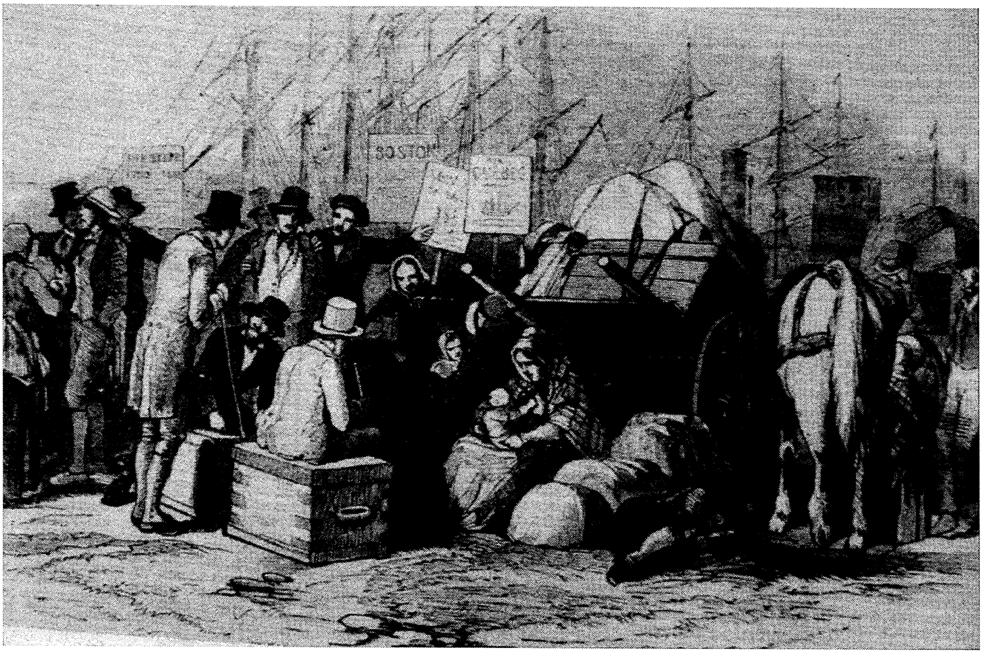
> June 2nd - Passed through Watertown in the forenoon. A very nice little place. Arrived at Lowell a small village and stayed all night. An awful night of thunder and lightining. Never saw anything like it before. The sky all in a blaze for two hours.
>
> June 3rd - Left Lowell early in the morning and were detained in Columbus by a thunder storm. A nice little place. Proceeded to Otsego and were overtaken by another thunder storm and heavy rain. Were obliged to remain all night in the "Prairie House" about 5 miles from Otsego.
>
> June 4th - Arrived all safe at Otsego in good health not without a good deal of fatigue on the 4th of June, 1852.

There, Isabella Mckinnon ended her diary with no mention of whom she might have joined in Otsego or her reasons for this destination. Isabella's detached written reaction to the trip, although not the difficulty of the ocean passage itself, is in stark contrast to Emilie Schramm Crusius's descriptive and good-humored memoir of her trans-Atlantic voyage on a steamship.

Emilie Schramm Crusius

In 1854, the unmarried Emilie Schramm and her mother crossed from Neckargartach, Germany, to Philadelphia on the maiden voyage of the screw steamship "City of Philadelphia." During this mid-1800s period, when sailing ships were being replaced by steamships for emigrant travel, the conditions for passengers did not improve immediately. However, the traveling time was cut from six weeks on a sailing ship to about ten days on a steamer, meaning a shorter time to endure the hardships and the tedium. Cabin passage on some liners became lush, but ship owners remained disinterested in the conditions for steerage passengers until William Inman began in 1850 providing ships on which emigrants in steerage could travel in relative comfort. His liners were built to accommodate emigrants, not to transport timber, mail, or other freight (Armstrong 34–35). Emilie and her mother were fortunate that the "City of Philadelphia" was an Inman steamer, because although they had paid for cabin passage, they were assigned bunks in the steerage section because of the large number of passengers.

From the beginning of her account, Emilie wrote as if the trip were an adventure. At age 28, Emilie took charge of the arrangements, and, by comparison, her mother seemed timid and scolding and always expecting the worst. Beginning with the steamboat trip down the Rhine River to



Emigrants. *Illustrated London News,* May 10, 1851.

Rotterdam, Emilie wrote with a great deal of descriptive detail and expressed an appreciation for any kindness shown her and her mother:

> On Thursday we boarded the steamer, "Victoria," and traveled down the Rhine, admiring the beautiful scenery, the many romantic ancient castles, and the high bluffs on either shore, covered with rows upon rows of fruitful vineyards. On board we found a rather boisterous group, but we always discovered some nice people with whom we could chat. We were traveling second class, but for some unknown reason the steward allowed us to occupy two beautifully upholstered easy chairs in a cabin with large gold-framed mirrors on the walls and beautiful rugs on the floor. I had never seen such regal splendor.

Emilie tended her seasick mother on the steamer and also recorded that her mother became ill after drinking the water in Rotterdam. Because milk soup was all her mother wanted to eat, Emilie sought out fresh milk and, when she could find it, cooked milk soup for her mother.

On the night before departure for Philadelphia, they waited with other travelers in the Emigrants' Hotel, and that evening a dance kept them awake most of the night: "We both wept to think of such levity and irresponsible behavior on the last night on terra firma. So many were very drunk in spite of having to start on the long perilous journey the next day." In boarding the tender that was to take them to the "City of Philadelphia," they faced trouble with their baggage:

> All passengers had to carry their own luggage. We were really in a bad situation. I tried to take some of our belongings to the tender, but there was such a crowd of passengers who pushed and crowded so persistently that it was impossible to make any headway, much less to go back after mother. I was beside myself; called to her and finally she came, hardly able to drag the remaining luggage with her. Just as she set foot on the boat it raised anchor. To this day I can't understand how we two helpless women overcame every obstacle as well as we did!

While her mother was again seasick, Emilie couldn't get enough to eat. Although the soup was too peppery, the smoked meat smelly, and the coffee served with molasses, she enjoyed the excellent potatoes and delicious white bread so unlike what she had eaten in Germany. Emilie soon made friends with Marie Siegel, another young adult traveling with her mother, and the two became friendly with the steward who "showered us with favors whenever possible." Emilie reported: "I really had no complaint, and so, just like pretty blond Marie, I was always in a happy mood. She and I were among the few who weren't seasick, spending most of our time on deck, healthy and gay as the fish."

This carefree passage to America was interrupted when the ship rammed a cliff near Newfoundland. Near midnight a terrific crash was followed by a furious rolling of the ship.

> All of us, including the sailors thought that this was the end, for we could feel the ship sinking lower and lower. . . . The yelling, the noise, and the panic was terrible. . . . The men who slept on the level below us tumbled out of their beds and immediately found themselves standing in a foot of water. Trying to save what they could, they grabbed the next best thing and rushed up the stairway. When they reached us, —but what was that? There the fellow stood, wearing nothing but a long white shirt and a high silk hat! We all screamed with hysterical laughter, but soon again soberly realized our perilous plight. Everyone was terrified; mother prayed fervently and I—I went to get something to eat. I recalled the story of Robinson Crusoe who was shipwrecked on a deserted island and learned to fend for himself without the help of the barest necessities. Of course, mother scolded me for thinking of food at a time like this when we stood so close to eternity.

By pumping out the engine room, the crew was able to back the ship onto a sandbar. The passengers were ordered to one side of the ship to counter-balance the tilt of the ship which continued to sink. Rockets were sent up, a little cask containing the names of the passengers and the crew thrown into the sea, and the lifeboats lowered. Amid terrific crowding and pushing, Emilie, holding her mother's hand and the zwieback and honey cakes from Germany, stepped down into a lifeboat. They were taken to a nearby island where the men made a big bonfire out of driftwood.

The next few days the crew rowed back to the ship several times and retrieved luggage and food. Their baggage was not recovered, and Emilie theorized that their cases had "probably plunged into the ocean through the great hole in the hull when we struck the rock." On the third day they heard a startling blast of a cannon from a ship that was to transport them to the city of St. John on the Canadian coast. When their turn came:

> We scrambled on to the little steamer, but it didn't leave until ten o'clock that night! Never, as long as I live, will I forget the awful nightmare of that trip. Frenzied, hysterical screams of "Fire! Fire!" suddenly awakened us out of

> a deep sleep. Poor mother, wringing her hands and weeping, kept lamenting, "We've escaped death by drowning, and now we'll be burned to death!" the fire at last brought under control and after a seemingly endless night we landed, exhausted, at St. John at 5 a.m.

Those people who were shipwrecked lodged with families in St. John for nearly a month, and Emilie was amused when "a mass was said for all of us poor victims of shipwrecks." Her proud mother refused offers of financial assistance as well as gifts including used clothing from a Protestant bishop, so Emilie sewed garments for them. She seemed happy in their cozy host home, appreciated the food, attended a church service at which they couldn't understand the sermon but enjoyed the music, and turned down social invitations because they lacked suitable dresses. However, they continued to be concerned by the high stormy seas and the reports of steamers sinking.

On a stormy October day they departed for Boston, but couldn't land there:

> We were supposed to disembark at Boston, but imagine our surprise when we passed it by, why we weren't told; but some of the passengers said it would have been impossible to land in Boston Harbor. This is a rough voyage, very stormy, with a dark, forbidding sea, and our boat, a small steamer, rocks and pitches like a cork on the angry waves. Poor mother has lost all hope thinking the good Lord has forsaken us now.

But eventually the strong wind subsided, and they entered Philadelphia harbor on a calm, placid sea.

Emilie and her mother settled with her brother in Sauk City, where Emilie became a school teacher and married Louis Crusius in 1860. While her travel narrative brims with youthful enthusiasm and optimism, her summation of her life written in a second memoir is heavily sad. She lost all but three of the nine children she bore. At age 73 she wrote:

> I was blessed with a sunny nature and really would have enjoyed life, had not misfortune after misfortune continually hunted me down. While my children were small I was so happy with them and it was my then carefree outlook which my dear husband so loved in me; but the tragic loss of one dear little one after the other threatened to break me down both mentally and physically. . . . It truly is a miracle I'm still alive; I must be a pretty tough weed. My one wish is just to be near my dear children.

Through the Great Lakes

While Emilie's travel memoir does not detail her methods of travel to Wisconsin, she may have joined the tens of thousands in this mid-1800s period who crossed the Great Lakes to settle in Wisconsin. Often beginning with a trip down the Erie Canal, approximately half of all trans-America migrants to Wisconsin during this period made part of their journey by steamboat through the Great Lakes. Steamers advertised regular schedules, speedy trips, and luxurious accommodations, but travel by Great Lakes steamer was not without mishaps. Seasickness among passengers was common as were accidents involving piers, ice, rocks, and other vessels. Larger steamers were especially prone to hang up on sandbars and beaches during low water or storms. Fires on board were sometimes deadly: the steamship "Niagara," taken by Isabella Mckinnon, was destroyed by fire in 1856 at a loss of over 60 lives (Jenson 212). Some passengers described their trips through the Great Lakes as more harrowing than crossing the Atlantic Ocean.

Racheline S. Wood

In 1838, Racheline S. Wood experienced an eventful trip west through the Great Lakes which included the rescue of passengers after their steamboat hung up on a reef of rocks. Her letters of 1837 to 1840 chronicle Racheline's travels from Vermont to Platteville, Wisconsin, where she settled. Each letter was addressed to her sister Maryann Wood, Enosburgh, Vermont, a place Racheline called home.

Racheline's letters show a degree of education and lofty language not found in the first two travel accounts. At times she projected the sense that she was above the station of many of her fellow travelers, and in frequent comparisons between the east and other areas through which she traveled, she left no doubt that New England was superior in most respects.

In a letter of December 1, 1838, Racheline described the highlights of her journey through the Erie Canal and Great Lakes and her loneliness. The previous distance that divided her from her sister in Vermont seemed short in comparison: "now hundreds of miles with the broad lakes roll between us." But although she and her sister were divided in body, Racheline said their spirits might converse through letters, and she began with the story of her journey. After deciding in mid-August 1838 to leave "dear New England for the far west," she traveled by private conveyance for three days to Troy, New York.

Her spirits fell as they entered New York state: "we rumbled along over those try patience roads gasping at the lofty eminences which rose on either side of us threatening to shut out the light of day." Having previously mentioned "the sterile fields, the frowning heights, the miserable huts" they passed in their travels, she became more cheerful as they came to an area of "highly luxuriant and fruitful fields" which extended all the way to Troy.

Arriving in Troy, she "spent there about three hours running up and down the city most delightfully, called at multitudes of stores and milliners shops and at 5 o'clock was glad to get on board of a canal boat bound for Buffalo on which I remained a week." Her summary of Troy was this:

> Yet with all the pride and advantages of the Yorkers I think New England has whereof to boast not only in morals but in the tidiness and good taste of their establishments. Their buildings are constructed very different from ours with much less good taste and with a general appearance of slackness.

Racheline's "brief sketch of our first nights repose" on the Erie Canal boat included a characterization of her fellow travelers as all grades and ages from the "poor to the man of honour, little babes of 3 weeks, squalling young ones of 1-2-3 years." The sleeping arrangements proved less than satisfactory. Near nine o'clock hammocks were swung to accommodate about half the passengers. In the small room appropriated to the ladies, she selected a place to sleep:

> The middle birth in the middle range was fairly laid there and congratulating myself in having found the best birth when crash went the one above me and down it fell. I sprang to evade it, which going down went mine with the one beneath. Such a racket, the ladies room called forth the simpathies of the gentlemen whose room resounded with mirth when ascertaining the cause of disturbance.

They picked up their berths and made beds on the floor, but she reported that she didn't get a wink of sleep with the "noise of the crew on the deck and the fussing of the rolling of babies upon my feet." During the day, she wrote, they were privileged to get out on the tow path and walk a mile or more.

Leaving the canal, Racheline joined the estimated 5,000 travelers who in a single day in 1838 steamed from Buffalo through the Great Lakes for the west (Channing 267). Racheline reduced the steamboat trip through Lake Erie to only a single line: "Thursday I took the steamboat at Buffalo had a pleasant ride to Detroit where we stopped some hours." After changing boats the passengers continued the journey through Lake Huron and into Lake Michigan, but Sunday morning their boat ran up on a reef of rocks opposite Beaver Island in the straits of Mackinac: "a punishment it would seem for travelling on the sabbath but I must do so or lose my company." The passengers were thrown from their berths as the first sign of disaster, and all attempts to free the boat failed. They waited "near 40 long, wearisome, trying hours" hoping for a boat to come and take them to shore which was about two miles away.

On Tuesday with the waters rising, freight was thrown overboard and the 400 passengers were taken to shore in a small boat:

> In haste we prepared to leave what had seemed our grave, and although the waves were so high as to hide the small boat from view when within but a few rods of our deserted home I never enjoyed a ride better. What inexpressible joy and relief did I experience when I set my feet on terra firma.

After the boat landed with difficulty still some distance from shore, Racheline was carried ashore on a gentleman's shoulders and the passengers took refuge in the fort. In a note written in the margin she regretted she did not have space to better describe "the thousands of Indians which I saw at Michaelimack in their bark canoes their tents which were placed along the Lake almost as far as the eye could reach."

Late in the afternoon enough freight had been thrown overboard so that their ship floated, and it was moored about six miles further out. On Wednesday the passengers were returned to board, and they continued to Chicago having been on the lakes "near a fortnight." "Carelessness was considered the cause of the disaster; as the boat was at least six miles out of its right course when she struck." Thus she ended her travel narrative but her marginal writing included a plea for a long and detailed letter from her sister. Her loneliness was clear in this marginal note:

> I seem to be clear out of the world. I cannot even realize how far I am from you and every relative on earth. When musing on what intervenes between me and those dearer than all resides on earth my heart sickens within me. I dash the thought away as poison.

In a final letter from Platteville, Wisconsin, dated March 10, 1840, Racheline urged her sister Mary to come and live with her and take up a teaching position. Racheline had planned a select school for girls, number limited to 20 and pay of $4 a quarter. She would not be taking the post because she was to be married:

> About a year since, I became acquainted with a Mr. Bass. . . . A strictly moral person, a member of the total abstinence society and is reputed to be worth. . . some thousands exclusive of all debts. I think it more than probable you will not like him but if I do no matter for your opinion.

After giving Mary traveling advice and asking her to bring a dozen good used silver teaspoons and a pair of sugar tongs, Racheline concluded: "I would like to have you live constantly with me." No further letters are available to indicate what Mary thought of these plans and whether she moved to Plattville.

Orpha Bushnell Ranney

Also urging her family to move to Wisconsin, Orpha Bushnell Ranney's letters provided details on farming in Wisconsin as well as a description of her trip west. As a new bride of 21, she traveled with her husband from New York State in September, 1847, settling first near Sun Prairie. In the first of her letters written over a period of 50 years to her sister in Connecticut, Orpha described her trip by canal boat through the Erie Canal and then by steamboat through the Great Lakes.

Of the four women in this article, Orpha appears the least educated. Her writing, with its lack of punctuation and capitalization (except for names), was not unusual for women's writing of the time. Her letters continued line after line with no sentence breaks and sometimes incorrect grammar and spelling. The spidery script penmanship of the period filled every inch of the paper.

Most letter-writers of this time used a standard 10"x15" sheet of paper which was folded once to provide three writing pages and one blank side. The written-on sides were folded inside the blank side until a 3"x 5" clean surface remained for the address. The folds were then sealed with wax. Orpha not only filled the three sides of her paper in the usual fashion but also filled all the margins as well by writing in them sideways. From the tone of her letters, and many others from this period, this practice of using every bit of space spoke not only of the frugality of the writer but the desire and urgency to use every opportunity to communicate with loved-ones left behind.

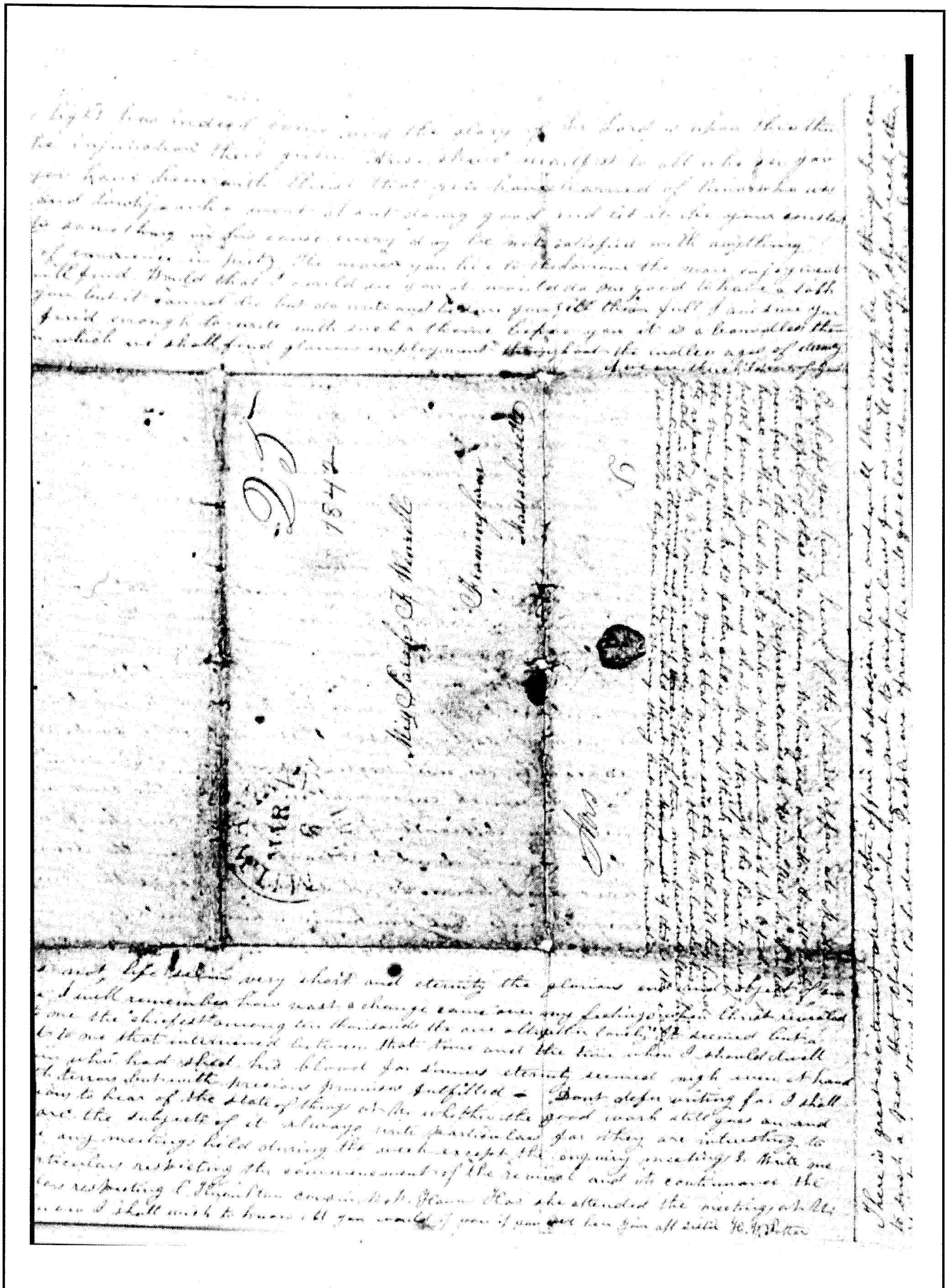
In her letter of September, 1847, Orpha seemed alternately engaged in the new experiences of the "long and tedious journey" and saddened by leaving family and friends.

> it was very pleasant on the canal i see a great many pleasant places and things and those that were interesting but when i looked back and thought of what i was leaving and where i was going it spoilt it all when i looked in to the water and see the little waves that receded back from the boat it seemed that every one was bearing me away from all my friends forever

Although lacking in education, Orpha's writing clearly conveyed her feelings of loneliness as well as her amazement and sometimes fear during some of the trip's happenings. She wrote that she loved to travel and "see so many things which you know are new to me." Orpha, probably from a lower social stratum than Racheline Wood, did not expect special favors and appreciated any that came her way. Describing the journey from Buffalo by steamboat through the Great Lakes, she wrote:

> we took Cabin passage had a room to ourselves which was pleasanter than to be obliged to stay with the rest of the passengers all the while if you want to see a table set in style and vituals cooked in style of all sorts and descriptions you must travel on board a steamboat there is a great deal to be learnt you are waited on in style if you take a Cabin passage you are as big as any of them

However, on the third day the weather became stormy, and Orpha became seasick as did her husband Edward: "the third the lake was rough enough the white caps rolled the boat rocked and tumbled we staggered about like a pack of drunkards i was as sick as death." She also feared that the boat would sink in the storm: "every time the boat stirred it seemed as if we should all sink to the bottom she would rock and twist



Letter of 1842. State Historical Society of Wisconsin Archives.

about and i thought she would all fall to pieces O how i wished i was on land."

The water remained rough for the remainder of the trip, and Orpha reported that the crossing took eight days rather than the general four days when the weather was good. One night the steamer struck a sandbar, and it took the crew most of the night to free it. On a second stormy night the boat was anchored on a sandbar behind an island, perhaps to evade the windy weather. In the process the engine was damaged: "when they were on the sand bar they strained there engine so that they could not keep up against head winds at all when the wind was ahead they had to stop I was afraid the old boiler would burst I was sick all the rest of the way."

Although her letter did not contain specifics on the route traveled, she wrote "we stopt at Cannada and at Mackinaw" where the passengers had some trout. She was impressed by an Indian camp probably on the north shore passing through the straits of Mackinac: "there was between two and three hundred Indians there boats and wigwams were scattered all along the shore they had on there blankets and their wampum and tassels on there heads they looked curious enough."

The travel portion of her letter ended with a visit ashore at one of their stops: "i went in and see the glass works how curious and the salt works it does not seem as if man could ever learn so much." So despite the stormy weather and seasickness, Orpha seemed to retain her sense of amazement at the things she was seeing on the trip.

From later letters and a short memoir, we know that Orpha and Edward Ranney lived the first winter of 1847 in Wisconsin with his brother and that their first child was born in January and died that September. The Ranneys' story was not one of successful Wisconsin settlers who easily put down roots. The family farmed only a short time in Wisconsin, moved back east to New York and then Connecticut. They returned to a Wisconsin log house and farming in Dane County in 1852. By the time they moved to Dunn County in 1855, first living in a shanty, Orpha had given birth to six children, five living. Edward soon built a house and, within weeks of moving in, Orpha gave birth to her seventh child who lived only minutes. After living for six years "on the prairie," Edward sold out, invested in timber, and moved the family to Cedar Falls, Dunn County. While her writings indicated that Edward was the decision-maker, Orpha wrote matter-of-factly about all these moves and followed no matter how harsh the conditions.

Edward's health failed and he died "of consumption" in May 1867. Their ninth child was born three months later. Orpha and the children stayed to farm—raising crops and hogs, cattle, and hens. The family got along pretty well, according to Orpha, and she continued to write her sister from Cedar Falls, Dunn County, Wisconsin, the last letter dated August 28, 1898 (Orpha was 74).

Conclusion

Each of these women wrote a highly personal account of her migration to Wisconsin, and each writing provides both glimpses of what happened on the journey as well as how each woman felt and reacted. These accounts vary from brief and detached to detailed and humorous and are expressed in styles from very educated to bordering on illiterate. Each trip was unique, but the sense of voyaging into the unknown was universal.

These narratives make clear that there were no uneventful voyages in route to Wis-

Wisconsin family. Wisconsin Visual Materials Archive.

consin. Because of storms, accidents, and shipwreck, each of these four women feared for her safety and her life during her travels. Every voyager bound for Wisconsin may not have experienced such life-threatening events, but all had to cope with unfamiliar and often harsh conditions on board and throughout their travels. While caught up in the rigors of the trip, travelers were also painfully aware of the distance between them and loved ones left behind. For most immigrants there would be no going back.

It is not surprising that these women voiced complaints and fears, described loneliness and bouts with seasickness. It is surprising that their writing and outlook is not more negative. They just as readily wrote with humor and matter-of-fact acceptance and expressed appreciation for kindnesses received and amazement at new sights and experiences. Their writings contain a mix of beautiful as well as bleak scenery, unease at unfamiliar types of fellow travelers and pleasure with new companions, strange food relished or found unpalatable, luxurious cabins as well as difficult sleeping accommodations, events that were amusing and fearful events that nearly led to a watery grave. They recorded their travels to Wisconsin with a keen eye, and amazingly their complaints were not in proportion to the conditions and events they endured during their trips.

Although Emilie describes herself and her mother as "we two helpless women," this characterization clearly does not hold for any of these women. They each accomplished their trips across unknown waters, the Atlantic and the Great Lakes, with a combination of resilience, sturdiness, and courage—qualities that stood them in good stead when they reached Wisconsin.

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James L. Theler

Animal Remains from Native American Archaeological Sites in Western Wisconsin

Since the 1950s archaeological teams have worked at excavating ancient Native American living sites in western Wisconsin to learn how the ancestors of modern American Indians lived and how their way of life changed over time. Included among the rich harvest of archaeological materials recovered from excavated sites are a large number of shells and bones from the animals that provided animal protein for the region's Native Americans prior to the arrival of Europeans. In addition, remains of small vertebrates recovered occasionally during archaeological work provide a glimpse of animals that were not used for food but were simply part of the local environment.

This summary has been compiled for people interested in documenting which species of animals were present in the western Wisconsin area of the Upper Mississippi Valley during the five thousand years prior to European arrival. The 190 species listed here were recovered as bones and shells from 32 Native American living sites, the majority of which are located in western Wisconsin (see Table 1 and Figure 1). Because they have passed through a series of "human filters," these archaeological faunal assemblages do not constitute statistically representative samples of local animal populations at the time the sites were occupied. First, these species were selectively chosen by ancient peoples for their suitability as food, clothing, and tool stock. Second, the archaeological recovery process itself can be selective for both the size and the type of faunal material recovered. Third, the existing archaeological faunal assemblages have been analyzed by people with varying levels of expertise. Nonetheless, these faunal remains provide a wealth of information on

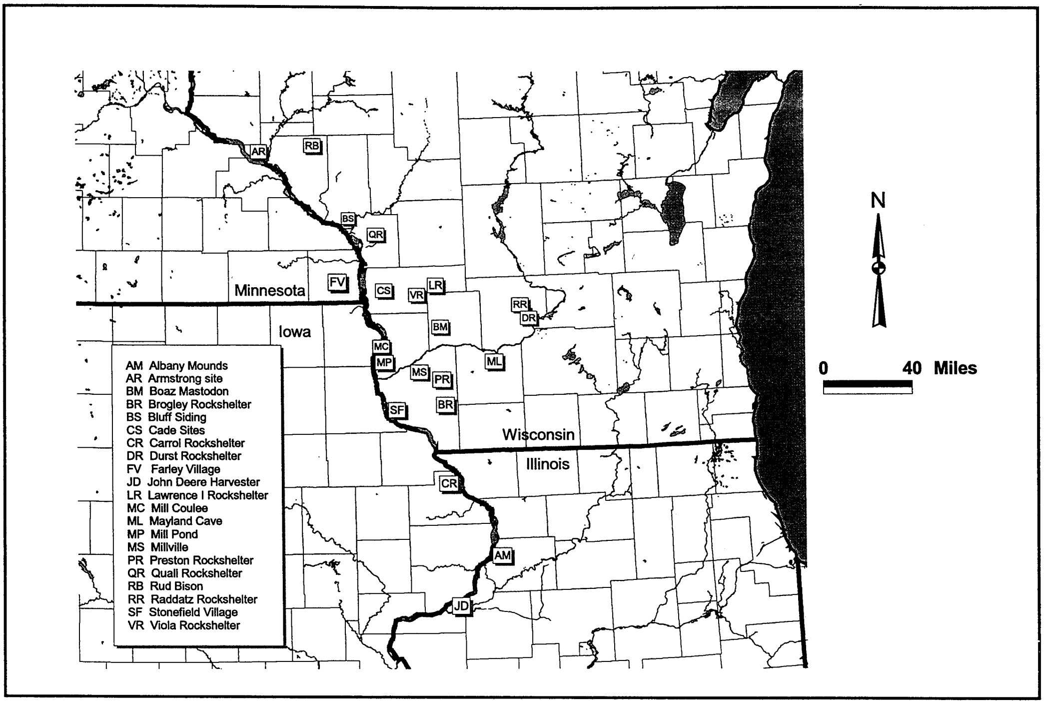

Figure 1. Archaic and woodland sites and selected Oneota sites outside of the La Crosse locality.

the animals used by Native Americans and also serve as a general index for the species once present in the region. Because of their particular relevance I have included a small number of archaeological sites outside western Wisconsin, including the John Deere Harvester site, Albany Mounds, Carroll Rockshelter, and the Farley Village (see Table 1 and Figure 1).

Methods and Materials

Most faunal remains recovered from archaeological sites are discarded food residue deposited with other debris as trash or refuse. At open-air living sites, archaeologists find much of this refuse in pits that the residents dug into the ground and used for storing agricultural produce or other products. When a pit fell into disuse, it was sometimes filled with camp refuse. Archaeologists can usually detect these pits by the dark staining that permeates the soil when organic material decays.

Protective rock overhangs, or rockshelters, were commonly used for human habitation and often contain animal remains in great abundance. These remains are sometimes found in refuse pits but are most abundant in middens that accumulated on the surface as trash repeatedly deposited in the same location. The rockshelters of western Wisconsin appear to have been commonly occupied during the cooler months of the year. The occupants tended to concentrate their living areas at the front of the shelter and toss unwanted materials, including animal bones, to the rear. Open middens or individual discarded bones were often scavenged by domestic dogs and wild

Table 1. List of archaeological sites with identified animal remains.

Abbreviation	*Site Name*	*Site Number*	*Location*	*References*
Oneota Sites				
PC	Pammel Creek	47Lc61	La Crosse Co., WI	Theler 1989, Arzigian et al. 1989
VV	Valley View	47Lc34	La Crosse Co., WI	Stevenson 1994
GU	Gundersen	47Lc394	La Crosse Co., WI	Theler 1994a, Arzigian et al. 1994
MV	Midway Village	47Lc19	La Crosse Co., WI	Scott 1994, Gibbon 1970, Theler 1994b
NS	North Shore	47Lc185	La Crosse Co., WI	Theler 1994b
JB	Jim Braun	47Lc59	La Crosse Co., WI	Theler 1994b
TS	Tremaine	47Lc95	La Crosse Co., WI	Styles and White 1993, Theler 1994b
SR	State Road Coulee	47Lc176	La Crosse Co., WI	Theler 1994b, Anderson et al. 1995
LC	Long Coulee	47Lc333	La Crosse Co., WI	Theler 1990
KS	Krause	47Lc41	La Crosse Co., WI	Theler n.d. a
SL	Sand Lake	47Lc44	La Crosse Co., WI	Theler 1985
OT	OT	47Lc262	La Crosse Co., WI	Styles and White 1993
FS	Filler	47Lc149	La Crosse Co., WI	Styles and White 1993, Penman and Yerkes 1992
AR	Armstrong	47Pe12	Pepin Co., WI	Savage 1978
FV	Farley Village	21Hu2	Houston Co., MN	Theler 1994b
Woodland and Archaic Sites				
CR	Carrol Rockshelter	13Db486	Dubuque Co., Ia	Collins et al. 1997
QR	Quall Rockshelter	47Lc84	La Crosse Co., WI	Theler n.d. b
VR	Viola Rockshelter	47Ve640	Vernon Co., WI	Theler n.d. c
CS	Cade sites	47Ve631, 643, 644	Vernon Co., WI	Theler et al. n.d.
MS	Millville	47Gt53	Grant Co., WI	Pillaert 1969, Theler 1983
SF	Stonefield Village	47Gt1	Grant Co., WI	Theler 1983
PR	Preston Rockshelter	47Gt157	Grant Co., WI	Theler 1987a
RR	Raddatz Rockshelter	47Sk5	Sauk Co., WI	Parmalee 1959
DR	Durst Rockshelter	47Sk2	Sauk Co., WI	Parmalee 1960
BR	Brogley Rockshelter	47Gt156	Grant Co., WI	Theler 1987b
MP	Mill Pond	47Cr186	Crawford Co., WI	Theler 1987a
MC	Mill Coulee	47Cr100	Crawford Co., WI	Theler 1987c
LR	Lawrence I Rockshelter	47Ve154	Vernon Co., WI	Berwick 1975
ML	Mayland Cave	47Ia38	Iowa Co., WI	Storck 1972
BS	Bluff Siding	47Bf45	Buffalo Co., WI	Theler 1981
JD	John Deere Harvester	11RI337	Rock Island Co., Il	Van Dyke et al. 1980
AM	Albany Mounds	11Wt1	Whiteside Co., Il	Klippel 1977, Benchley et al. 1977
Other Sites Mentioned in Text				
RB	Rud Bison		Buffalo Co., WI	Theler et al. 1994
BM	Boaz Mastodon		Richland Co., WI	Palmer and Stoltman 1976

animals, causing loss of the least resilient portions of the bone assemblage and damage to surviving bone.

Native Americans harvested huge quantities of freshwater mussels in portions of the Upper Mississippi River Valley, especially in the vicinity of the Rock Island Rapids in Illinois and Prairie du Chien in Wisconsin. At these locations, Native Americans made seasonal mussel harvests over many hundreds of years. The resulting discarded shells built up to create large shell middens that blanket portions of these areas.

Recovery and Identification of Animal Remains

During the past fifty years, as archaeologists have become interested in understanding the contents of living sites, they have generally used some type of screening device to separate artifacts and animal remains from the excavated soil. An archaeological screen is an open-topped box with wood sides and a metal screen attached as the bottom. Screen mesh sizes have varied depending on the excavators' objectives. Some excavators in the past used screen with a 1/2-inch mesh, but today the minimum standard is 1/4-inch mesh. Since the 1970s many archaeologists have employed finer screens with a mesh size of 1/16 inch or less to recover both animal and carbonized plant remains. The recovery method is a critical factor in the types and frequencies of animal species recovered. Few fish or small mammal remains are recovered with 1/2- or 1/4-inch screen.

Another critical factor is how the animal remains are identified. The remains analyzed by J. Theler as cited in this summary were identified through direct comparisons of the archaeological specimens to modern specimens of known species. Collections of "synoptic" reference skeletons and shells used in these analyses are housed at the University of Wisconsin–La Crosse and at the Zoology Museum at the University of Wisconsin–Madison. A number of experts have provided identifications for specimens that were difficult to identify because of a lack of reference material and/or expertise.

Archaeological specimens for which species identification was ambiguous are not included in the tables accompanying this summary, although they are listed in the original reports. Most faunal analysts note ambiguous identifications by the use of "cf.," which indicates that a specimen "compares favorably" but cannot be definitely assigned to the species. Mallards, for example, are often cited as "mallard (?) cf. *Anas platyrhynchos*" or "probable mallard, *Anas* cf. *A. platyrhynchos*" because most mallard bones are difficult or impossible to distinguish from those of the black duck *(Anas rubripes)*. Many archaeological sites of the Upper Mississippi region document the presence of "cf." mallard, but these identifications are not included in this summary, causing mallards to appear rather uncommon in the tables. The taxonomic nomenclature used in this summary for mammals follows Hazard (1982), except for elk (see Thomas and Toweill 1982). Birds follow Robbins (1991), amphibians and reptiles are after Vogt (1981), fish are after Becker (1983), crawfishes are after Page (1985), and mollusks follow Turgeon et al. (1988).

Animal Remains Excluded from This Summary

Bone, antler, or shell of many animal species were commonly used as raw material for making tools and ornaments. Bone tools, even if identifiable to species, were not included in this summary because the materials were often collected or retained in a very different way from animal products used for food. Certain skeletal elements, such as antlers dropped by elk and deer in mid-winter, appear to have been collected and saved for future conversion into tools (Theler 1989). During certain periods in pre-European times, bones and shells of some species seem to have been traded as raw materials for tool manufacture.

One example of tool stock are the shoulder blades (scapulae) of bison, used for the manufacture of agricultural hoes. The latest prehistoric people in the La Crosse area were the Oneota, agriculturalists who grew domestic plant crops in the region between A.D. 1250 and A.D. 1650 (Figure 2).

The most common large Oneota artifact is the bison scapula hoe, with nearly one hundred specimens recovered at local sites. Unworked, non-scapula bison bones, however, are very rare at all sites in the La Crosse area, indicating that living bison were uncommon locally. The most likely source of Oneota bison scapulae was the region west of the Mississippi River in Iowa and Minnesota.

This summary does not give the number of recovered bones for each animal species or the number of individual animals, although that information is usually available in the cited reports. There is evidence that many groups deboned large mammals at the kill location, retaining only selected bones to be used as tool stock, or left smaller bones on the hide to aid in carrying the meat/hide bundle back to the camp or village (Perkins and Daly 1968; Skinner 1923:142). Elk and white-tailed deer seem to have been consistently deboned in the field during the later prehistoric period (Theler 1989:223, 1994a:40-41).

Two other types of remains are also omitted from this summary. The first are animal remains occasionally found as possible ritual items placed with human burials. The second are faunal materials that represent long-distance trade, such as marine shell *(Marginella apicina)* beads recovered at the Overhead and Sand Lake sites and a single unworked American alligator *(Alligator mississipiensis)* tooth from the State Road Coulee site (see Anderson et al. 1995).

Pre-European Native American Cultures and Time Units

Four archaeological cultural/time units are used in this summary. They represent a simplified version of the subdivisions of the pre-European human prehistory of the region. The best archaeological evidence indicates that the first people to enter the Upper Mississippi River Valley, the Paleo-Indians, arrived about 12,000 years ago. They were the peoples who hunted mammoths *(Mammuthus)* and mastodon(t) *(Mammut americanum)* in North America. Not included in the present summary are the remains of animals associated with the last Ice Age or Pleistocene period, which ended about 11,000 years ago. At the Boaz mastodon site in Richland County, Wisconsin, mastodon remains appear to be associated with a spear point, suggesting PaleoIndian-mastodon contact (Palmer and Stoltman 1976). Animal remains associated with the early portion of the current postglacial (Holocene) period, but without human association, are not included in the tables. One such early Holocene paleontological site is the Rud Bison site (Theler et al. 1994), which produced several partial skeletons of the extinct bison *(Bison occidentalis)* in Buffalo County, Wisconsin.

Following the Pleistocene, the descendants of the PaleoIndians settled into the region. These Archaic groups followed an annual subsistence cycle of hunting and gathering wild resources. They did not make pottery containers or build earthen mounds

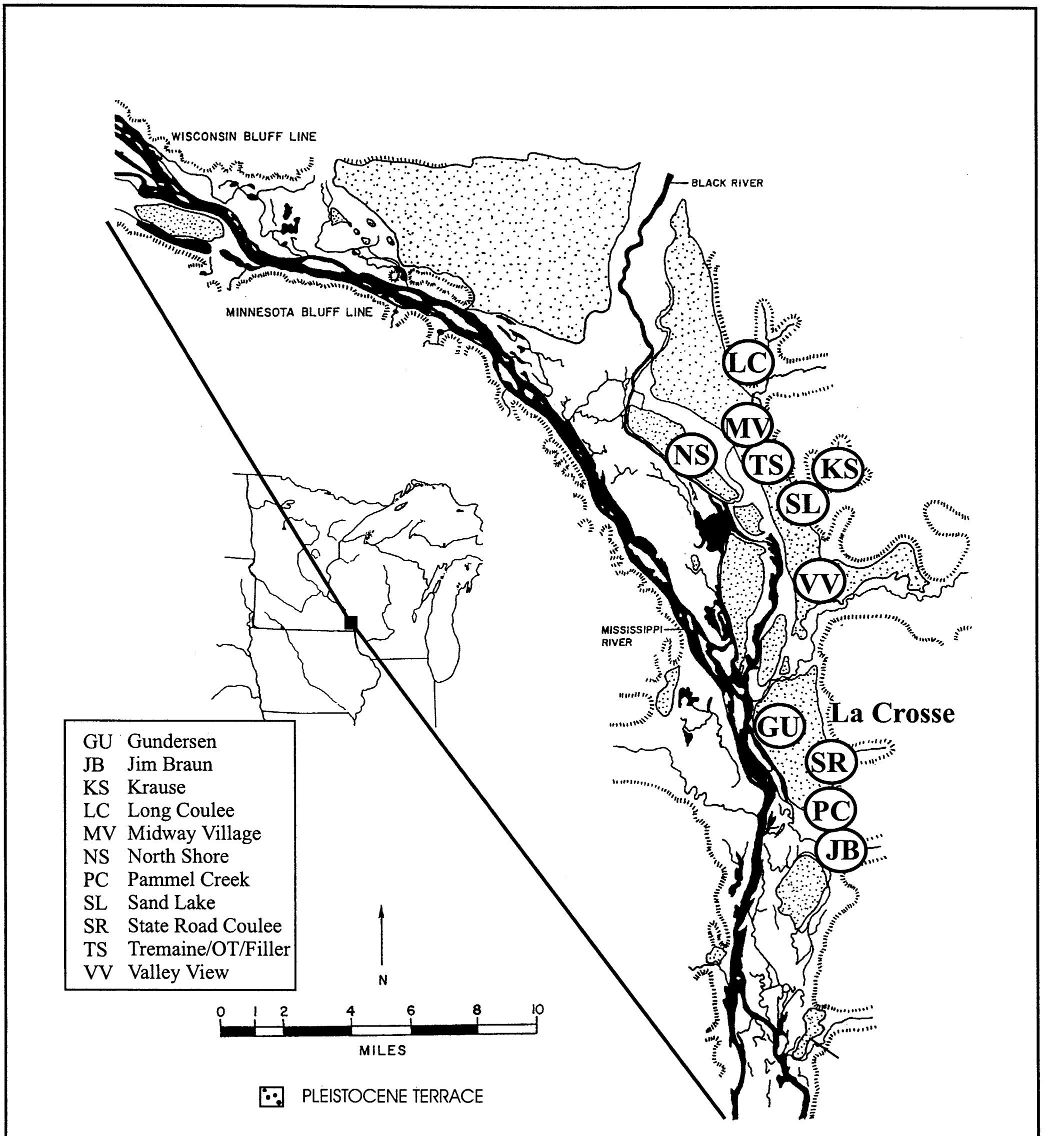

Figure 2. Oneota sites at the La Crosse locality.

to cover their dead. The Archaic period lasted from about 11,000 to 2,000 years ago. The subsequent Woodland peoples (2,000 to 800 years ago) are characterized by the use of pottery vessels and constructed burial mounds. In the later part of the Woodland period, there is evidence for the use of the bow and arrow, the building of effigy mounds, and adaptation to domestic plant cultivation. The final pre-European residents of western Wisconsin, the Oneota, lived in the area between 800 and 400 years ago. These village agriculturalists raised corn, beans, squash, and tobacco. They harvested local game during the summer and seasonally hunted bison and other large game west of the Mississippi River. In early historic times the La Crosse area Oneota are believed to be people known as the Ioway Indians.

Results

Mammals

There are 44 species of mammals represented at the 32 archaeological sites covered in this summary (Table 2). Those interested in the distribution of Late Quaternary mammals recovered from archaeological or paleontological contexts in North America are referred to Faunmap (Faunmap Working Group 1994). The human remains listed in Table 2 do not represent burials, but rather isolated bones or teeth that are occasionally found during excavations of habitation areas.

It is clear that the most economically important animal utilized by pre-European groups was the white-tailed deer *(Odocoileus virginianus).* The remains of this species are especially numerous at Archaic and Woodland fall-winter occupations in western Wisconsin rockshelters. The occupation zones in these rockshelters often contain thousands of deer bones, broken open for extraction of the fat-rich marrow. The fall-winter white-tailed deer provided a perfect package, in both size and quality, of meat, fat, and hide (Gramly 1977). While not nearly as abundant as deer, bones of elk *(Cervus canadensis)* are present at most sites. These bones are usually from the hoof. Presumably, they were left on the hide to help transport the hide/meat bundle, while most of the skeleton was left at the kill location.

The situation for bison *(Bison bison)* is similar to that for elk, though found at fewer sites. The few unmodified bison bones at Oneota sites on the La Crosse terrace are mostly hoof bones (phalanges). Bison remains are almost unknown at sites in Wisconsin's Driftless area, with an exception in the Archaic component at Preston Rockshelter in Grant County. At the Carroll Rock Shelter, a Late Woodland site in Dubuque County, Iowa, a different pattern is represented with bison apparently taken close to the occupation area and the meat with some associated bone returned to the site (Collins et al. 1997).

The remains of black bear *(Ursus americanus)* are widely but thinly represented, particularly at La Crosse area Oneota sites. Most of these remains are mandible/maxilla sections and bones associated with leg extremities (e.g., metacarpals, metatarsals, and phalanges), presumably bones left on the skin. The presence of bear skull parts seems to relate to an interest in acquiring the animals' large canine teeth.

Mustelids, the members of the weasel family, are rare at all sites and often are represented only by skull parts (mandibles or crania). River otter *(Lutra canadensis)* and mink *(Mustela vison)* remains are found at many Oneota sites in the La Crosse area. It is possible that the particular elements represented relate to special or ritual use of these animals (Parmalee 1959b:89, 1963:67, Plate 2; Skinner 1925:150-51, Plates 25-26; 1926:248, Plate 41; Theler 1989, 1994:42-43).

Other mammals of some importance are the muskrat and beaver. The remains of both riparian species were widespread at regional sites. At La Crosse area Oneota sites, beaver are represented largely by skull parts. Numerous lower jaws (mandibles) of beaver have been found with the incisors carefully removed. This pattern is believed to be related to the use of beaver incisors as woodworking tools (Theler 1989, 1994).

In pre-European times, the dog was the only domestic animal in the Upper Mississippi River Valley. Domestic dogs were

Table 2. Mammals.

Common Name	*Scientific Name*	*Oneota*	*Woodland*	*Archaic*
Opossum	*Didelphis virginiana*		QR/PR	
Masked Shrew	*Sorex cinereus*	FV		
Short-tailed Shrew	*Blarina brevicauda*	VV/SR/FV	VR/CR	PR/RR
Prairie Mole	*Scalopus aquaticus*	PC/VV/FV/SR/SL/MV	QR/MS/PR/CR	PR/RR
Big Brown Bat	*Eptesicus fuscus*			RR
Eastern Cottontail	*Sylvilagus floridanus*	VV/SR	QR/VR/PR/DR/ML	PR/RR/DR
Eastern Chipmunk	*Tamias striatus*	VV/MV/FV	QR/VR/MS/PR/DR/MC	CS/PR/RR/DR
Woodchuck	*Marmota monax*	VV/MV	QR/VR/MS/PR/DR/MP/ML	PR/RR/DR
Thirteen-lined Ground Squirrel	*Spermophilus tridecemlineatus*	PC/VV/FV/KS/OT	QR/PR/AM	PR
Gray Squirrel	*Sciurus carolinensis*	VV	VR/MS/PR/DR/ML	PR/RR/DR
Fox Squirrel	*Sciurus niger*	VV		
Red Squirrel	*Tamiasciurus hudsonicus*		QR/AM	PR/RR
Flying Squirrel	*Glaucomys volans*		QR/PR	PR/RR
Plains Pocket Gopher	*Geomys bursarius*	VV/GU/MV/FV/SR/SL/OT/AR	QR/VR/CS	
Beaver	*Castor canadensis*	PC/GU/MV/JB/SR/FV/KS/SL/OT/FS/AR	QR/VR/CS/MS/PR/DR/MP//ML/AM/CR	PR/RR/DR
Deer Mouse	*Peromyscus maniculatus*	PC/KS		
White-footed Mouse	*Peromyscus leucopus*		CS	
Meadow Vole	*Microtus pennsylvanicus*	PC/FV/KS/SL/FS	CS	
Prairie Vole	*Microtus ochrogaster*	KS/SL	CS	CS
Southern Bog Lemming	*Synaptomys cooperi*		CS	RR
Muskrat	*Ondatra zibethicus*	PC/VV/GU/MV/TS/SR/FV/KS/SL/OT/AR/FS	QR/VR/CS/MS/PR/DR/MP/ML/AM	CS/PR/RR/DR
Meadow Jumping Mouse	*Zapus hudsonius*	KS		
Porcupine	*Erethizon dorsatum*	VV	VR	
Domestic Dog	*Canis familiaris*	PC/GU/MV/KS/OT	MS	
Coyote	*Canis latrans*		DR	DR
Wolf	*Canis lupus*	PC	QR/MP	PR/RR/LR
Red Fox	*Vulpes vulpes*		DR/AM	
Grey Fox	*Urocyon cinereoargenteus*		PR/AM	
Black Bear	*Ursus americanus*	PC/VV/GU/MV/JB/TS/FV/SE/KS/SL/AR	DR/ML	LR
Raccoon	*Procyon lotor*	PC/VV/GU/JB/FV/KS/SL/MV	ML/AM/QR/VR/MS/PR/DR/MP/MC	CS/PR/RR/DR
Pine Marten	*Martes americana*	MV		RR
Fisher	*Martes pennanti*		QR/PR/DR	RR/DR
Long-tailed Weasel	*Mustela frenata*		PR	PR/RR

Table 2, continued.

Common Name	*Scientific Name*	*Oneota*	*Woodland*	*Archaic*
Mink	*Mustela vison*	PC/VV/GU/ SR/SL/AR	MS/DR	
Badger	*Taxidea taxus*	VV/FV/SR	QR/MS	
Striped Skunk	*Mephitis mephitis*	OT	QR/PR	PR
River Otter	*Lutra canadensis*	PC/VV/GU/ SR/SL/FS	MS/PR/DR	
Mountain Lion	*Felis concolor*			RR/LR
Bobcat	*Lynx rufus*	GU	MS/AM	RR
American Elk	*Cervus canadensis*	AR/PC/VV/GU/ MV/JB/TS/FV/ SR/KS/SL/OT	JD/BS/VR/CS/ MS/PR/DR/MP/AM	CS/PR/ RR/DR
White-tailed Deer	*Odocoileus virginianus*	OT/FS/AR/PC/ VV/GU/MV/NS/ JB/TS/SR/FV/ KS/SL	MC/LR/ML/AM/ JD/QR/VR/CS/ MS/PR/DR/MP	LR/ML/ CS/PR/ RR/DR
Moose	*Alces alces*	FV		
Bison	*Bison bison*	PC/VV/MV/JB/ SR/KS/OT/AR	CR	PR
Human	*Homo sapiens*	PC/MV/TS/SR/ KS/SL/OT/AR	QR/CS/PR	

associated with Native peoples throughout most of North America over the past 10,000 years. Dogs were important in Native societies as pack animals (Henderson 1994), assistants in the hunt, village alarm systems, disposers of unused food, and sometimes a food resource (Snyder 1991). Dog remains have been found at a number of archaeological sites where they appear to have been used as a food. A complete set of four discarded lower leg extremities (paws) was found adjacent to a refuse pit at the Pammel Creek site (Theler 1989:181, Figure 5.3), and another set was found in pit fill at the Krause site. Two dog skulls were recovered in a refuse-filled pit at the OT site (O'Gorman 1989). Intentional dog burials appear to be rare at Woodland or Oneota sites in the Upper Mississippi River Valley. One dog burial was found in a conical mound at the Raisbeck Mound group in Grant County, Wisconsin, by W. C. McKern in 1932 (Rowe 1956:41).

Birds

In all, 51 species of birds are represented in the 32 faunal assemblages (Table 3). As noted in the Methods and Material section, bones with uncertain identifications were excluded from the table.

The most widely represented bird species is the wild turkey *(Meleagris gallopavo).* In southwestern Wisconsin, turkey remains are represented by a range of skeletal elements. They are fairly abundant at both Archaic and Woodland sites south of a line from Green Bay to Prairie du Chien that marks the species' distribution before European contact (Schorger 1942, 1966: Figure 6). Ten La Crosse area Oneota sites have produced turkey remains. These bones are primarily those from the wing tips (carpometacarpus, phalanges, and digits) that support the stout primary feathers. Primary feathers are the best choice for arrow fletching, according to Schorger (1966:361-62) and Loran Cade, a Wisconsin primitive archery

Table 3. Birds.

Common Name	*Scientific Name*	*Oneota*	*Woodland*	*Archaic*
Common Loon	*Gavia immer*	VV/AR		
Great Egret	*Casmerodius albus*	SL		
American Bittern	*Botaurus lentiginosus*	SR/AR		
Tundra Swan	*Cygnus columbianus*		AM	PR
Trumpeter Swan	*Cygnus buccinator*	MV/SL/AR	AM	
Canada Goose	*Branta canadensis*	PC/VV/MV/SR/ KS/FS/AR	QR/MS/DR/PR/AM	RR
Woodduck	*Aix sponsa*	PC/VV/GU/MV	AM	RR
Green-winged Teal	*Anas crecca*	GU/AR	QR/ML	
Blue-winged Teal	*Anas discors*	MV	MS	
Mallard	*Anas platyrhynchos*	MV/SR	MS/DR/ML/AM	RR
Northern Pintail	*Anas acuta*		AM	PR
Northern Shoveler	*Anas clypeata*	VV		
Gadwall	*Anas strepera*		PR	
Redhead	*Aythya americana*	VV	MS	
Ring-necked Duck	*Aythya collaris*	VV	ML	
Common Goldeneye	*Bucephala clangula*		ML	
Bufflehead	*Bucephala albeola*	GU/AR	CR	
Common Merganser	*Mergus merganser*	PC	MS/AM/CR	
Hooded Merganser	*Lophodytes cucullatus*	VV/AR		
Turkey Vulture	*Cathartes aura*			RR
Northern Harrier	*Circus cyaneus*	SL		
American Kestrel	*Falco sparverius*			PR
Merlin	*Falco columbarius*	VV		
Peregrine Falcon	*Falco peregrinus*	FS		
Red-tailed Hawk	*Buteo jamaicensis*	AR	PR	RR/PR
Bald Eagle	*Haliaeetus leucocephalus*		VR	
Red-shouldered Hawk	*Buteo lineatus*		DR	
Ruffed Grouse	*Bonasa umbellus*		DR/ML/PR	RR/DR/PR
Greater Prairie Chicken	*Tympanuchus cupido*	MV	PR	PR
Wild Turkey	*Meleagris gallopavo*	PC/VV/GU/MV/ TS/SR/FV/SL/ OT/FS	VR/MS/DR/ML/ PR/AM/CR	PR/CS/ RR/DR/LR
Virginia Rail	*Rallus limicola*	AR		
Common Moorhen	*Gullinula chloropus*	AR		
Sora	*Porzana carolina*	VV/GU/MV		RR
American Coot	*Fulica americana*	GU/TS/SR/ KS/AR	PR/AM	RR
Sandhill Crane	*Grus canadensis*	PC/VV/SR/FS/AR		
Upland Sandpiper	*Bartramia longicauda*	VV		
Passenger Pigeon	*Ectopistes migratorius*	VV/FV/SR/MV	VR/DR/PR	RR/PR
Sharp-tailed Grouse	*Tympanuchus phasianellus*		QR/MS/DR/ML/PR	RR/DR/PR
Eastern Screech-owl	*Otus asio*	VV	PR	RR
Great Horned Owl	*Bubo virginianus*	VV/SR		

Table 3, continued.

Common Name	*Scientific Name*	*Oneota*	*Woodland*	*Archaic*
Barred Owl	*Strix varia*	VV		RR
Belted Kingfisher	*Ceryle alcyon*	VV		
Red-headed Woodpecker	*Melanerpes erythrocephalus*	PC/SR		RR
Northern Flicker	*Colaptes auratus*	VV/GU	PR	
Blue Jay	*Cyanocitta cristata*	AR		RR
American Crow	*Corvus brachyrhynchos*	VV	AM	RR
Common Raven	*Corvus corax*	VV		
Red-bellied Woodpecker	*Melanerpes carolinus*		VR	
American Robin	*Turdus migratorius*		PR	PR
Red-winged Blackbird	*Agelaius phoeniceus*	PC/GU/MV/TS/ FV/KS/SL	VR	RR
Northern Cardinal	*Cardinalis cardinalis*			RR

enthusiast (personal communication, 1993). This distribution of bones seems to indicate that turkey wing tips, with the primary feathers attached, were saved during seasonal travel or hunts or perhaps traded into the La Crosse area during the Oneota occupation.

Waterfowl are present at many sites, with Canada geese and dabbling ducks being most common. Canada geese are the most widespread, with both bones and eggshell having been recovered. According to an analysis of bone size and eggshell structure (Speth 1987), the Canada geese harvested in the La Crosse area were the "giant race" *(Branta canadensis maxima).* Mallards *(Anas platyrhynchos)* and wood ducks *(Aix sponsa)* have been found at several sites. The presence of eggshell and medullary bone (Rick 1975) in some elements indicates spring harvest of waterfowl eggs and nesting birds. The trumpeter swan *(Cygnus buccinator)* is represented at three La Crosse area Oneota sites.

A wide range of raptorial birds (e.g., hawks, owls) as well as crows and ravens show up in small numbers at archaeological sites. It is well known that Native American peoples often assigned ritual significance to certain bird species (Skinner 1923, 1925:89; Wilson 1928). Although not included in the tables, two burial sites of the Upper Mississippi River Valley contain interesting bird remains. A "headdress" found with a human burial in a Sauk County, Wisconsin, mound included the remains of two bird skulls and portions of four wing bones from the common raven (*Corvus corax,* see Wittry 1962). At the Flynn site, a protohistoric Oneota cemetery uncovered during road construction in Allamakee County, Iowa, a raven skull was also associated with a human burial (Bray 1961).

Smaller species of perching birds (Passeriforms) are rare or absent in the faunal assemblages from sites of all time periods. The single exception is the red-winged blackbird *(Agelaius phoeniceus),* represented at seven Oneota sites in the La Crosse area. The bones of this species are sometimes found charred, indicating their probable use as food. Red-winged blackbirds are a noted agricultural pest and would have been a common summer resident near Oneota villages and cornfields.

Fishes

There are 35 species of fish represented at the 32 archaeological sites (Table 4). The most widespread species is the freshwater drum *(Aplodinotus grunniens),* and the most common fish are the catfishes, particularly the black bullhead *(Ictalurus melas).* Many fish species, including northern pike *(Esox lucius)* and members of the sucker family (Catostomidae), were taken during spawning periods. Others (gar, bowfin, and bullheads) were taken during the summer months by seining or trapping in shallow backwaters along the Mississippi River. The thick, durable rhombic scales of gar (Lepisosteidae) are present at most sites along the Mississippi River, but well-preserved skull bones are necessary to separate the longnose gar *(Lepisosteus osseus)* from the shortnose gar *(Lepisosteus platostomus).* The exterior surface of gar scales often exhibit evidence of being burned or scorched, an indication that entire fish may have been roasted in their armor-like scale covering.

Exceptionally large flathead catfish *(Pylodictis olivaris)* of 50 pounds or more and large channel catfish *(Ictalurus punctatus)* are present at many Woodland and Oneota sites adjacent to the Mississippi River. These catfish were probably harvested from their nest sites during the mid-summer. There is no indication based on estimated size or species distribution that gill nets were used or swift waters fished. For example, juvenile individuals of the flathead and channel catfish that are typically associated with relatively swift water are almost unknown from the late prehistoric sites of the Upper Mississippi River.

Amphibians

The bones of frogs, toads, or salamanders are occasionally found by use of fine-screen recovery techniques at archaeological sites. In most cases these remains appear to be part of the natural rain of small-scale fauna preserved at some sites, rather than a regular part of the human diet. Four amphibian species are represented at the sites considered here (Table 5).

Two occurrences of amphibians are worthy of mention. The skeletal remains of nine leopard frogs *(Rana pipiens)* were found in the bottom of a refuse-filled pit at the Tremaine site, an Oneota site on the La Crosse terrace. It is unclear whether these individuals represent a natural inclusion or were brought to the site as food items. The rock fill at the base of the pit lay directly on the bones of these frogs.

Also of interest are the skeletal remains of at least three tiger salamanders *(Ambystoma tigrinum)* recovered from pit fill at the Krause site, an Oneota habitation area on the La Crosse terrace. The zone of pit fill that contained the salamander bones also produced over 14,000 bones representing more than 400 individual fish (mostly small black bullheads) of 16 species. Thrown into this mix were crawfish remains, the bones of a coot *(Fulica americana),* and the paws of a dog. This deposit is thought to largely represent a seining episode in a backwater habitat. The occurrence of the tiger salamander is of interest given the historic absence of the species in the unglaciated Driftless Area of southwestern Wisconsin, except for one historic report (Vogt 1981:45).

Reptiles

The remains of turtles occur at many of the 32 archaeological sites considered, with nine species represented (Table 5). They are typically represented by segments of the upper and lower shells (the carapace and plastron). Turtle remains appear most frequently at the open-air Woodland and Oneota sites found adjacent to the Mississippi River and its wetlands.

Table 4. Fishes.

Common Name	*Scientific Name*	*Oneota*	*Woodland*	*Archaic*
Lake Sturgeon	*Acipenser fulvescens*	PC/VV/MV/FS		
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*	PC		
Paddlefish	*Polyodon spathula*	SL		
Shortnose Gar	*Lepisosteus platostomus*	PC/MV		
Longnose Gar	*Lepisosteus osseus*	PC/MV	MS	
Bowfin	*Amia calva*	PC/VV/GU/MV/ NS/JB/TS/SR/ KS/SL/OT/FS	QR/MS/MP/MC	CS
Northern Pike	*Esox lucius*	PC/GU/SR/KS/ OT/FS		
Bigmouth Buffalo	*Ictiobus cyprinellus*	PC/VV/SR		
Smallmouth Buffalo	*Ictiobus bubalus*	VV/SL	MC	
Quillback	*Carpiodes cyprinus*	VV/OT		
River Carpsucker	*Carpiodes carpio*	VV		
Black Redhorse	*Moxostoma duquesnei*	PC/KS		
Golden Redhorse	*Moxostoma erythrurum*	PC/VV/KS/SL	VR/MC	
Silver Redhorse	*Moxostoma anisurum*	PC		
Shorthead Redhorse	*Moxostoma macrolepidotum*	PC/VV/MV/ TS/FV/SL/FS	QR/VR	
River Redhorse	*Moxostoma carinatum*	VV/KS		
Northern Hog Sucker	*Hypentelium nigricans*	OT		
White Sucker	*Catostomus commersoni*	PC/VV/FV/SR/OT		
Black Bullhead	*Ictalurus melas*	PC/VV/GU/MV/ NS/TS/KS/SL/ OT/FS	PR	
Brown Bullhead	*Ictalurus nebulosus*	PC/VV/MV/NS/ TS/KS/SL/OT		
Yellow Bullhead	*Ictalurus natalis*	PC/VV/MV/NS/ TS/KS/SL/OT/FS		
Channel Catfish	*Ictalurus punctatus*	PC/VV/GU/MV/ JB/TS/FV/SR/ KS/SL/OT/FS	VR/PR/MP	
Tadpole Madtom	*Noturus gyrinus*	PC/KS		
Flathead Catfish	*Pylodictis olivaris*	PC/VV/MV/JB/ SR/SL/OT	MP/MC	
Smallmouth Bass	*Micropterus dolomieui*	VV/GU		
Largemouth Bass	*Micropterus salmoides*	PC/MV/RB/SL	MP/MC	
Green Sunfish	*Lepomis cyanellus*	VV/GU		
Pumpkinseed	*Lepomis gibbosus*	PC/VV/KS/SL		
Bluegill	*Lepomis macrochirus*	VV/MV/KS		
Rock Bass	*Ambloplites rupestris*	VV/MV/FV/ST		
White Crappie	*Pomoxis annularis*	VV/KS		
Black Crappie	*Pomoxis nigromaculatus*	PC/VV/MV		
Walleye	*Stizostedion vitreum*	PC/VV/GU/KS/FS		
Yellow Perch	*Perca flavescens*	PC/VV/GU/MV/ FV/SR/SL	QR/MS	
Freshwater Drum	*Aplodinotus grunniens*	PC/VV/GU/MV/ NS/JB/TS/SR/FV/ KS/SL/OT/FS/JD	QR/MP/MC	CS

Table 5. Amphibians, reptiles and crawfish.

Common Name	*Scientific Name*	*Oneota*	*Woodland*	*Archaic*
Amphibians				
Eastern Tiger Salamander	*Ambystoma tigrinum*	KS		
American Toad	*Bufo americanus*	SR/KS		
Northern Leopard Frog	*Rana pipiens*	MV/TS/SR/KS	VR	
Green Frog	*Rana clamitans*	MV		
Reptiles				
Snapping Turtle	*Chelydra serpentina*	AR/JD/PC/VV/ GU/MV/NS/SR/ KS/SL/OT/FS	QR/VR/MS/ DR/AM	RR/DR
Stinkpot Turtle	*Sternotherus odoratus*		MP	
Wood Turtle	*Clemmys insculpta*		VR	
Blanding's Turtle	*Emydoidea blandingi*	TS/SR/AR	MS/DR/MP	RR/DR
Ornate Box Turtle	*Terrapene ornata*		PR/DR/AM	RR/DR
Painted Turtle	*Chrysemys picta*	PC/VV/GU/MV/ JB/SR/OT/AR	QR/VR/MS/ PR/AM	RR
Map Turtle	*Graptemys geographica*	PC/VV/MV/ SR/OT	QR	
False Map Turtle	*Graptemys pseudogeographica*	PC/GU		
Softshell Turtle	*Trionyx*	JD/PC/GU/MV/ JB/TS/SR/KS/ SL/OT/FS	QR/MS/DR/ MP/AM	
Bullsnake	*Pituophis melanoleucus*	PC/GU/MV	QR/VR	
Garter Snake	*Thamnophis radix*	KS		
Timber Rattlesnake	*Crotalus horridus*		QR/VR	
Eastern Hognose Snake	*Heterodon platyrhinos*	SR		
Fox Snake	*Elaphe vulpina*	SR	VR	
Crayfish				
Papershell Crayfish	*Orconectes immunis*	PC		
Northern Crayfish	*Orconectes virilis*	PC		
Devil Crayfish	*Cambarus diogenes*	PC		
White River Crayfish	*Procambarus acutus*	KS		

The most widespread turtle remains are those of the snapping turtle *(Chelydra serpentina)*. Although the remains are present on many sites, only one or two individuals are represented in most of the site assemblages. Scorching on the exterior of many shell fragments indicates that when captured (perhaps during spring egg-laying on dry land), turtles were cooked in their shell. The softshell turtle *(Trionyx)* is also widespread, but few individuals are represented. The softshell turtle is easy to identify to the genus level by the distinctly sculptured exterior surface of its shell, but it is difficult to distinguish between the two species (*Trionyx spiniferus* and *Trionyx muticus*) found in the

Upper Mississippi Valley. Therefore, the tables include this common taxon only at the genus level. The ornate box turtle *(Terrapene ornata)* has been recovered at archaeological sites (e.g., Preston Rockshelter in Grant County) adjacent to this species' historically known range on the sand terraces along the lower Wisconsin River (Vogt 1981:99-100). The box turtle is absent from the archaeological sites at the Prairie du Chien and La Crosse terraces. A variety of other turtles show up infrequently. The Blanding's turtle *(Emydoidea blandingi)* has been found at a few sites, and its deeply cupped upper shell was sometimes modified for use as a container.

The vertebrae of five species of snakes have been recovered. Snakes are believed to be part of a natural accumulation of smaller vertebrates that can become incorporated into archaeological site deposits. There is no indication that snakes were harvested for any reason by Native Americans of the Upper Mississippi River Valley. The late prehistoric Oneota sites of the La Crosse terrace do show several occurrences of the bullsnake *(Pituophis melanoleucus)*. The bullsnake's presence is not surprising given that many La Crosse terrace Oneota sites contain bones and burrows of the Plains pocket gopher *(Geomys bursarius)*, a common prey species of the bullsnake.

Crayfish

Crayfish remains have been recovered from refuse-filled pits at the Krause and Pammel Creek sites, both Oneota villages (Table 5). At Pammel Creek, hundreds of burned crawfish carapace (shell) fragments occurred in ash zones that also produced red-winged blackbird bones and carbonized wild rice *(Zizania aquatica)* grains (see Arzigian et al. 1989). These three food items may have been harvested during the mid-summer period at a single floodplain habitat.

Freshwater Mussels

There are 39 species of freshwater mussels represented at the 32 archaeological sites (Table 6). Many Native peoples of the Upper Mississippi River Valley harvested large numbers of freshwater mussels as a seasonal food source. One Woodland period shell midden near Prairie du Chien, Wisconsin, is estimated to contain more than a million shells, the result of many seasons of use (Theler 1987a). Although mussels were used primarily as food, their shells were sometimes converted into tools (Theler 1991, 1994) and crushed into the tempering agent used in Oneota shell-tempered pottery (Theler 1990). In a few cases, attractive shells such as the elephant-ear *(Elliptio crassidens)* were buried with the dead (see Mead 1979:164).

While the shells of large, heavy mussels such as the washboard *(Megalonaias nervosa)* were sometimes traded or carried over some distance (Theler 1991:324-25), most shells were evidently discarded adjacent to the body of water in which they were harvested. These shells accumulated to form middens or were used as fill for storage pits that had fallen into disuse. The archaeological record of freshwater mussel distribution provides a unique view of the geographic distribution of these animals prior to European disruption of the native aquatic ecosystem. A case in point is the assemblage of mussels from the Brogley Rockshelter, located along the Platte River in Grant County, Wisconsin. Brogley Rockshelter produced thousands of individual shells of more than 20 mussel species (Theler 1987b). This site is an important example because it demonstrates the rich freshwater mussel fauna that occupied the interior small streams of western Wisconsin's Driftless Area prior to European settlement. The two most abundant species at Brogley were the spike *(Elliptio*

Table 6. Freshwater mussels.

Common Name	*Scientific Name*	*Oneota*	*Woodland*	*Archaic*
Cylindrical Papershell	*Anodontoides ferussacianus*		QR/PR	PR/BR
Giant Floater	*Anodonta grandis*	PC/VV/GU/MV/NS/SR/SL/FS	QR/VR/PR/BR	PR/BR
Squawfoot	*Strophitus undulatus*	VV/SR/FV	QR/VR/DR/MP/BR/BS	BR
Elktoe	*Alasmidonta marginata*	PC/GU/MV/AR	VR/MS/BR/JD	BR
Slippershell Mussel	*Alasmidonta viridis*		BR	BR
Rock-Pocketbook	*Arcidens confragosus*	NS	MC	
White Heelsplitter	*Lasmigona complanata*	PC/VV/GU/SR/SL/AR	BS/QR/PR/DR/MP/AM/BR/JD	
Fluted-Shell	*Lasmigona costata*	GU/AR	QR/VR/MS/DR/MP/BR/BS	BR
Creek Heelsplitter	*Lasmigona compressa*	FV	BR	BR
Washboard	*Megalonaias nervosa*	VV	MS/BR/JD	BR
Pistolgrip	*Tritogonia verrucosa*	PC/VV/GU/MV/SR/SL/FS	MS/SF/MP/MC/JD/BS	
Maple Leaf	*Quadrula quadrula*	PC/VV/GU/MV/NS/LC	MS/MP/MC/JD/BS	
Winged Maple Leaf	*Quadrula fragosa*	GU/MV	MP/MC/BS	
Monkeyface	*Quadrula metanevra*	PC/VV/GU/NS/JB/LC/SR/FS/AR	MS/SF/MC/AM/JD/CR	RR
Wartyback	*Quadrula nodulata*		MP/MC/JD	
Pimpleback	*Quadrula pustulosa pustulosa*	PC/VV/GU/MV/NS/JB/LC/SR/SL/FS	MS/SF/MP/MC/AM/JD/BS/CR	
Threeridge	*Amblema plicata*	PC/VV/GU/MV/NS/JB/SR/LC/SR/SL/FS/AR	QR/MS/SF/PR/DR/MP/MC/AM/BR/JD/BS	DR/BR
Ebonyshell	*Fusconaia ebena*	PC/VV/GU/MV/NS/JB/SR/LC/SL/FS	QR/MS/SF/MD/MC/AM/BR/JD/CR	
Wabash Pigtoe	*Fusconaia flava*	PC/VV/GU/MV/NS/JB/SR/LC/SL/FS/AR	MS/SF/MP/MC/AM/BR/JD/BS	BR
Purple Wartyback	*Cyclonaias tuberculata*	JB/LC	SF/DR/MP/MC/AM/JD	
Sheepnose	*Plethobasus cyphyus*	VV/GU/NS/LC/SR	MS/SF/DR/MP/MC/AM/JD	RR
Round Pigtoe	*Pleurobema coccineum*	PC//VV/GU/MV/NS/JB/LC/SR/FS/AR	MS/SF/MP/MC/JD/BS	
Elephant-ear	*Elliptio crassidens*		QR/SF/MP/MC/AM/JD/CR	
Spike	*Ellipio dilatata*	PC/GU/JB/AR	QR/VR/MS/PR/DR/MP/MC/AM/BR/JD/BS	BR/PR/RR/DR
Threehorn Wartyback	*Obliquaria reflexa*	PC/VV/MV/NS/SL/FS	SF/MP/MC/JD	
Mucket	*Actinonaias ligamentina*	PC/VV/MV/JB/SR/FS	QR/MS/SF/DR/MP/MC/AM/BR/JD/CR	RR/DR/BR

Table 6, continued.

Common Name	*Scientific Name*	*Oneota*	*Woodland*	*Archaic*
Butterfly	*Ellipsaria lineolata*	PC/VV/GU/MV/ NS	SF/MP/MC/AM/ JD/CR	
Hickorynut	*Obovaria olivaria*	PC/VV/GU/MV/ NS/LC/SR	MS/SF/MP/MC/ AM/JD	
Deertoe	*Truncilla truncata*	VV/MV/NS/JB/LC	MP/MC/JD	
Fragile Papershell	*Leptodea fragilis*	PC/VV/GU/MV/NS		
Pink Heelsplitter	*Potamilus alatus*	PC/VV/GU/MV/ SR/SL/FS/AR	QR/MS/PR/DR/ BR/JD/BS	PR/DR/BR
Pink Papershell	*Potamilus ohiensis*	VV	MP	
Black Sandshell	*Ligumia recta*	PC/SL/AR	QR/MS/MP/MC/ BR/JD/BS/CR	RR
Ellipse	*Venustaconcha ellipsiformis*		VR/BR	BR
Rainbow	*Villosa iris*			BR
Yellow Sandshell	*Lampsilis teres*	FS	MS/SF/MC/AM	
Fatmucket	*Lampsilis siliquoidea*	PC/VV/GU/MV/ NS/SR/SL/AR	QR/VR/MS/SF/ PR/DR/MP/BR/BS	PR/RR/BR
Higgins Eye	*Lampsilis higginsi*	VV/LC	SF/MP/MC	
Plain Pocketbook	*Lampsilis cardium*	PC/VV/GU/MV/ SR	QR/MS/SF/PR/ DR/MP/MR/AM/ BR/JD/BS	PR/RR/ DR/BR

dilatata) and the ellipse *(Venustaconcha ellipsiformis).* These species, along with an array of other small-stream mussel taxa (e.g., *Alasmidonta viridis, Lasmigona compressa,* and *Villosa iris iris*) are unknown in the region today and illustrate the importance of the archaeological record for producing well-dated assemblages to aid in an accurate biogeography.

Summary and Conclusions

The pre-European peoples of western Wisconsin occupied a region rich in animal resources. These people followed an annual round to harvest subsistence resources. This round involved a schedule of movement to place people at the best location during the season most advantageous for taking favored plants and animals. By 7000 years ago, Archaic peoples of the region harvested deer during the fall and winter as a major food resource along with many other animal species. The spring-summer resource base of Archaic peoples is not known.

During Woodland times, human groups were engaged in an annual fall-winter harvest of deer and elk as their primary source of meat and skins for leather. Cool season camps were generally positioned in the game rich valleys of the dissected uplands, often many miles from larger river valleys. The largest number of deer seem to have been taken in the fall of the year when these animals are in prime condition. Animal bones were broken open at these fall-winter camps in a process to extract the nutrient- and fat-rich marrow. This marrow was perhaps mixed with dried (jerked) meat and sometimes berries to produce a sausage-type product known in the early historic period as pemmican, which could be kept for a year or more and often served as a winter food resource.

During the summer months, many Woodland groups were concentrated along the margins of larger waterways to harvest fish, freshwater mussels, turtles, waterfowl, and riparian mammals. At many locations summer camps were strategically positioned near beds of mussels and floodplain lakes seasonally replenished with fish. In the mid- to late summer as water levels dropped, nets were apparently be used to harvest fish. In addition to netting in backwaters, fish appear to have been taken while spawning in the spring and early summer months.

It is not until the end of the Late Woodland period at about A.D. 900-1000 that the peoples of western Wisconsin become involved in horticulture by tending small garden plots planted in corn. The adoption of gardening did not occur until the seasonal round of wild food harvest became difficult under the stress of increased population density. This prevented effective cool season movement as the dissected uplands became occupied by some Woodland peoples on a year-round basis.

At the end of prehistory we see the development of the Oneota, who represent a distinct cultural tradition. The Oneota were the first to practice corn agriculture using field systems, rather than the hypothesized Woodland garden plots. In addition to cultivated plants, the Oneota made extensive use of fish, mussels, waterfowl, and mammals during their summer residence at farming villages. During the cool season, most of the Oneota along the Mississippi are believed to have traveled west to hunt bison, deer, and elk, as well as trade with neighboring peoples.

Domestic dogs were kept by the Archaic, Woodland, and Oneota peoples of Wisconsin. Dogs were the only domestic animal found in pre-European Wisconsin. They served many functions in these Native American societies that included carrying burdens during annual movements and acting as an alarm system when intruders approached encampments. Dogs also ate animal and vegetable products that were not eaten by people. In times of special need, or for certain ceremonies, dog would be eaten. Dogs served as storage on-the-paw to convert and store protein until needed by humans.

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