TRANSACTIONS

of the Wisconsin Academy of Sciences, Arts and Letters

Volume 84 • 1996

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

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

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Contents

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From the editor

"All the world's a stage." Among the annual highlights of summer in Wisconsin for my wife Barbara and me is our weekend of drama at the Wisconsin Shakespeare Festival (WSF) in the Center for the Arts on the campus of the University of Wisconsin Platteville. This year's 20th Anniversary Season featured a marvelous trio of plays in repertoire: *Macbeth, Twelfth Night,* and *Taming of the Shrew.* As always, the Festival's productions were marked by energetic acting, fresh interpretations of character, imaginative staging, and stunning costuming. In fact, as a special anniversary attraction, the Henry Nohr Gallery in the adjacent UW Platteville Student Center featured an eye-pleasing exhibition of selected costume designs by Wendy Collins, who has served as resident costume designer for the WSF since its inception.

"All the world's a stage." Our yearly pilgrimage to Platteville delights us, moreover, nearly as much for the beautiful drive to and from Oshkosh, the interesting attractions in town and country along the way, and the renewal of friendly ties with the hosts at our favorite bed and breakfast, as for the actual hours spent enjoying Shakespeare's incomparable art. The landscape and people of Wisconsin all seem to be staging a marvelous event for us, always in full costume. From the green farmlands in the glaciated terrain between Oshkosh and Madison to the urban scurry around the Beltway and the sights and smells of Middle Eastern dining at a downtown Lebanese restaurant, from the rainbow explosion of wildflowers along state highway 151 between Verona and Mt. Horeb to the Cornish ambience of Mineral Point, from the breathtaking roller-coaster vistas of southwestern Wisconsin's driftless zone to the many colors of Platteville itself bustling with visitors come for Shakespeare, for the art fair in the square, and for the spectacle of the Chicago Bears football summer training camp on the University campus—what a marvelous procession of scenes and scenery!

"All the world's a stage." Playwrights and their plays are not without their critics, whose insights add to our appreciation of the drama. In this issue of *Transactions* we offer

you, our readers, several scholarly analyses of portions of the ever-unfolding play of life in Wisconsin.

As is often the case on our pages, several of our contributors offer studies of the flora and fauna associated with Wisconsin's lakes, streams, and wetlands.

Terry Balding and **Nancy Balding** publish the results of their 1989 to 1994 summer surveys of bivalve mollusks along some 120 miles of the Upper Chippewa River from Eau Claire north to the Chippewa flowage at Winter Dam.

William Hilsenhoff reports on some significant changes in the insect fauna of Otter Creek, which flows south out of the Baraboo Hills in Sauk County, before and after a catastrophic flood in Baxter's Hollow in 1993.

In a complementary study, **Richard Lillie** and **Rebecca Isenring** present the findings of an April 1992 survey of the aquatic insect communities of 24 streams, including Otter Creek, that drain the Baraboo Range.

Fish Lake in nearby Dane County, notes **Richard Lillie** in a second article, was the site of annual surveys from 1991 to 1994 that yielded an unusual discovery: an aquatic weevil may deserve credit for a major decline in Eurasian watermilfoil, which has been a nuisance in the lake for some two decades.

James Evrard teams up with **Richard Lillie** to offer readers an exhaustive biological inventory of the flora and fauna in the waterfowl production areas (wetlands and adjacent grassy uplands) of northern St. Croix and southern Polk counties in northwestern Wisconsin along the St. Croix River and the Minnesota border. The inventory represents the results of 10 years of field observation and documentary reports by Evrard, Lillie, and others from 1982 to 1991.

From Green Lake County comes an ambitious inventory of another sort. **Thomas Eddy** catalogues the non-cultivated plants that grow or have grown in the county, mainly on the basis of specimens collected from 1979 to 1995 and now housed in the University of Wisconsin Oshkosh herbarium. Like several of the studies mentioned above, this work may well serve as a baseline reference for future researchers.

Finally, we are pleased to feature three articles that afford some scenes of Wisconsin's people from the end of the nineteenth through the first half of our twentieth century.

Susan Talbot-Stanaway takes us to the Green Bay area for a look at how popular photography, from about 1890 to 1920, recorded folks enjoying their favorite pastimes in the outdoors, which usually served as little more than a contrived scenic backdrop for the poses of these local residents at leisure.

As **Mark Davis** reminds us, during these same years when northeastern Wisconsinites were first experimenting with family photographs among the trees, farmers and would-be farmers in Vilas and Oneida Counties were trying to get rid of the trees—or, at least, the stumps! The great land-clearing program of 1900 to 1925, however, ultimately gave way to efforts to rebuild the forest and renew the natural heritage of the northern lakes country of Wisconsin.

Finally, **Paul Wozniak** chronicles a quarter of a century (1927 to 1949) of early anti-pollution efforts on the Lower Fox and East Rivers in northeastern Wisconsin. Lawyers, politicians, journalists, government, business, and conservation organizations all entered the fray that helped raise public awareness and advance the national political agenda about issues of water quality.

"All the world's a stage." Applause, applause for all who contributed articles to this 1996 *Transactions,* thereby helping to shine a spotlight on significant features of Wisconsin from the 1890s to the 1990s, from one end of the state to the other, and from its natural to its human heritage. Applause also for the many reviewers, for managing editor Patricia Duyfhuizen, and for editorial staff and assistants. Their tireless efforts behind the scenes helped enormously towards the production of this issue.

Bill Urbrock

Editor's Preview of Coming Attractions

Look for a special issue of *Transactions* in 1997 devoted entirely to original short fiction by Wisconsin writers. Meanwhile, we warmly invite submission of the usual scholarly manuscripts for consideration for 1998.

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.

Terry and Nancy Balding

A qualitative survey of bivalve mollusks of the Chippewa River, Wisconsin: From Eau Claire, Wisconsin to the Chippewa Flowage

Abstract *During the summers of 1989–1994 we collected 10,020 shells from an approximately 196 km stretch of the Chippewa River between Eau Claire, Wisconsin, and the Chippewa Flowage near Winter, Wisconsin. Eighteen species were identified, including* Cumberlandia monodonta, Plethobasus cyphyus, *and* Cyclonaias tuberculata, *which are listed as Wisconsin endangered species.* Actinonaias ligamentina *and* Elliptio dilantata *were co-dominants. Comparisons are made between the lower and upper Chippewa River, the lower having greater species richness, larger-sized shells, and less abundance. Unionid abundance and species richness were both positively related to the length of the riverine reach in the upper Chippewa River.*

Bivalve mollusks are sometimes called clams, freshwater mussels, or even naiads; in this paper they are referred to as unionids because all specimens collected, with the exception of one Margaritiferidae, belong to the family Unionidae. Unionids are filter feeders, long lived, and relatively immobile; therefore, they are good ecological indicators of stream quality. The objective of this study was to provide baseline data so that future studies can document changes in unionid abundance, distribution, or species richness caused by disturbances such as bridge and dam construction, mining, pollutants, and the impact of the impending zebra mussel (*Dreissena polymorpha*) invasion.

In earlier Wisconsin studies Chadwick (1905, 1906*a*, and 1906*b*) conducted unionid surveys primarily in the southeast. Baker (1928) was more statewide in scope, but cited only a few species found specifically in the Chippewa River. Morrison (1932) and Flowers (1975) apparently did not collect from the Chippewa River, although they did collect from tributaries of the Chippewa. Mathiak (1979) completed a survey of the streams of Wisconsin, but only collected from six sites on the Chippewa River.

Balding (1992) arbitrarily divided the Chippewa River into three study areas: (1) the lower main stem, from the mouth of the Chippewa with the Mississippi River to the first dam in Eau Claire, Wisconsin; (2) the upper main stem from the Eau Claire Dam to the Winter Dam, which forms the Chippewa Flowage; and (3) the east and west forks to their source. An intensive qualitative survey was completed on the lower Chippewa River (Balding 1992). In that study 26 species were recorded, four of which are on the Wisconsin endangered and threatened species list. Most of these species had not been previously reported for the Chippewa.

The current study of the Chippewa River surveys the second study area, the upper main stem. We began this qualitative bivalve mollusk survey of the Chippewa River in 1989 and ended in 1994. Rather than using scientific names suggested by Turgeon et al. (1988), we used scientific names consistent with our earlier study and according to how the voucher specimens were catalogued by Dr. David Stansbery of the Ohio State University Museum of Biological Diversity.

The study area was an approximately 196 km (121.8 mile) stretch of the Chippewa River in northwest Wisconsin, where eight hydroelectric power dams divide the river into seven reaches (Figure 1, Table 1). In 1993 the farthest downstream gauging station at Chippewa Falls, Wisconsin, recorded a mean annual discharge of 171.4 cubic meters per second (cms), while the discharge recorded at the farthest dam upstream was 24.3 cms (Holmstrom et al. 1993). The dam with the lowest operating head was approximately 7 m. Most of the dams are located on granite or metamorphic bedrock, with very large boulders nearby. Downstream from the dams, the boulders become smaller, and eventually the river becomes more riverine, with patches of sand and gravel between and below smaller glacial rocks; some river reaches are all sand. Riverine areas typically had riffles, runs, and pools, usually not exceeding 2 m in depth. Sometimes the distance between dams does not allow a particular reach of river to become riverine before becoming impounded from the downstream dam (Table 1).

Table 1. Riverine and impounded segments of each of the seven reaches of the study area downstream to upstream.

Reach		*Riverine (km)*	*Impounded (km)*
1.	Eau Claire Dam – Chippewa Falls Dam	9.3	14.8
2.	Chippewa Falls Dam – Wissota Dam	0.5	3.7
3.	Wissota Dam – Jim Falls Dam	0.8	22.1
4.	Jim Falls Dam – Cornell Dam	2.4	15.0
5.	Cornell Dam – Holcombe Dam	0.0	9.3
6.	Holcombe Dam – Radisson Dam	78.1	17.4
7.	Radisson Dam – Winter Dam	18.2	4.5
	Total	109.3	86.8

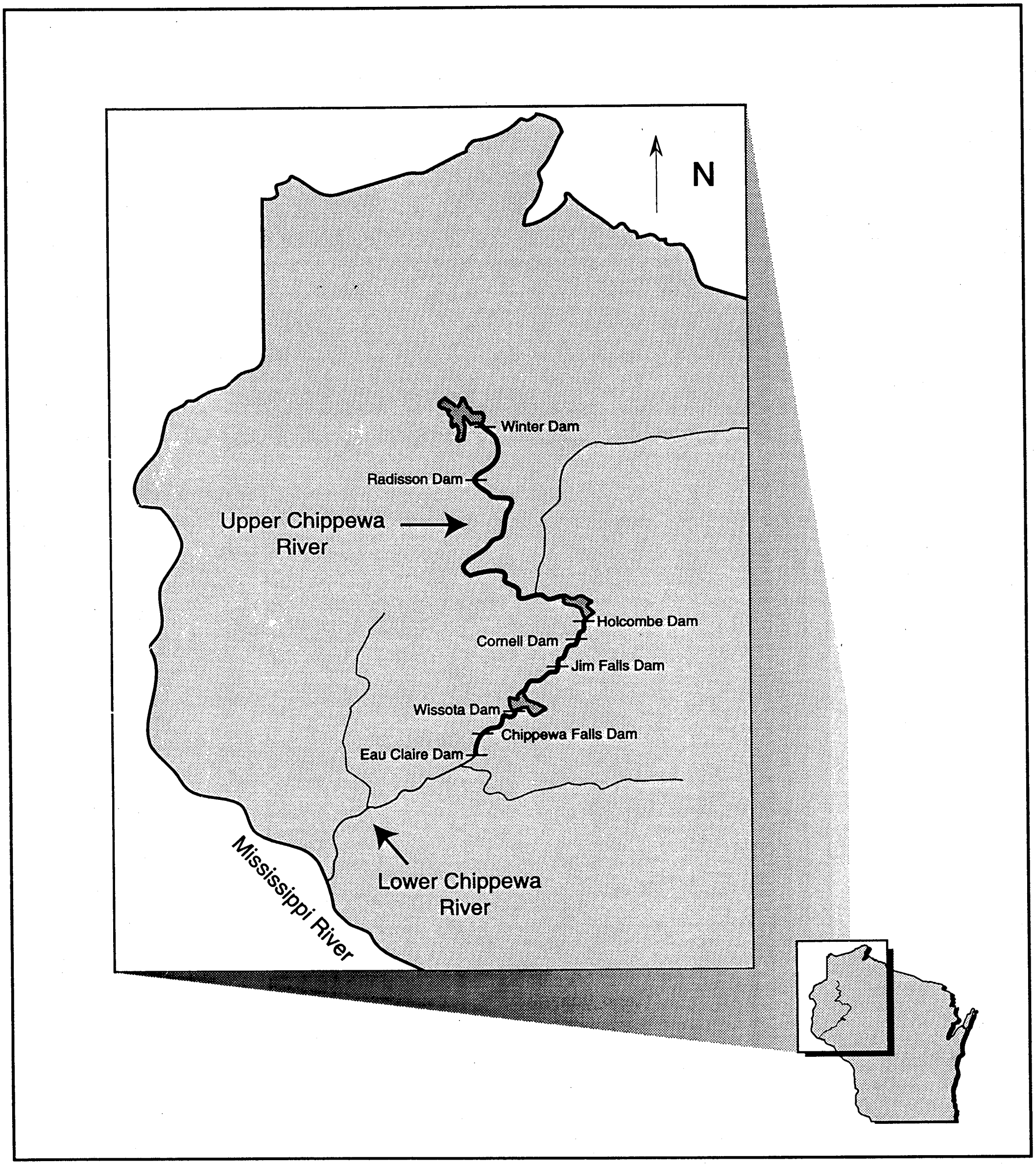

Figure 1. Reaches of the upper Chippewa River study area, from the Eau Claire Dam to the Winter Dam.

Methods

According to U.S. Geological Survey topographic maps, the upper Chippewa River flows through 78 different sections; in this study each of these sections was a sampling station. In a previous study of the lower Chippewa River (Balding 1992), unionids were not plentiful, and the search of an entire mile section of river was sometimes necessary. In this study, unionids were abundant in some parts of the river; for those sections a sample was taken, rather than searching the entire section.

To determine an adequate sample size, a site was arbitrarily selected, a presample was taken, and the number of specimens was plotted against the number of new species. After 108 specimens were located, nine species were represented (108 specimens usually fill a 15 liter container). A tenth species was not found until specimen 142. We decided a 15 liter sample would yield adequate species representation and that additional effort was not warranted.

Wading with and without a glass-bottomed bucket and snorkeling were the major methods used to locate unionids in riverine reaches. Boating and wading were done along shorelines in impounded reaches. A diver with SCUBA was used on several occasions in some impoundments or transition zones. A transition zone is a deeper part of the river having riverine and impounded qualities dependent upon whether a downstream dam is open or holding water.

Live unionids were placed in mesh bags and kept in the river until a section was searched or a 15 liter sample was collected. All unionids were measured for length, identified to species, counted, and released alive in suitable substrata. Recently dead unionids in identifiable condition were collected, along with specimens from midden piles (empty shells left by predators), although these data are not reported here. Representatives of all species were sent as vouchers to the Ohio State University Museum of Biological Diversity where their identification was verified by Dr. David Stansbery.

Results and Discussion

This study found 17 live species of Unionidae (Table 2) and one live species of Margaritiferidae. Mathiak (1979) found only nine of these species. The Holcombe to Radisson reach had the greatest abundance and species richness; it was also the longest riverine section. In fact, a very close positive relationship exists between both abundance and species richness to the length of riverine habitat (Tables 1 and 2). The relationship may be partially biased because the method of search was more intense and better suited for riverine areas than impounded areas.

The two dominant species within riverine reaches, *Actinonaias ligamentina* and *Elliptio dilatata*, comprise 65% of the 5,957 live unionids found (Table 3). Shells such as *E. dilatata* are possibly underrepresented as they are smaller and often buried deeply; hence they may not be detected as easily as larger, more exposed shells like *A. ligamentina*. There was generally a positive relationship between a unionid's abundance and how frequently it was found (Table 3).

Live unionids 30 mm or smaller were collected for some species. Generally, shells of this size are less than four years old and represent juveniles, indicating recent reproduction. Occurrence of juveniles, together with the great abundance found in the Holcombe to Radisson reach, suggests that most unionid species have healthy populations. Although data collected on dead specimens are not presented, it should be noted that there was a high percentage of dead *Amblema*

Table 2. Distribution and numbers of live unionids in seven study areas of the Chippewa River, Wisconsin, 1989–1994.

Species	*Eau Claire to Chippewa F*	*Chippewa F to Wissota*	*Wissota to Jim Falls*	*Jim Falls to Cornell*	*Cornell to Holcombe*	*Holcombe to Radisson*	*Radisson to Winter*	*Total*
Actinonaias ligamentina (Lamarck, 1819)				3		2,933	2	2,938
Elliptio dilatata (Rafinesque, 1820)	1		1	41	1	923	13	980
Pleurobema sintoxia (Rafinesque, 1820)				2		459	7	468
Lampsilis radiata (Lamarck, 1819)	20		3	7	3	278	98	409
Lampsilis ventricosa (Barnes, 1823)	15			2	1	194	53	265
Ligumia recta (Lamarck, 1819)	2			4		187	51	244
Obovaria olivaria (Rafinesque, 1820)				1		172		173
Quadrula pustulosa (Lea, 1831)	1			2		127		130
*Cyclonaias tuberculata** (Rafinesque, 1820)				2		109	6	117
Lasmigona costata (Rafinesque, 1820)						72		72
*Plethobasus cyphyus** (Rafinesque, 1820)						50		50
Fusconaia flava (Rafinesque, 1820)	2					28	16	46
Strophitus undulatus (Say, 1817)						30		30
Alasmidonta marginata Say, 1818						17		17
Anodonta grandis Say, 1829	2						3	5
Amblema plicata (Say, 1817)	1					11		12
*Cumberlandia monodonta** (Say, 1829)	1							1
Total specimens	45	0	4	64	5	5,590	249	5,957
Total species	9	0	2	9	3	15	9	

*Wisconsin endangered species

Table 3. Data for unionids from the study area with frequencies given for riverine reaches of the Chippewa River from Eau Claire to the Chippewa Flowage.

Species	*Number Live*	*Range in Length*	*Mean Length (mm)*	*Standard Deviation*	*Frequency % of 78 Sites*
Actinonaias ligamentina	2,938	25 - 136	93.3	1.50	66.7
Elliptio dilatata	980	26 - 109	61.7	1.05	74.4
Pleurobema sintoxia	468	21 - 97	64.7	1.18	67.9
Lampsilis radiata	409	27 - 110	60.0	.94	66.7
Lampsilis ventricosa	265	38 - 127	83.9	1.69	78.2
Ligumia recta	244	38 - 146	108.1	1.65	65.4
Obovaria olivaria	173	30 - 93	59.6	.97	55.1
Quadrula pustulosa	130	14 - 82	51.8	1.34	34.6
Cyclonaias tuberculata	117	40 - 109	78.6	1.54	48.7
Lasmigona costata	72	28 - 107	84.3	1.37	38.5
Plethobasus cyphyus	50	36 - 105	70.9	1.56	25.6
Fusconaia flava	46	30 - 90	55.0	1.38	15.3
Strophitus undulatus	30	28 - 71	58.1	.99	14.1
Alasmidonta marginata	17	40 - 63	53.0	.72	17.9
Anodonta grandis	5	62 - 125	88.2	1.93	3.8
Amblema plicata	12	47 - 130	95.1	2.62	14.1
Cumberlandia monodonta	1	——	154.0	——	1.3
Total specimens	5,957				
Total species	17				

plicata and *Ligumia recta*, suggesting that these two species are in decline in the upper Chippewa.

Otters and muskrats are predators of unionids along the Chippewa River. They remove the soft parts and leave the empty shells in middens. Since middens were rare in the lower Chippewa River and common in the upper Chippewa, it is possible these predators could have biased the number of juveniles we found in the upper Chippewa River. Hanson et al. (1989) observed size selectivity of unionids by muskrats along a lakeshore.

Three species identified in this study, *Cyclonaias tuberculata*, *Plethobasus cyphyus*, and *Cumberlandia monodonta*, are on the Wisconsin endangered species list. Only one live specimen of *C. monodonta* was collected, despite an extensive search in the area, where it was found using SCUBA. We assume this is a relic species not likely to be found in the Chippewa again. Contrary to *C. monodonta*, the other two endangered species seem to occur frequently in the Holcombe to Radisson reach. *C. tuberculata* and *P. cyphyus* rank nine and eleven in abundance among the seventeen unionid species we observed (Table 3). Not enough *P. cyphyus* were collected to present a meaningful size class distribution; however, *C. tuberculata* is well represented in many sizes, reflecting a stable population (Figure 2). No juvenile *C. tuberculata* were collected below 40 mm (about five years of age). This is more likely due to predation or a collecting bias than lack of reproduction. Small unionids are difficult to find, and perhaps they may have been in habitats that were not searched.

Quantitative data were collected at certain selected sites and are also not presented here. However, the highest density measured was 74 specimens/m^2. Considering the large size of the dominant species, *A. ligamentina*, and the amount of rock in the river, a higher density might not be physically possible.

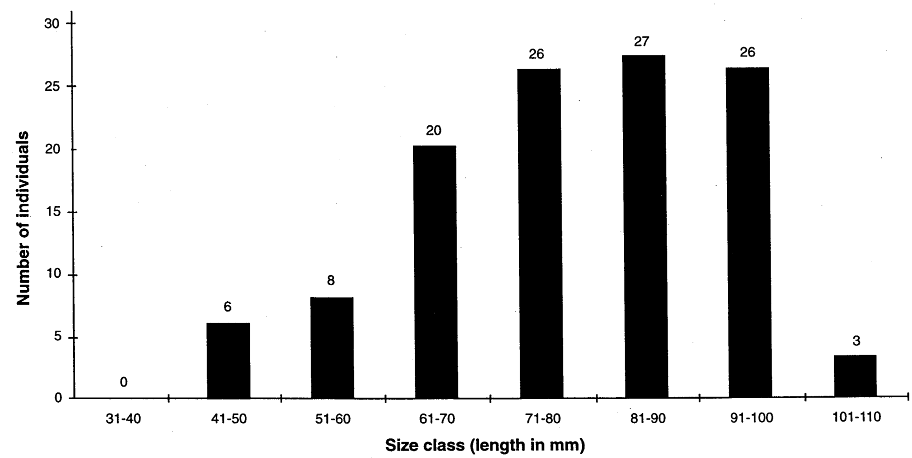

Figure 2. Size class frequency of *Cyclonaias tuberculata* in the upper Chippewa River, Wisconsin.

Using SCUBA, we were able to document that two impoundments above the Holcombe and Jim Falls dams did contain good unionid representation, although not with the abundance or species richness of the riverine areas. In other impoundments, three species, *Lampsilis radiata*, *Anodonta grandis*, and *Anodonta imbecillis,* were the most frequently occurring.

Comparison to lower Chippewa River

The total number of species identified for the Chippewa River, from both the lower river study (Balding 1992) and this study, is 29; 6 of these are listed by the Department of Natural Resources as endangered or threatened. With the exception of *A. imbecillis*, *C. monodonta*, and *C. tuberculata,* the 18 species collected in this study were also found in the lower Chippewa River (Balding 1992). *A. imbecillis* was found only in impounded portions of this study area, and since only the riverine portion of the lower Chippewa River was searched, it is likely also present in backwater areas of the lower Chippewa River. Mathiak (1979) did find *A. imbecillis* in the backwater of the lower Chippewa River. Greater species richness was found in the lower Chippewa River than in the upper Chippewa. It has long been known that species richness increases with increased river size (Coker et al. 1921; Baker 1922).

Dominant species differed between the upper and lower Chippewa River. *A. ligamentina* and *E. dilatata*, the co-dominants of this study area, and the next most common species, *Pleurobema sintoxia*, were rare in the lower Chippewa River. Conversely, the three most dominant species found in the lower Chippewa River, *Fusconaia flava*, *Obovaria olivaria*, and *Leptodea fragilis*, were absent or not as abundant in this study area.

Of interest is the comparison of Wisconsin endangered and threatened species in the lower Chippewa and in this study area. *C. mondonta* and *C. tuberculata* were found during this study, but not in the lower Chippewa River in the earlier study. In contrast, *Quadrula metanevra, Tritogonia* *verrucosa,* and *S. ambigua* were only found in the lower Chippewa, while *P. cyphyus* lives in both study areas. Mudpuppies *(Necturus maculosus),* the host for *Simpsonaias ambigua,* were observed in the upper Chippewa and were also reported by Vogt (1981). However, no live or dead *S. ambigua* were collected, although we did not specifically search under flat rocks for *S. ambigua* because of time constraints.

Of special note in the comparison between the lower Chippewa and this study area is the overall difference in abundance. In studies related to this one, which are to be reported elsewhere, transects were placed across the river in the Holcombe to Radisson reach, according to predetermined features of the shoreline such as a bridge or tree. The mean number of unionids/m^2 was nearly 12. This overall greater density of unionids collected more frequently led us to conclude that the Holcombe to Radisson reach has a much more plentiful unionid population than any other reach of the Chippewa.

The mean shell length for all species was always smaller in the upper Chippewa. Although many factors may be involved, this is generally what is expected in the more fluctuating environment typical of the upper reaches of rivers. An area for future study would be to investigate if the smaller mean shell length in the upper Chippewa is due to a decrease in growth, longevity, or both.

In summary, there was a positive relationship of both abundance and species richness to the length of riverine habitat. Two Wisconsin endangered species, *C. tuberculata* and *P. cyphyus,* were common in some areas. There are considerable differences between the species found in this study and those found in our earlier study of the lower Chippewa River, although of the 18 species collected alive in this study, all but *A. imbecillis, C. monodonta,* and *C. tuberculata* were found in the lower Chippewa River. Also, it is our opinion that unionids are much more plentiful in some sections of the upper Chippewa than in the lower Chippewa.

We feel that abundance of unionids, species richness, widespread distribution, and the presence of juvenile shells indicate the Holcombe to Radisson portion of this study area has a healthy unionid population. No zebra mussel or other exotic bivalve mollusks were found.

Acknowledgments

Thanks for help in collecting unionids are due to Shawn Balding, Susan Caley, Rod Cook, Derrik Duchesneau, Marc Harper, Sheri Harper, Dan Kelner, Lori Lyons, and John Reed. We would like to thank Craig Koltes and Kristi Minahan for their assistance in tabulating data. We are very appreciative of the many generous landowners who gave us access to the Chippewa River. We are once again indebted to Dr. David Stansbery of the Ohio State University Museum of Biological Diversity for his verification of the unionid identification. Thanks are also due to many reviewers.

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Terry and Nancy Balding have been studying the red-shouldered hawk and bivalve mollusks of the Chippewa River and its tributaries for the past ten years. Terry is Professor of Biology at the University of Wisconsin-Eau Claire. ***Address:*** *Department of Biology, University of Wisconsin–Eau Claire, Eau Claire, WI 54702-4004*

Mark Davis

"Getting rid of the stumps": Wisconsin's land-clearing program— The experience of the northern lake country, 1900–1925

Looking out of his train window in the winter of 1912, newly appointed county agent Ernest L. Luther liked what he saw of northern Wisconsin: "The old saw mills of boyhood days, real mackinaws, not the crudy-college [sic] kind, here one sees brawn, and a great free movement...." He noted rough shacks, neat farms, "rambling but well-painted towns." The one drawback he noted was stumps, remnants of the forest that had once covered the North. "S-T-U-M-P-S," Luther exclaimed, "Durn the stumps. I can see my job....Stumps, S-T-U-M-P-S, Stumps!"[1] The stumps were a blot on the landscape and they had to be removed (Figure 1).

Luther's new job was a part of a thirty-year campaign on the part of northern farmers to get rid of the stumps. In the end they failed, but their vain struggle stands as a symbol of the entire effort to convert northern Wisconsin into productive farmland. Nowhere did the attempt to clear land falter more than in the northern lake country in Oneida and Vilas counties. Dotted with more than 1,700 lakes, the region comprises 1.1 million acres located around the towns of Rhinelander and Eagle River.[2]

Creating the cutover in the lake country began in 1856, when the Fox and Helms Lumber Company of Stevens Point opened a logging camp in the region. Other lumbermen followed, attracted by magnificent stands of white pine that grew on the sandy lakeshores. Over the next thirty years, thousands of acres of northern forest disappeared. The railroad arrived in the lake country in the 1880s and the scope of the destruction increased. By the end of the century, most of the original forest was gone, replaced by brushy second-growth woodlots and miles and miles of stump-filled cutover.[3] In 1902, the

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Figure 1. A farmer sits in his uncleared field of rocks, rubble, and stumps. Courtesy State Historical Society of Wisconsin.

popular writer Ray Stannard Baker could find "no desert more pitifully forlorn, more deserted, more irreclaimable, and more worthless than the man-made deserts of northern Wisconsin.... [They are] hideous, grotesque, pitiful, a reminder of the reckless wastefulness of man."[4]

In the face of such utter devastation, the Wisconsin legislature passed two bills in the 1890s that addressed the future of the northern part of the state. One, in 1895, authorized the University of Wisconsin College of Agriculture to launch an intensive campaign to promote northern farming; the other, in 1897, inaugurated a forestry program in Wisconsin, which by 1905 included plans for a state forest reserve in the lake country.[5] For the next twenty years, advocates of forestry and of agriculture pushed their separate agendas. The foresters purchased thousands of acres to set aside for the reserve, while agricultural boosters produced a flood of promotional material hyping the northern "Empire in Waiting."[6]

Both sides floundered. Opponents of forestry challenged the reserve for wasting good farm land and interfering with northern economic development. They also argued that the program broke Wisconsin's constitutional proscription against state involvement in internal improvements. Although the voters elected to amend the constitution, opponents discovered that the legislature had not followed the proper procedures, and they succeeded in having the Supreme Court declare the forestry program unconstitutional in 1915.[7] Meanwhile, the blitz of agricultural promotion was not producing the results that its backers desired. Although the number of farms in the lake country had increased from 433 to 837 between 1900 and 1910, local boosters were still disappointed. Most of the cleared farm land was owned by a few large corporate potato farms that had moved into the lake country. Meanwhile, the "actual settlers," whom the boosters saw as the foundation of the new north, were struggling simply to hold onto their farms.[8]

To boost settlement and to help distressed northern farmers, the College of Agriculture created the office of county agent in 1912 and implemented an array of programs to help farmers improve their yield and market their products.[9] With the end of forestry in 1915, the assistance provided by the College took on added significance. For two decades, agriculturalists had argued that the North could sustain a farm economy. It was time for them to prove their case, and of all the things standing in their way, the stumps seemed to be the foremost.[10]

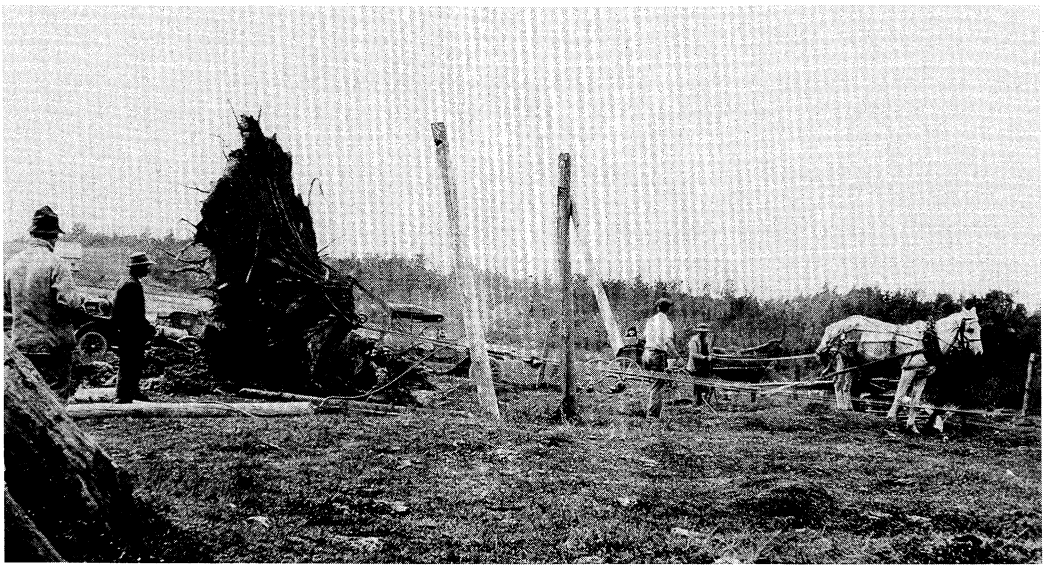
Land clearing was an arduous and daunting task that broke the spirit of many would-be farmers. An average acre of cutover land in the lake country contained 117 stumps.[11] Smaller hardwoods rotted quickly and were relatively easy to remove. Larger pine stumps were another matter. They resisted decay and had a deep, wide-spreading root system that tenaciously anchored the stump to the ground.

Work began in the spring when the ground was still frozen. Settlers fractured the stumps into several pieces with dynamite and then yanked them out using a team of horses or a mechanical stump-pulling machine. After removing a stump, workers knocked the dirt off and dragged and hoisted it onto a huge pile for burning. The first try seldom removed all the deep roots. They required more explosives, more digging, and more pulling. When the stump was finally gone, children filled in the crater left behind, burying what little topsoil remained after all the dynamiting and digging. Even then the work was not finished. Before the settlers could cultivate their land, they must clear brush (a never-ending job), remove logs and other debris, dig out rocks, and level the ground (Figure 2).[12]

Clearing land was not only a slow process, it was expensive as well. Amounts varied, but between 1902 and 1926, the cost of tools, dynamite, and labor averaged about twenty dollars per acre in the lake country.[13] Only corporate potato growers or those farmers who brought ample savings with them could come up with that kind of money. Most immigrant families arrived in the North with little capital. After making a down payment on their land and building a house and barn, they had no money left for stump removal. In need of an income and without cleared land on which to plant a cash crop, many of them sought jobs off their farms. Most settlers became part-time farmers, who, lacking both money and time, cleared less than two acres a year. At that rate, they needed three to five years just to begin to earn enough from their land to pay off their mortgages.[14]

To overcome the hardships of stump removal, farm promoters began offering to help settlers clear their land as early as 1900. Manufacturers peddled tools, tractors, and dynamite, while bankers offered credit to pay for them. Farmers helped themselves by forming co-ops to buy stump-pulling machines, or by designing their own, such as the popular Conrath piler, a homemade derrick for lifting stumps onto burning piles (Figure 3). Swindlers got into the act. In 1908, a farmer near Rhinelander advertised a mixture of acids that he said would turn stumps into a "charred pulpy mass that could be spread over the soil as fertilizer."[15] It later proved to be a sham.

Land sellers tried to lure buyers into northern Wisconsin with a variety of land-clearing schemes. In 1915, the G. F. Sanborn Company of Eagle River, for example, offered to sell forty-acre tracts for $1,100. In its advertisements, the company issued a common challenge to the settlers' toughness, warning them that the first year



WHi(x3)45192

Figure 2. Farmers using a team of horses to pull out a stump. Courtesy State Historical Society of Wisconsin.

WHi(D482)6801

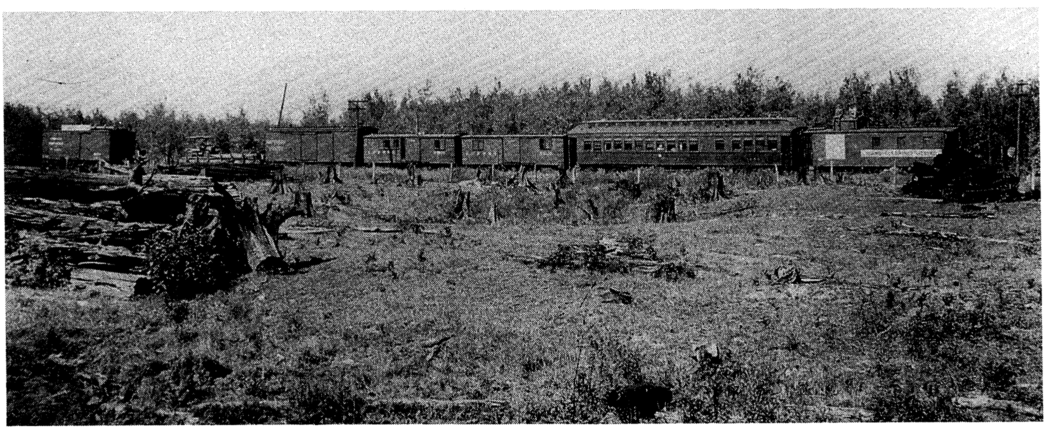
Figure 3. A Conrath piler lifting stumps onto a pile for burning. The team of horses provide the power to lift the stump. Courtesy State Historical Society of Wisconsin.

"tries men's souls up here and decides whether they have the right stuff in them." To help farmers through the tough times, Sanborn included in his offer a cabin, a cow, pigs, and chickens, and two cleared acres of land. Farm families could then sustain themselves while they put their "best licks in getting [their] land in shape for a crop." For their part, settlers had to put $250 down, pay taxes and 6 percent interest for three years, and then pay off the balance in three equal installments.[16]

The chief source of land-clearing assistance was the College of Agriculture, whose county agents gave free advice, tested tools, and exposed swindlers. With the end of the forestry program, the College stepped up the aid it provided. In 1916, it cooperated with manufacturers and railroad companies to sponsor the first "Land Clearing Special." These trains, two of which crisscrossed northern Wisconsin during the summer, brought in experts to show farmers the latest land-clearing techniques.[17] At each stop, "stump dentists" blasted, tugged, and pulled, while crowds stood around, watched, and compared the "Hercules Horse Stump Puller" to the "Kirsten One-Man" machine. College personnel kept records and sold dynamite, while other boosters urged local officials to organize land-clearing co-ops and coaxed bankers into extending credit to farmers so they could buy the demonstrated products. The trains made several stops in the lake country; about 200 people attended each demonstration (Figure 4).[18]

In October, the College held a Land Clearing Congress at Rhinelander to assess the effectiveness of the trains. State and local boosters attended the meeting. Although a few participants questioned the need for the trains, the majority congratulated themselves on a job well done, and agreed they should do more.[19] During the winter, the College established a Land Clearing Department and named a former county agent, John Swenehart, to head it. Meanwhile, the state legislature appropriated money for Swenehart to run the Land Clearing Special in 1917 and 1918 and authorized him to buy dynamite in quantity and, working through the county agents, to sell it to farmers at cost.[20]

The bill was controversial. State senator A. B. Whiteside, who represented the lake country, opposed selling dynamite because



WHi(x3)36966

Figure 4. A Land Clearing Special prior to setting up a demonstration. Courtesy State Historical Society of Wisconsin.

he feared that speculators, not settlers, would benefit.[21] A. D. Campbell, head of the Wisconsin Advancement Association, one of the state's largest agricultural booster groups, also opposed the bill, favoring instead that the state purchase 300 Kirsten stump pulling machines to rent to farmers for 25 cents a day.[22] John Swenehart, on the other hand, was pleased with the legislation. He hoped the trains would increase the pace of land clearing, and while they ran, they did arouse a modicum of interest in the lake country. In 1917, for example, six hundred people showed up for the demonstrations, purchased ten tons of the College's dynamite, and used it to clear 9,000 acres.[23] It was not enough, however. By 1920, only 37,884 acres, less than 3 percent of the region, had been cleared of stumps. Most of that belonged to large potato growers.[24]

Time was working against the agricultural boosters. Five years after the end of the forest reserve, they still had not induced many settlers into the lake country.[25] The question was why. To the farm promoters, the answer could not be the poor soil or climate, the lack of markets, or the north's still primitive living conditions. It must be the stumps. Boosters looked at their bleak landscape and wondered if all its ragged-looking stumps were discouraging settlers from coming to the North.[26] They received some backing from agricultural experts, who said the stumps lowered farmers' incomes by taking up too much room in the fields, hindering plowing, and preventing agricultural diversification. According to John Swenehart, land clearing was the final stave that was missing from the northern "barrel of prosperity," and so in the early 1920s, the effort to get rid of the stumps intensified.[27]

The crusade found an ally in the federal government. During World War I, it had stockpiled several million pounds of TNT. After the armistice, the government planned to dump the TNT into the ocean. Seeing its possible use to northern farmers, the College of Agriculture asked that it be made available for stump removal. Believing that TNT was toxic and dangerous, the government required the College to first study its suitability for land clearing. After a month of tests in May 1919, John Swenehart reported that TNT was both safe and economical.[28] The government then agreed to release it, and by the end of 1920, county agents had distributed 900,000 pounds of it to Wisconsin farmers. Its chief benefit was its cost—10 cents a pound compared to the 15 cents that farmers were paying for the College's dynamite.[29] Beginning in 1921, as the TNT ran out, Swenehart switched to other government explosives—picric acid, sodatol, and pyrotol, selling them in the lake country for as low as 5 cents a pound (Figure 5).[30]

Despite Swenehart's efforts, many farmers in the lake country remained aloof from the land-clearing programs. The costs were still too high, and in any case, most settlers were not relying on only their farms to support themselves.[31] Potatoes, one of the region's two chief farm products, were an unpredictable crop, subject to blight and rot and often not worth digging.[32] The other, dairy products, had a small local market, and the necessity of strong food for the cows during the long winter made it very expensive.[33] The plight of local farmers was made worse when, beginning in 1920, national farm prices fell and agriculture tumbled into a severe economic depression.[34] For many settlers, jobs off the farm, which ranged from guiding hunters and fishermen to working in a paper mill, promised more income than growing potatoes or tending cows ever would. With the higher tax assessments for cleared land added to the burdens that set-

WHi(x3)5462

Figure 5. During the 1920s the College of Agriculture conducted an extensive "Pyrotol Pete" safety campaign to show settlers the proper use of government explosives. Courtesy State Historical Society of Wisconsin.

tlers already bore, many decided that pulling out stumps was simply a waste of their time and money.

In the face of such indifference, the farm boosters redoubled their efforts to lure the settlers into the battle against the stumps. John Swenehart acknowledged the farmers' concerns, but argued that land clearing was "laying a foundation for the better prices and better times to come." The editor of the Eagle River *Review* agreed: "The man who can show the stuff of which he is made by clearing land will soon earn a position for himself in the community and be able to secure the credit he needs for future development."[35]

While the men talked, the C-S Club, a group of farm wives, initiated the Vilas County Land Clearing Association. More than 225 people showed up at the Eagle River Opera House for its first meeting in February 1921. After enjoying a luncheon prepared by the C-S Club, which, no doubt, was the main attraction of the gathering, they paid 25 cents to join, received a red button to wear, ordered explosives, and signed an agreement to clear a specified number of acres during the upcoming summer.[36]

The Land Clearing Association's campaign to attract members continued into the spring. Boosters held more meetings to induce farmers to sign up and agree to clear land. They held contests. The *Review* promised to pay a dollar for the best answer to the question "Why should I join the Land

Clearing Association." When it received "no deluge of answers" the paper upped the prize to include "a purple, hand-painted honor ribbon that will be more lasting than money."[37] Meanwhile, the Association announced a contest to see who could clear the most land by the end of the summer. When settlers complained that larger farmers had an unfair advantage, the Association evened things out by subtracting points for the use of machines and hired help. Merchants chipped in with prizes. Druggist H. A. S. Egbert, for example, donated a bottle of McConan's Liniment to the "contestant developing the greatest backache."[38] When the weather warmed up, the Association sponsored picnics that offered lunch, races, and dances, and gave settlers another chance to see Swenehart's crews demonstrate how to remove stumps.[39] During the summer, farmers in Vilas County cleared 1,282 acres.[40] In September, Rhinelander businessmen, upset that Oneida County farmers had only cleared 950 acres during the summer, spearheaded the Oneida County Land Clearing Association.[41]

The land-clearing campaigns in the lake country peaked in 1922. Both county organizations began by setting goals for the year. After agent C. P. West told members that another 4,500 acres were needed to feed a larger dairy herd, the Oneida County Association established that as its target for the year. To reach it, each farmer had to clear five acres of land.[42] Not to be outdone, Vilas County boosters announced a goal of 5,000 acres, the equivalent of 10 acres per farm.[43]

To reach their lofty goals, boosters undertook another round of hoopla-filled campaigns urging farmers to get out the stumps. Newspapers retold stories of Paul Bunyan's land-clearing exploits, suggesting settlers follow in the footsteps of the legendary logger.[44] Posters carried the same message: One showed a scruffy axe-wielding woodsman, Paul Bunyan, no doubt, with the caption: "Drive Them Out! Blow Them Out! Pull Them Out! Anyway To Get Them Out, But Get Them Out Of Vilas County!"[45] To go along with the posters and slogans, the boosters held more land-clearing meetings during the winter at which, typically, a College of Agriculture faculty member addressed the settlers with a stirring pep talk and a "bully good Moving Picture."[46] Farmers ordered explosives, and in Oneida County, 407 farmers signed pledges to clear 4,324 acres in 1922.[47] In the spring, there were more contests, picnics, and demonstrations. "Come prepared to spend the entire day," advised one editor. "The programs will be both instructive and entertaining."[48] Local newspapers estimated that 2,000 people attended six of the demonstrations in Oneida County and ordered more than a ton of picric acid.[49] The highlight of the season surely must have been the day the Vilas County Association blew up an acre of stumps in one gigantic blast.[50]

The land-clearing associations did more than engage in spirited public relations. Oneida County boosters raised $10,000 in 1922 and loaned 56 farmers more than $6,000 to pay for stump removal.[51] The associations also helped to distribute explosives. For their big campaigns in 1922, county agents dispensed 67,000 pounds of picric acid obtained from the government, while the boosters added another 187,000 pounds of commercial dynamite. So armed, Oneida County farmers surpassed their goal and cleaned up 4,586 acres. Although many of the farmers ran out of money and failed to meet their pledges, large corporate farms in the county took up the slack. In Vilas County, farmers fell short of their goal of 5,000 acres and cleared only 3,500.[52]

After the 1922 campaign, the excitement, the contests, and the demonstrations petered out. Despite the efforts of state and local agricultural boosters, settlers came to the realization that devoting limited resources to land clearing was simply not in their interest. The time and effort put into land clearing could not overcome the region's poor soils and lack of markets. If settlers were to survive in the lake country, they had to fashion an income from sources other than just farming. Even with the contests and the cheap explosives, removing stumps took settlers away from other more productive work off the farm.

Although county agents continued to distribute government explosives for five more years, most of it went to corporate potato farms. By the end of 1928, area farmers had used 600,000 pounds of surplus explosives and at least that much commercial dynamite to double the amount of cleared land in the lake country. Still, twelve years after the first "Land Clearing Special" in 1916, only 65,000 acres, 5 percent of the lake country's 1.1 million acres, had been turned into farmland[53] (Figure 6).

Just at the time the struggle to get out the stumps peaked in the early 1920s, the state legislature reintroduced the forestry program, including another reserve. Initially hesitant, lake country boosters were soon among its most enthusiastic supporters. If farmers did not want to come to the region, the boosters discovered that vacationers and wealthy summer residents did. These tourists were not interested in cleared potato fields, but in forests, lakes, and scenic drives. They wanted the reserve. The fruitless battle against the stumps, then, was the last wholesale assault on the lakeland's environment. Ever since, northern residents have been trying, successfully or not, to rebuild their forest.


WHi(x3)14296

Figure 6. Land better left to the forest. Courtesy State Historical Society of Wisconsin.

Endnotes

[1]E. L. Luther to "Professor" [K. L. Hatch], Feb. 7, 1912, Ernest L. Luther Papers, box 1, State Historical Society of Wisconsin, Madison (hereafter cited as Luther Papers).

[2]Wisconsin Conservation Department, *Wisconsin Lakes*, Publication 218-51 (Madison, 1951), unpaginated. Oneida County is 576,640 acres; Vilas County is 533,120 acres; combined they are 1,109,760 acres.

[3]Vilas County *News*, May 23, 1923; George O. Jones, Norman S. McVean, et al., *History of Lincoln, Oneida, and Vilas Counties, Wisconsin* (Minneapolis, 1924), 171; Joe Botsford, *The Curran Story: The Beginning of Rhinelander* (Rhinelander, 1953), 8; Edmund C. Espeseth, "Early Vilas County: Cradle of an Industry," *Wisconsin Magazine of History* 37 (1953), 27; T. V. Olsen, *The Rhinelander Country*, vol. 2, *Birth of a City* (Rhinelander, 1983), 114; Filbert Roth, *On the Forestry Conditions of Northern Wisconsin*, Wisconsin Geological and Natural History Survey, Bulletin no. 1, Economic Series no. 1 (Madison, 1898), 62, 65.

[4]Ray Stannard Baker, "The Great Southwest," *Century Magazine* 42 (1902), 216.

[5]*Laws of Wisconsin*, 1895, Chapter 311; *Laws of Wisconsin*, 1897, Chapter 229.

[6]B. G. Packer, untitled manuscript, n.d., in the Wisconsin Department of Agriculture, Immigration Division Records, 1920–1930, State Record Series 729, State Historical Society of Wisconsin, Madison. For the complete story of the conflict between farmers and foresters see: Dennis East, "Water Power and Forestry in Wisconsin: Issues of Conservation, 1890-1915" (Ph.D dissertation, University of Wisconsin, 1971); Vernon Carstenson, *Farms of Forests: Evolution of a State Land Policy for Northern Wisconsin, 1850–1932* (Madison, 1962).

[7]Carstenson, *Farms or Forests*, 79–89; East, "Water Power and Forestry," 399–406.

[8]*Thirteenth Census of the United States (1910): Vol. 6*, Agriculture, 918–19; E. L. Luther to K. L. Hatch, Jun. 2, 1912, Luther papers, box 1.

[9]"History of the Agricultural Extension Service, Instigated By Alpha Sigma Chapter, Epsilon Sigma Phi," 1935, Luther Papers, box 1.

[10]W. H. Grover, *Farm and College, The College of Agriculture of the University of Wisconsin, A History* (Madison, 1952), 283; Henry L. Russell, untitled manuscript, 1916, in College of Agriculture: Administration, Office of the Dean and Director, General Subject Files, Deans Henry and Russell, 1880–1930, box 21, University of Wisconsin Archives, Madison (Hereafter cited as Henry and Russell Papers).

[11]University of Wisconsin Agricultural Experiment Station, *Getting Rid of Stumps*, Wisconsin Bulletin 295 (Madison, 1918), 23. The figures are calculated from those given for Rhinelander and Mercer.

[12]Carl Schels, *A Trapper's Legacy* (Harrisburg, 1984), 39–40; Sherwood W. Shear, "A Survey of Settler's Progress in Upper Wisconsin" (Ph.D. Dissertation, University of Wisconsin, Madison, 1924), 63–67; Theodore Francis Groves, *Land Of the Tamarack: Up-North Wisconsin* (Berkeley, 1968), 161, 169–75.

[13]L. K. Wright, "Agricultural Resources of Northern Wisconsin," in *Annual Report Of the Wisconsin State Board of Agriculture, 1902*, 304; E. L. Luther to K. L. Hatch, Apr. 30, 1912, in Luther Papers, box 1; William Potts to Richard Runte, Nov. 15, 1926, in Cyrus Carpenter Yawkey and Aytchmonde Perrin Woodson Papers, 1887–1957, box 51, State Historical Society of Wisconsin, Stevens Point.

[14]Shear, "A Survey of Settlers Progress," 52, 63, 94.

[15]Minoqua *Times*, Sept. 3, 1908; Vilas County *News*, Sept 9, 1908, Dec. 15, 1909.

[16]Eagle River *Review*, Dec. 24, 1915.

[17]H. L. Russell to the Board of Regents, May 3,

1916, typed form letter, October 6, 1916, Henry and Russell Papers, box 23; W. A. Rowlands, "Land Clearing Research Investigation and Demonstration Have Added Wealth to Wisconsin's Agriculture," typed manuscript, in Walter A. Rowlands Papers, University of Wisconsin, College of Agriculture, Agricultural Economics Department, ss 1, box 23, University of Wisconsin Archives, Madison; Rhinelander *New North*, Apr. 6, 1916.

[18]Rhinelander *New North*, Apr. 27, June 1, 1916; Eagle River *Review*, May 5, 26, 1916; Grover, *Farm and College*, 282. All in all, the train made thirty-three demonstrations in northern Wisconsin before a reported 20,000 people. The term "stump dentists" is from *Farm and Fireside*, Oct. 21, 1916.

[19]Rhinelander *New North*, Oct. 5, 1916; untitled typed report of the Rhinelander Conference, [1916], Henry and Russell Papers, box 21.

[20]*Laws of Wisconsin*, 1917, Chapter 476; "Statement Submitted to the Join Finance Committee relative to Bill 387-s Introduced by Senator A. H. Wilkinson," n.d., Henry and Russell Papers, box 21; *Biennial Report of the Wisconsin Department of Agriculture, 1917-1918*, 34. The legislature subsequently authorized the Land Clearing Special for a third year, 1919, which was the last year that it ran. Also in 1917, the legislature passed the Settler's Reclamation Bill which set up a program to provide farmers with loans to pay for the costs of land clearing. *Laws of Wisconsin*, 1917, Chapter 288. The law was little used.

[21]W. B. Angelo to H. L. Russell, May 21, 1917, Henry and Russell papers, box 21.

[22]College of Agriculture to A. D. Campbell, May 4, 1917; Unsigned memo, Jun. 18, 1917. Shortly after the passage of the bill the Wisconsin Advancement Association fired Campbell. E. P. Arpin to F. M. White, May 18, 1917. All in Henry and Russell Papers, box 21.

[23]"Annual Report of the Oneida County Agricultural Agent, 1917," and "Annual Report of the Vilas County Agricultural Agent, 1917," both in College of Agriculture: Agricultural Extension, County Agricultural Agents Annual Reports, 1915–1952, Vilas and Oneida Counties, University of Wisconsin Archives, Madison.

[24]*Fourteenth Census of the United States, 1920, Vol. 6, Agriculture, part 1*, 404. Total acreage in Vilas and Oneida counties was 1,354,880 acres, of which 37,884 (2.80%) was improved farm land.

[25]From 1910 to 1920, the number of farms increased from 837 to 1,141 (+304), a slower growth rate than the previous decade when the number of farms increased by 404. *Fourteenth Census (1920), Vol. 6, Agriculture*, 404.; *Thirteenth Census (1910): Vol. 6, Agriculture*, 918–19.

[26]See the comments of E. O. Brown, untitled report of the Rhinelander Conference, 7, Henry and Russell Papers, box 21.

[27]*Getting Rid Of the Stumps*, 3–5; John Swenehart, *Clear More Land*, Agricultural Experiment Station Bulletin 320 (Madison, 1920), 3–5; Eagle River *Review*, May 6, 1921; Rhinelander *New North*, Feb. 9, 1922; "Annual Report of the Oneida County Agent, 1923."

[28]"TNT As a Land Clearing Explosive;" "War Explosives At Useful Work," typed manuscripts in Rowlands Papers, ss 1, box 1.

[29]"Wisconsin's Use of Salvage War Explosives For Land Clearing" and "Statement Regarding Land Clearing Work By the University of Wisconsin," typed manuscripts, Henry and Russell Papers, box 23; Grover, *Farm and College*, 283; Helgeson, *Farms In the Cutover*, 107–08.

[30]"Annual Report of the Oneida County Agricultural Agent, 1923." By 1928, when the state land clearing program came to an end, 19,000,000 pounds of surplus explosives had

been distributed in Wisconsin. Fifty thousand farmers spent more than $1,000,000, and in the process, blew up, to one degree or another, 4.5 million acres of land. Helgeson, *Farms in the Cutover*, 109; Grover, *Farm and College*, 285.

[31]Shear, "A Survey of Settlers' Progress," 13; Robert J. Gough, "Richard T. Ely and the Development of the Wisconsin Cutover," *Wisconsin Magazine of History* 75 (Autumn 1991), 16–17.

[32]Walter Ebling, *Wisconsin Agriculture: A Statistical Atlas, 1926–1927*, Bulletin 90, Co-operative Crop and Livestock Reporting Service (Madison, 1928), 46; J. W. Milward, "Report on Extension Projects in Potato Breeding and Disease Control," radio transcript, n.d., J. W. Milward Papers, microfilm, reel 5, State Historical Society of Wisconsin, Madison; William Connor, Sr. to William Connor, Jr., Oct. 16, 1924, box 5, Connor Forest Industries Records, State Historical Society of Wisconsin, Madison; Vilas County *News*, Feb. 23, 1921.

[33]Eric E. Lampard, *The Rise of the Dairy Industry in Wisconsin: A Study in Agricultural Change, 1820-1920* (Madison, 1963), 275; E. L. Luther, "Histories of County Extension Work," handwritten manuscript, Luther Papers, box 3.

[34]Robert C. Nesbit, *Wisconsin: A History*, 2nd ed. (Madison, 1989), 459–60; Paul Glad, *The History of Wisconsin, Vol. 4, War, a New Era, and Depression, 1914–1940* (Madison, 1990), 133–36; Gough, "Ely and the Cutover," 26.

[35]Both quotations are in Eagle River *Review*, May 6, 1921.

[36]Eagle River *Review*, Dec. 17, 1920; Feb. 4, 11, Mar. 4, 1921. One editor praised the women for "setting a pace for the men, and placing them where they belong—in the ranks of the progressive farmers of the states." Vilas County *News*, Feb. 16, 1921.

[37]Eagle River *Review*, May 25, 1921.

[38]Eagle River *Review*, Mar. 11, 1921.

[39]Vilas County *News*, June 10, 1921; Rhinelander *New North*, Aug. 18, 1921.

[40]The Rhinelander *New North* Sept. 29, 1921, reported that in 1920 there were 8,444 cleared acres in Vilas County. The Eagle River *Review*, Dec. 23, 1921, reported that at that time there were 9,726 acres of cleared land. I am assuming that the difference between the two is the amount of land cleared in 1921.

[41]Rhinelander *New North*, Sept. 29, Oct. 6, 1921.

[42]"Annual Report of the Oneida County Agricultural Agent, 1922."

[43]Eagle River *Review*, Dec. 23, 1921.

[44]Vilas County *News*, Dec. 21, 1921, Jan. 11, 1922.

[45]Taken from a poster included with "Annual Report of the Vilas County Agent, 1922."

[46]Vilas County *News*, Jan. 11, 1922.

[47]Rhinelander *New North*, Mar. 16, 23, 30, 1922.

[48]Rhinelander *New North*, May 11, Jun. 8, 1922.

[49]Rhinelander *New North*, Jun. 8, 1922.

[50]A photograph of the blast is in the "Annual Report of the Vilas County Agricultural Agent, 1922."

[51]Jones, *History*, 111; Rhinelander *New North*, Dec. 11, 14, 1922.

[52]"Annual Report of the Vilas County Agent, 1922;" "Annual Report of the Oneida County Agent, 1922;" Rhinelander *New North*, Dec. 14, 1922.

[53]"War Explosives History," Rowlands Papers, ss 1, box 1; "Annual Report of the Oneida County Agent, 1928." The exact figure cited was 598,273 pounds.

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A vascular flora of Green Lake County, Wisconsin

Abstract *The main part of this report is a catalog of vascular plants that grow or have grown without cultivation in Green Lake County, Wisconsin. Presently, the county flora contains 921 cataloged species. Of these there are 31 pteridophytes, 8 gymnosperms, 283 monocotyledons and 599 dicotyledons. Plant records are based mainly on specimens in the University of Wisconsin-Oshkosh herbarium (OSH) that were collected from 1979 to 1996. During this study it was determined that nine Wisconsin threatened and endangered species are members of the county flora. Of these,* Cypripedium candidum, Gentiana flavida, Habenaria flava *var.* herbiola, Opuntia fragilis, Parthenium integrifolium, Polytaenia nuttallii, *and* Tofieldia glutinosa *are threatened, while* Armoracia lacustris *and* Scirpus cespitosus *var.* callosus *are endangered. In August 1989 a native grass,* Muhlenbergia richardsonis, *previously unknown in Wisconsin, was discovered at the Berlin Fen, a state scientific natural area. To date,* M. richardsonis *is not known to occur elsewhere in the state.*

The original land survey records for Green Lake County, circa 1834, along with old letters and journals, document the presettlement vegetation as predominantly oak savanna. Various oak communities, notably oak openings, were prevalent throughout the county prior to European settlement and were a tie-in between the oak forests and grasslands. Tallgrass prairie covered the flat uplands in the southeastern part of the county, while in the northwestern half, wetlands occupied floodplain throughout most of the Upper Fox River Valley and its tributaries. Two small tracts of climax maple-basswood forest were established in the county—below the Prairie du Chien escarpment southeast of Green Lake and a small area in what is now part of Berlin. Adding to this diverse vegetation complex, a small forest of mixed red and white pine extended north of Lake Puckaway to within 3 miles south of Princeton.

This vascular flora, which is based on a thesis submitted in partial fulfillment of the degree of Master of Science at the University of Wisconsin-Oshkosh, is a record of the non-cultivated plants that grow or have grown in Green Lake County, Wisconsin. It serves as a reference for comparison with the flora of the same area in the future and adds to the broader regional botanical record. During this study the known distribution ranges were extended for many species that had been previously unreported for the county. In addition, this county flora documents the occurrence of state threatened and endangered plants, the possible extirpation of one species, and the appearance of a native grass previously unreported in Wisconsin. Since it is probable that some plants were inadvertently overlooked during the study, and because the flora of any region changes with time, it is expected that others will contribute to this record. Monitoring these floristic changes are essential for the protection of rare species and the restriction of nuisance plants.

The conservation of a diverse county flora and the preservation of native biodiversity at all levels depends on intelligent and sustainable land-use practices. Modern agricultural methods and commercial, residential, and recreational expansion can have an irreversible impact on the vegetation. In Green Lake County the development and implementation of a comprehensive land-use plan is essential for natural resources protection. Updating the county's GIS (geographical information system) digital layers via a comprehensive land-use inventory; revision of land zoning ordinances; identification of environmentally sensitive areas; and educating the township and county board officials, as well as the general public about the inherent value of natural areas will, in the long run, provide the most reliable protection for the county's native flora.

Location and Land Use

Green Lake County is located in east-central Wisconsin approximately 60 miles northeast of Madison and 30 miles southwest of Oshkosh (Figure 1). The parallel 43°45' North Latitude and the meridian 89°00' West Longitude intersect in the county (Figure 2). Two state geographical provinces divide the county roughly in half (Martin 1965). The northwestern half lies on the western edge of the Central Plain and is characterized by gently rolling topography. The southeastern half of the county, which is part of the Eastern Ridges and Lowlands province, consists of numerous escarpments and valleys. The county is slightly below Wisconsin's tension zone, a region of transition between Wisconsin's northern hardwood province and the prairie-forest province (Curtis 1959). Although oak savanna is the dominant vegetation cover throughout the county, some species that are more typical north of the tension zone grow here. Of the 72 Wisconsin counties, Green Lake County ranks 65th in area size. The total land area for the county is 355 square miles, or 226,816 acres. Land use in the county, based on the 1995 Statistical Report of Property Values, is summarized in Table 1 (Wis. Dep. Revenue 1995). Tax exempt lands, which include state wildlife management areas and county and city parks, account for 1,331 acres, or approximately 0.6% of the total land area.

Table 1. Land use in Green Lake County

Land Use Type	*Acres*	*% of Total Taxable Land Area (Acres)*
Residential	8,889	4%
Commercial	2,040	1%
Manufacturing	1,741	1%
Agricultural	140,652	71%
Swamp	26,003	13%
Forest	20,847	10%

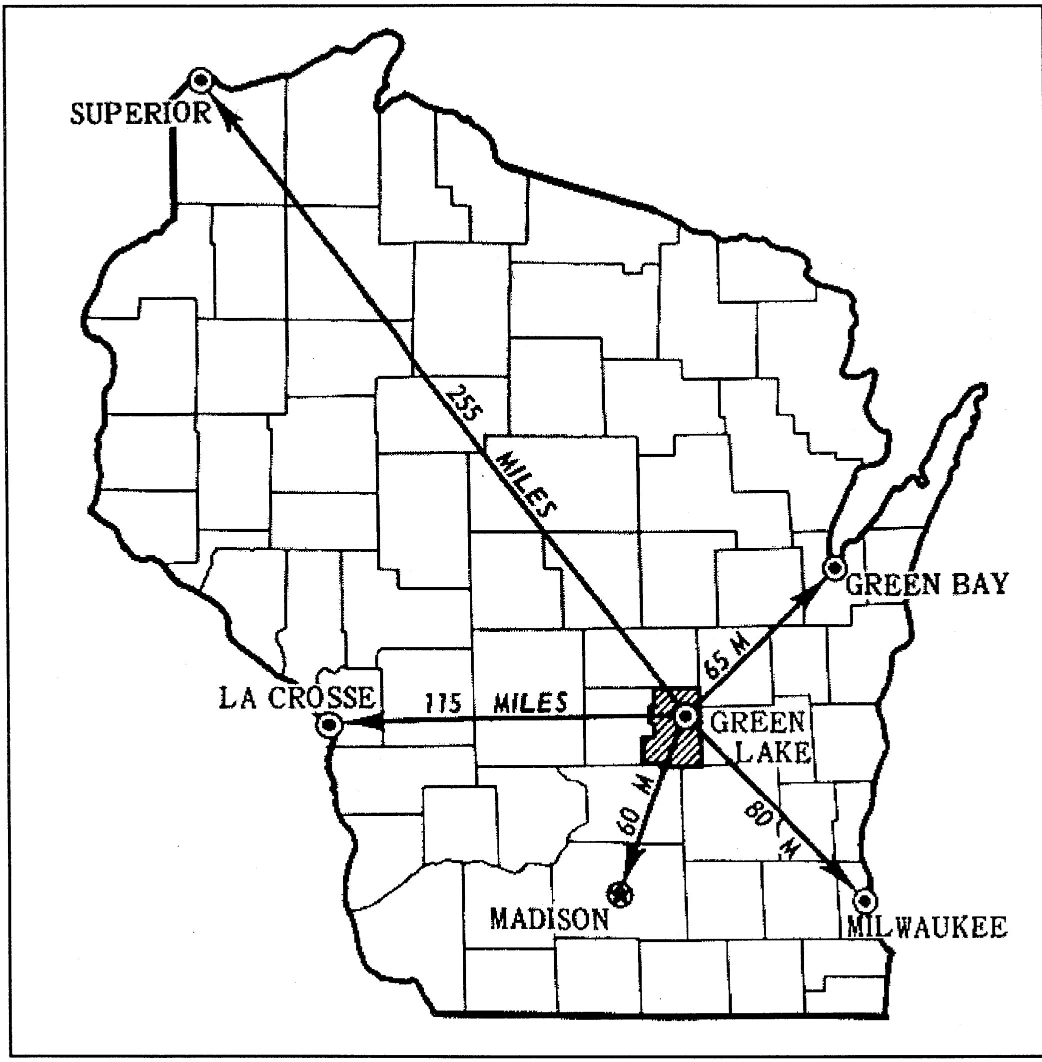

Figure 1. Location of Green Lake County, Wisconsin (U.S. Dept. Agr. 1977).

Physiography and Geology

The northwestern half of Green Lake County is occupied by an extinct glacial lakebed within the Central Plain's Upper Fox River Valley. The altitude of the valley ranges from 750 to 780 ft above sea level. The southeastern half of the county, which is part of the Eastern Ridges and Lowlands, is composed of several parallel ridges and wide valleys that lie in a general northeast-southwest direction. The southeastern uplands attain altitudes of 1,170 ft above sea level, while the surface relief varies from 100 to 270 ft relative to the lake level of Green Lake.

Local physiography within the two contrasting provinces consists of three general land areas. The northwestern region of the county, which is typified by sandy soils and wetlands, has low, nearly level terrain. The poor surface relief is occasionally broken by

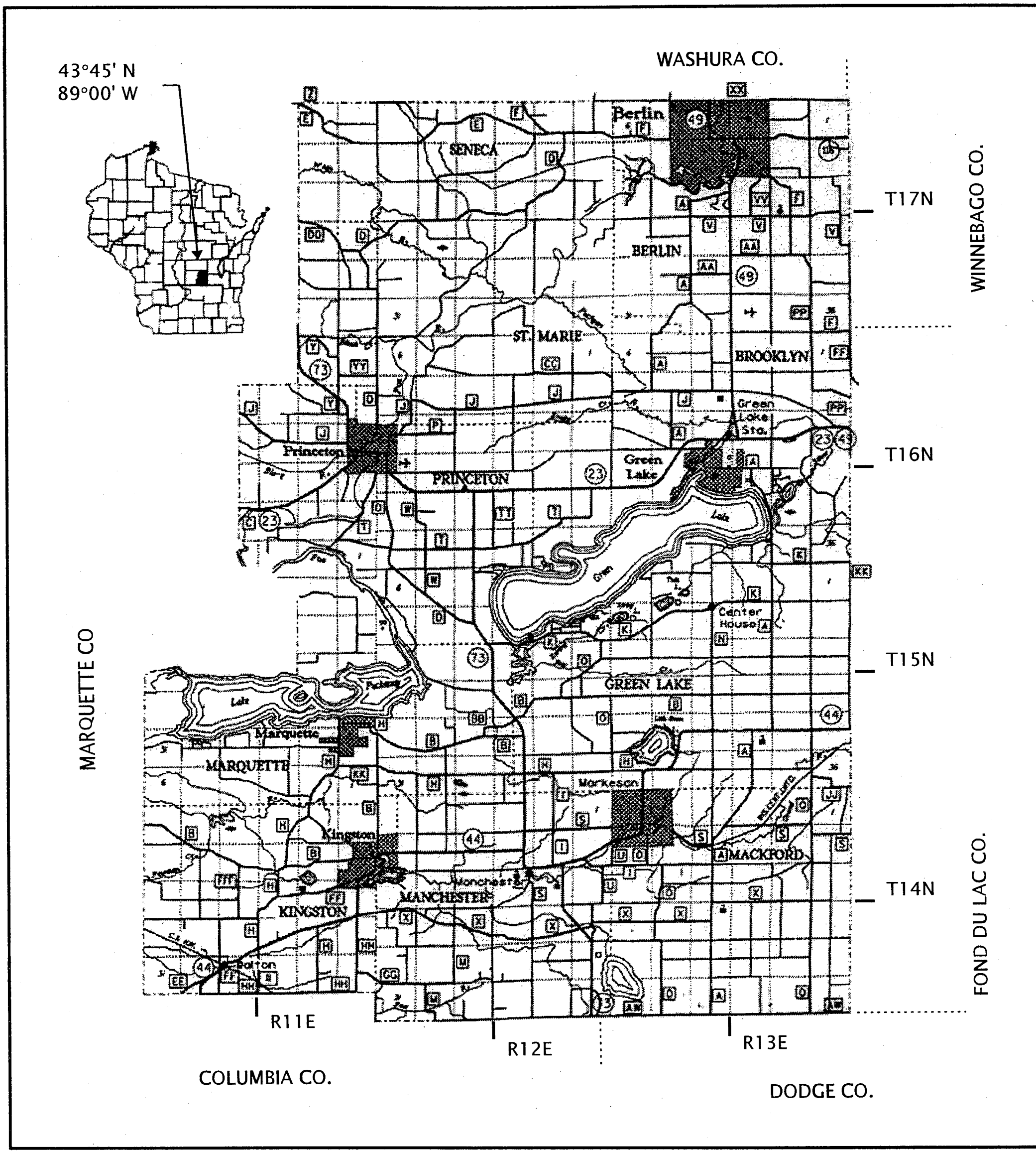

Figure 2. Green Lake County, Wisconsin, highway map (adapted from the Wisconsin Department of Transportation, 1988).

morainal deposits that form low hills and ridges. The southeastern part is formed by a high plain on the backslopes of two dolomitic limestone cuestas, and a smaller area in the southwestern portion of the county is interconnected by knolls and lowlands.

Green Lake County is underlain with five bedrock types that appear in different locations throughout the county. The oldest is Precambrian igneous rock that outcrops as rhyolite at Berlin, Pine Bluff, the abandoned village of Utley, and near Marquette. In the past the igneous bedrock was quarried at all four locations.

The Precambrian rock is overlaid by four younger sedimentary units of Cambrian and Ordovician ages. Cambrian sandstone underlies the Central Plain region and is the upper bedrock for nearly 70% of the county. To the southeast, Ordovician bedrock layers underlie the Eastern Ridges and Lowlands. In the order from oldest to youngest these include Prairie du Chien dolomite, St. Peter sandstone, and Platteville-Galena dolomite and limestone.

Surface features in the county are the result of erosion and deposition by the Green Bay glacial lobe during the Woodfordian stage of Wisconsinan glaciation, 12,000 to 23,000 years before the present (B.P.). Ground moraine covers the high plain in the southeastern portion of the county, while drumlins and outwash deposits are common to the southwestern part. A broken line of recessional moraines were deposited from the northwest corner of the county to the southeast. A recessional moraine forms a morainal dam on the west end of Green Lake and is responsible, in part, for creating Wisconsin's deepest inland lake at 237 ft. Spring Lake, East and West Twin lakes, and Little Green Lake are kettle lakes.

The Woodfordian drift in the northwestern half of Green Lake County is covered by glacio-lacustrine sediments from the Valders stage, 6,000–12,000 years B.P. Wetlands and sandy plains in the northwestern half of the county occupy the extinct lake bed of Glacial Lake Oshkosh (Paull and Paull 1977).

Water Resources

Two of Wisconsin's major drainage systems are present in Green Lake County. The Fox-Wolf River drainage basin drains nearly all of the county except for the southeastern portion of Mackford Township, which is drained by the south branch of the Rock River basin (Fassbender et al. 1970). Major sub-watersheds include the White, Puchyan, and the Grand rivers. Of these, the Grand River system is the largest.

There are 36 lakes and 58 streams in the county, encompassing 18,555 acres, or 8% of the total land area. The four largest rivers comprise 972 acres, or 94% of the total stream area. In the order of greatest area and length these include the Fox, Grand, Puchyan, and White rivers. Approximately 95% of the surface water area is made up by Green Lake, Lake Puckaway, Grand River Marsh, and the Fox River (Fassbender et al. 1970).

The Fox River flows through the northwestern half of the county from southwest to northeast. Tributary streams, while relatively few, are perennial and enter the Fox River at right angles from the northwest and southeast, e.g., the White and Puchyan rivers. With the exception of some potholes and Lake Puckaway, which is actually a widening of the Fox River, the Central Plain region in Green Lake County is devoid of lakes.

Most of the named lakes in the county are located in the southeastern half. The main direction of stream flow is from east to west, with the Grand River being the major flowage present. Compared to the Central Plain, the tributaries of the Eastern Ridges and Lowlands have higher flow gradients, notably during seasonal precipitation and runoff. Intermittent tributaries are more common in the southeastern half of the county due to the presence of heavier soils, which are not conducive to percolation.

Soils

Vegetation patterns and species distribution are closely related to three general soil categories that are present in Green Lake County: loams, sands, and peats. Loams cover the southeastern region and are represented almost exclusively by two major soil associations. The Plano-Mendota-St. Charles and Kidder-Rotamer-Grellton associations include shallow loams on glaciated uplands and account for about 57% of the land area (U.S. Dep. Agr. 1977). These loam soils are derived from glacial dolomitic parent materials and are relatively fertile for agriculture.

The five remaining soil associations are found almost exclusively in the northwestern half of the county. Sandy loams and wind-deposited sands conceal the glacio-lacustrine deposits that were laid down during the Valders stage of glaciation. The sands are mainly derived from calcareous glacial lake deposits and cover the level to rolling plains in the Central Plain region of the county.

Wetlands, which cover about 17% of the county, include peat soils of the Willette-Poy-Poygan and Adrian-Houghton associations (U.S. Dep. Agr. 1977). The mainly acidic and poorly drained peat soils are derived from glacial lake deposits and oxidized plant material. The peat soils are invaluable for absorbing and storing excess water during flooding.

Climate

The continental climate of Green Lake County produces winters that are cold and snowy and summers that are warm and humid. Prevailing winds are westerly in winter and southerly in summer. The mean annual high temperature is 34.2°C, and the mean annual low is -28.6°C (U.S. Dep. Agr. 1977). July is the warmest month and January the coldest. Frost-free days average about 136, ranging from May 13 to September 26. The county receives approximately 30 inches of annual precipitation, 60% of which falls from May to September. The mean annual snowfall totals 39 inches, with an average of 77 days of snow cover of one inch or more.

Presettlement Vegetation

Ethnobotany

Indians were the earliest humans to influence the nature of the vegetation in ways that mostly related to obtaining food (Curtis 1959). There is strong circumstantial evidence that the use of fire by Winnebago Indians, the primary inhabitants of the region, indirectly influenced the vegetation cover (Dorney 1981). The presence of oak savanna and open wetlands vegetation in Green Lake County supports this view because all of these plant communities originate from recurrent fires and depend on periodic burnings for their perpetuation.

Some of the earliest descriptions of the vegetation in the region were made by the French Jesuit missionary, Jacques Marquette. In 1673 Marquette and Louis Joliet traced Jean Nicolet's 1634 exploration of the Fox River. Marquette recorded these observations at the time of their visit to the Mascoutin village, a large Indian encampment within or very near the county's borders:

> I took pleasure in observing the situation of this village. It is beautiful and very pleasing; For, from an Eminence upon which it is placed, one beholds on every side prairies, extending farther than the eye can see, interspersed with groves or with lofty trees. The soil is very fertile and yields much indian corn. The savages gather quantities of plums *[Prunus]* and grapes *[Vitis riparia]*, wherewith much wine could be made if desired. (The Jesuit Relations, 1673–1677, Reuben Gold Thwaites, ed.)

Marquette also observed that "rushes," perhaps *Scirpus* or *Typha,* were used by the Indians for making wigwams. His reference to the scarcity of bark in the region is further evidence of an oak savanna landscape.

> As Bark for making cabins is scarce in this country, They use Rushes; these serve Them for making walls and roofs, but do not afford them much protection against the winds, and still less against the rains when they fall abundantly. The Advantage of Cabins of this kind is, that they make packages of Them, and easily transport them wherever they wish, while they are hunting. (The Jesuit Relations, 1673–1677, Reuben Gold Thwaites, ed.)

Farther upstream from the Mascoutin village, Marquette described the bounty of "wild oats."

> But the road [Fox River] is broken by so many swamps and small lakes that it is easy to lose one's way, especially as the River leading thither is so full of wild oats that it is difficult to find the Channel. (The Jesuit Relations, 1673–1677, Reuben Gold Thwaites, ed.)

"Wild oats" refers to wild rice, *Zizania aquatica* and *Z. palustris,* a notable food crop of the Indians that grew abundantly in the area waterways.

Among the Indian antiquities in Green Lake County, thirteen Indian campsites, three main planting grounds, and numerous food caches have been discovered within the immediate vicinity of Green Lake (Brown 1917). The oak forests that surrounded Green Lake yielded great quantities of acorns, which were ground, dried, and stored in buried caches for use in winter.

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

Maple sugar was made from *Acer saccharum* from at least two localities in climax forest near the east end of Green Lake (Brown 1917). The maple sugar was stored in birch bark baskets that were fashioned from *Betula papyrifera.*

> ...We had no sugar, save maple made by Indians, and this was very dirty. The natives used to pack this sugar in large baskets of birch-bark, and sell it. (Dart 1910)

The area woodlands also supplied wood for fuel, poles and bark for wigwams, and wood for making tools and weapons. Wooden bowls were carved out of ash, *Fraxinus* species, and American basswood, *Tilia americana* (Heiple and Heiple 1976). Shagbark hickory, *Carya ovata,* and red cedar, *Juniperus virginiana,* were utilized to make hunting bows (Brown 1917).

Wild ginseng, *Panax quinquefolium,* may have been one of the few plants in the county that was overharvested by the Indians and later the Europeans, until it was nearly extirpated from the region. The late Mrs. Walter (Polly) Bartel provided this account where *P. quinquefolium* and *Juniperus virginiana* grow near the Bartel farm today:

> Chief Highknocker's family always came out to the Twin Spring Farm [Brooklyn Township, circa 1890], pitched their tents, and picked ginseng *[Panax quinquifolium]* and also Juniper berries *[Juniperus virginiana]*. (Heiple and Heiple 1976)

Among those species reported to have been introduced by Indians, both intentionally and by accident, and which are part of the county flora, are *Acorus calamus, Allium tricoccum, Apios americana, Nelumbo lutea,* and *Prunus americana* (Curtis 1959).

Government Survey Records

The early government land survey records for Green Lake County, circa 1834, contain the most comprehensive record of the vegetation prior to European settlement. The field notes of the surveyors contain references to the vegetation, as well as to specific plants, making it possible to interpret the general vegetation cover for the county. Wherever possible, individual trees that intersected section lines were recorded by the early surveyors, along with bearing trees that helped identify corners. To supplement and verify entries, surveyors recorded a summary of the vegetation along the section lines, and often included sketch maps of each township. When the survey of interior section lines of a township had been completed, a general summary of the vegetation for the township was included.

According to the surveyors' field notes, the original vegetation of Green Lake County was predominantly oak savanna (Finley 1976) (Figure 3). Oak forest was prevalent throughout much of the county, giving way to wetlands vegetation along the lower Grand River and throughout most of the Fox River Valley and its tributaries. Where the oak forest canopy was one-half or more open, surveyors often acknowledged the scattered spacing of trees and recorded the vegetation as oak opening. Because the field notes do not consistently mention the spacing between trees, it is possible that areas of what is mapped as oak forest may have really been oak opening (Finley 1976).

Oak forests in Green Lake County were generally widespread, established along the limestone and dolomitic escarpments in the southeast, as well as on knolls and sandy plains in the northwestern half of the county. Forest trees that are recorded in the field notes include white oak, *Quercus alba;* black oak, *Q. velutina;* bur oak, *Q. macrocarpa;* northern red oak, *Q. borealis;* and shagbark hickory, *Carya ovata.*

Land surveys conducted west of Lake Maria and for areas surrounding most of the eastern half of Green Lake include numerous references to oak openings. The oak opening, a transitional community between oak forest and grasslands, resembles a park-like scattering of individual and small clusters of oak trees with a prairie groundlayer. In the field notes bur oak, *Quercus macrocarpa,* is frequently cited as a marker tree at oak openings.

Where the oaks diminished in numbers, notably on the flat uplands in the southeastern part of the county, the landscape was treeless and covered by mesic prairie. The tallgrass prairie abruptly gave way to climax forest where the Prairie du Chien escarpment overlooks the mouth of Silver Creek, Green Lake's inlet. Marker trees mentioned at this forested site were sugar maple, *Acer saccharum,* and American basswood, *Tilia americana.* A sizable part of this rich climax woodland still exists today as part of Mitchell's Glen.

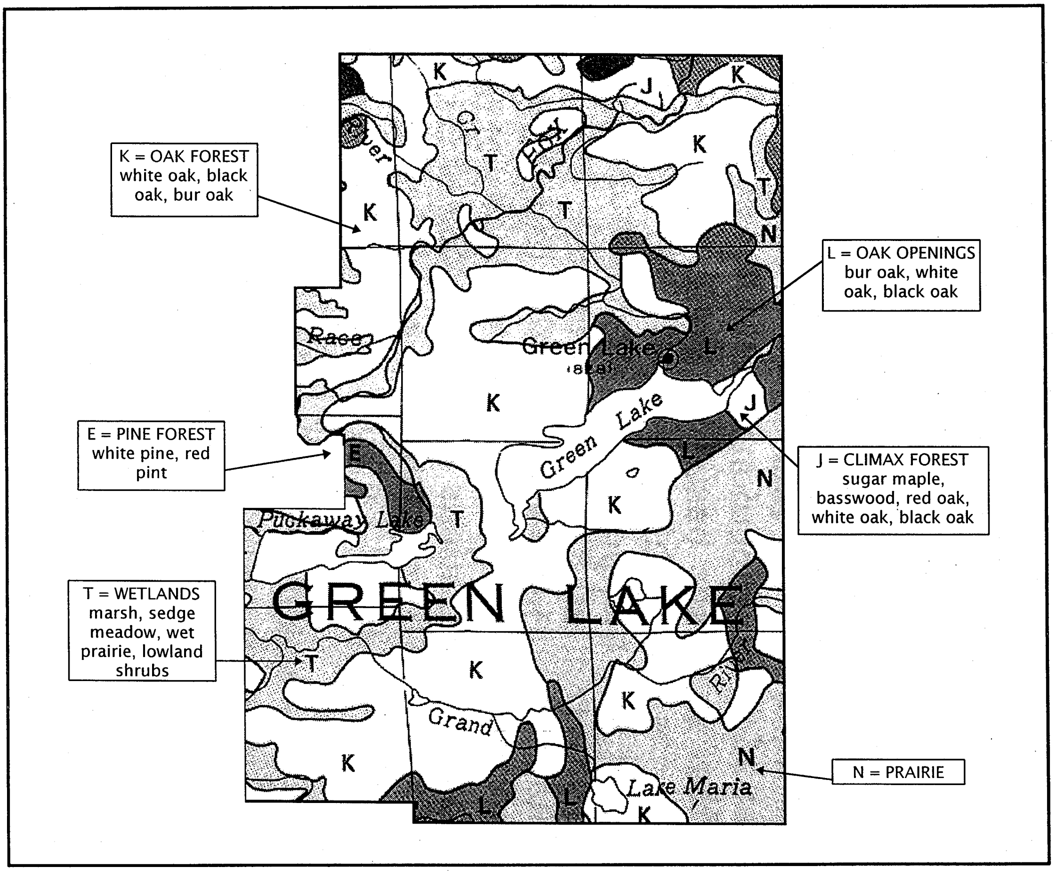

Figure 3. Presettlement vegetation of Green Lake County, Wisconsin, circa 1834 (adapted from Finley, 1976).

Three miles north of Green Lake between sections 14 and 15 at T16N and R12E the field notes describe the area where the Prairie du Chien escarpment and the central plain lowlands converge. For the purpose of clarity, the survey measurements are excluded here.

> Descend a Ledge (sand stone)...W Oak...Enter Tamk swamp *[Larix laracina]*...Leave Tamk swamp & Enter marsh...stream [Snake Creek]...Set post corner sections 10, 11, 14, 15...south of swamp hilly and stoney, third rate Blk & W Oak *[Quercus velutina* and *Q. alba]*. (General Land Office Survey 1834)

At the same township and range, between sections 12 and 13, the field notes read, "Land low wet Marsh...Flagg Rushes Grass." "Flagg" refers to large blue flag, *Iris versicolor,* common to the Snake Creek wetlands, while "Rushes" is a possible reference to *Scirpus.* While low prairies, fens, and sedge meadows were certainly present, they were not distinguished from marsh by the early surveyors.

In 1851 Deputy Surveyor Ira Cook described the township at T15N and R11E, which is located in the southwestern part of Green Lake County and includes Lake Puckaway:

> The land in this township in the Northwestern part is Rolling, in the Southern & Eastern it is level, low & wet. The soil, where it can be cultivated is of a good quality. The timber in some portions of the town is of a good quality consisting of White, Black, Bur & Red Oak & Pine. The Township contains 12 or 13 settlers, besides a good many claims have been made but not yet improved. (General Land Office Survey 1851)

Common names of lowland trees and shrubs mentioned in the field notes at T15N and R11E include black ash, *Fraxinus nigra;* white ash, *F. americana;* silver maple, *Acer saccharinum;* and quaking aspen, *Populus tremuloides.* Speckled alder, *Alnus rugosa,* and willows, *Salix* species, are mentioned as "undergrowth."

A small pine forest extended north of Lake Puckaway to approximately 3 miles south of present-day Princeton. The survey records distinguish "Pine," which is white pine, *Pinus strobus,* from "Black Pine," or red pine, *P. resinosa.* The field notes report that black oak, *Quercus velutina,* and white oak, *Q. alba,* were often mixed in with the pines.

Early Settlement

After the land was surveyed and became available for purchase through the Green Bay Land Office, early settlers were drawn to the area primarily because of agricultural opportunities. Numerous accounts of early settlement recorded by pioneering men and women include the common names of specific plants, as well as references to entire plant communities. In 1840 Anson Dart and his family established the first permanent white settlement on Green Lake. Richard Dart, then twelve years old, later recalled these observations of his family's arrival to Green Lake.

> It took us two days to wind up through the marshes to Green Lake. [From the mouth of the Puchyan River, approximately seven miles.] The last night we camped opposite the present Dartford boat-landing, where the road-bridge crosses toward Sherwood forest resort. It was then surrounded with alders *[Alnus rugosa]* and marshes, and we did not know, that beautiful June night (June 11, 1840), that we were so near the lake. When we passed out from the thickets into Green Lake, the next morning, we shouted with joy!
>
> There was at this time no heavy timber around the lake, except at the foot [Silver Creek inlet], in the marshes—only what were called "clay openings," [oak openings] burned over each autumn by the prairie fires. (Dart 1910)

Soon after the Dart family's arrival to the Green Lake area, they acquired more land. The "clay openings," which consisted of oak savanna vegetation on dry knolls and glacial moraines, were difficult to farm.

> All the while, we were clearing and breaking land. It was thin and poor in the clay openings, and as yet we did not know how to farm to advantage. Father used to repair grist-mills and sawmills as far off as Watertown, leaving us boys to run the farm. Finally we got enough money together to go up on the prairie and buy a "forty" of better land, with richer soil.
>
> ...We got him [Pete Le Roy, the Dart's nearest neighbor] and his ox-team to come over that month and break up for us a half acre that had been cleared by the boys, and in which we planted yellow corn. (Dart 1910)

The rolling prairies and oak openings that merged with wetlands were frequently mentioned by early settlers and visitors in letters and journals. Julia Peck Sherwood, in a letter to her sister Harriet (Hattie) Sage and family, dated August 28, 1854, described a trip from Green Lake to Ripon as follows:

> Last Friday I went with Mr. S [William C. Sherwood] to Ripon, a village about seven miles from Dartford that was the farthest I have rode since I arrived here and the first time that I have past over any green prairie [where Hwy 23 lies between Green Lake and Ripon].
>
> It was a beautifully grand prospect to see one uninterrupted, unbroken undulating meadow as far as the eye could extend towards the Missippie [sic] with occasionally a herd of cattle of thirty or forty, they always keep in companys [sic]. The land was cultivated along where the road passed, or some of it was, but it looks strange to see so few fences where the country looks as if it had been cleared. Mr. S has no prairie, he has one large marsh that serves him for a meadow [wetlands bordering Green Lake Mill Pond], but all the cattle in the vicinity feed on it if they choose, but there is good pasturage in the woods here, the trees are so small and scattering. They are all oaks, and there are places that they call oak openings of many acres that there are no trees or stumps. (Original letter loaned by Clarence F. Busse)

In another section of his narrative, Richard Dart described the prairie wildflowers around Green Lake, circa 1840:

> I wish I could adequately describe the prairie flowers. Every month during spring and summer they grew in endless variety—such fields of changing beauty, I never saw before. It was a flower-garden everywhere. You could gather a bouquet any time, that couldn't be equalled in any greenhouse of New York or Chicago. There were double lady-slippers *[Cypripedium calceolus var. pubescens?]*, shooting-stars *[Dodecatheon meadia]*, field-lilies *[Lilium superbum]* etc., etc. Some of them still linger beside the railway tracks. We tried over and over to transplant them, but only the shooting-stars would stand for the change. There was also the tea-plant *[Ceanothus americanus* L. var. *pitcheri?]*, whose leaves we dried for tea. When in blossom, the oak and clay [prairie] openings, for miles around, were white with it, like buckwheat. We also had splendid wild honey from the bee-trees. (Dart 1910)

Once, while returning from a trip to Ripon, Richard Dart and his companions accidentally found a large wild strawberry patch, Fragaria virginiana.

> We were coming up near where you go down Scott Hill, by a thicket on the prairie, about the site of the old Bailey farm [Section 25, T16N, R13E], when we snuffed a delightful odor—the smell of ripe strawberries. We followed it up and found a place as big as an eighty-acre lot, that had been burned over, all covered with ripe wild strawberries as big as any tame ones you ever saw, and so thick that you could not lay your hand down without crushing berries. The ground was red with them, bushels and bushels for the picking. We carried home our handkerchiefs full, also everything else we had to hold them. (Dart 1910)

From 1843 the accelerated settlement of Green Lake County brought about significant changes in the vegetation. Even though commercial logging did not occur on any appreciable scale, forests played an important role in the development of farming by furnishing the materials for building homes, barns, fences, and bridges.

Richard Dart explained how some of the local timber resources were utilized when his family arrived in 1840.

> We soon crossed the lake and reached our land, of which my father recognized the quarter-section corner. [The original Dart farm was in Section 5, T15N, R13E.] We lugged our stuff up by hand from the lake [near Sandstone Bluff], erected a shanty for shelter, and at once went to work to build a plank house. We split and hewed white oak *[Quercus alba]* planks, about two inches thick by six feet long, and set them upright, two lengths end-to-end twelve feet high, held together by grooved girts or stringers. We used poles for rafters and "shakes" for shingles, the latter shaved out of green oak. (Dart 1910)

Dart also described how they prepared corn meal from yellow field corn, an early staple of the settler's diet.

> There being no mill, we made a huge mortar by boring out a hard, white-oak log, and with a heavy hickory *[Carya ovata]* pestle, we ground our corn. As the mortar held but two quarts, it was only by rising at four o'clock that we could get enough meal pounded for a Johnnie-cake. The coarser part we boiled as samp, for dinner, and had cornmeal fried for supper, with neither milk nor butter. (Dart 1910)

Besides being dependent on local timber resources for constructing their buildings, the early settlers relied on the surrounding oak forests and openings for heating fuel.

> Even after the house was finished it was very cold, for the joints were not tight. We tried to plaster up the cracks with white marl, but when dry this came tumbling off. Sometimes we used old newspapers, as far as we had any, to paste over the cracks. While we had no thermometer to measure the cold, I am sure that the winter of 1843–44 was the worst we ever experienced. . . .
>
> We nearly froze in our rudely-built house, for we had no stove—only a big fireplace, where in twenty-four hours we would sometimes burn two cords of four-foot wood. It took hard work for the boys just to keep the fires going. (Dart 1910)

Great quantities of wood were also burned as the land was cleared for farming. Such fires often escaped and did much damage to the remaining timber by injuring or destroying trees and consuming the accumulated leaf mulch on the ground. It was a common practice to "green up the woods" for pasture by burning. These routine fires were started and left unattended to burn where they would. In some instances, controlled burns were practiced for safety reasons, as explained by Richard Dart: "Every fall we had to burn round everything—house, sheds, and stacks—to save them from these fires that annually swept the prairies" (Dart 1910).

The first commercial production of cranberry *(Vaccinium macrocarpon)* in Wisconsin began in Green Lake County about 1860 (Wis. Dep. Agr. 1958). Natural wetlands were modified for cranberry growing by building irrigation systems and water reservoirs. Some planting was done, but the greater part of the early crops was harvested from the wild marshes in the northern half of the county. In another letter to her sister Hattie, dated November 26, 1854, Julia Peck Sherwood explained that she made "cranberry pie" for Thanksgiving dinner. Not surprising, she did not reveal if the pie was made from local cranberries (original letter loaned by Clarence Busse).

No voucher specimen of *Vaccinium macrocarpon* or any of the associated bog ericads were found during this study. The most likely habitats, tamarack swamps and boggy meadows, are lacking most typical bog species. It is conceivable that early efforts to promote cranberry production eventually contributed to the extirpation of entire relic bog communities.

Similarly, wetlands that bordered Green Lake were altered greatly by the construction of artificial impoundments. Before the Dartford dam was built in 1841, a lowland forest occupied the eastern shore of Green Lake. After the waters of the lake were raised, much of this land was submerged, killing the trees that were later removed, thereby creating more open water (Brown 1917).

Until 1890 steamboats carrying freight and passengers on the Upper Fox River from Lake Winnebago to the Wisconsin River at Portage played an important role in the settling of the county. Wetlands in the Fox River Valley were modified or completely eliminated near Berlin, Princeton, and on the White River because of dredging activities and the installation of locks on the Fox. Portions of Green Lake, Berlin, Princeton, Kingston, and Marquette are built on former wetlands that have been almost entirely drained and filled in.

Water transportation was replaced by railroads after the first train arrived at Berlin in 1857. The railroad system enhanced development of the territory and further divided the unbroken expanses of oak savanna vegetation. Ironically, the right-of-way embankments along some railroads and abandoned railways harbor original oak opening and prairie remnants.

Noteworthy Plants

Two state endangered species are known from Green Lake County, *Armoracia lacustris* and *Scirpus cespitosus* var. *callosus.* Lake-cress, *Armoracia lacustris,* is a lake macrophyte that was last collected in Green Lake in 1921 and it is uncertain whether it is still extant in the county (Patman and Iltis 1961). *Scirpus cespitosus,* a common arctic species, is very local to calcareous fens and has a limited distribution statewide.

State threatened species include *Cypripedium candidum, Gentiana flavida, Habenaria flava* var. *herbiola, Opuntia fragilis, Parthenium integrifolium, Polytaenia nuttallii,* and *Tofieldia glutinosa.*

Of the various plant communities in Green Lake County, fens are the least common. Locally, fens are mainly situated in the southeastern half of the county where they reside along the base of dolomitic limestone escarpments. Threatened and endangered fen species, *Cypripedium candidum, Scirpus cespitosus,* and *Tofieldia glutinosa,* occur in a calcareous fen that is part of the Snake Creek Wetlands state natural area. At the same site, a small collection of rare sedges grows in and around the perimeter of calcareous seepages: *Carex limosa, Cladium mariscoides, Eleocharis robbinsii, Rhynchospora alba, R. capillacea,* and *Scleria verticillata.* Other non-sedge species associated with this assemblage are *Hypericum kalmianum, Juncus alpinus, J. brachycephalus, Liparis loesellii, Triglochin maritima,* and *T. palustris.* It is interesting to note that *Gentianopsis procera,* which thrives in a different Snake Creek fen less than one-half mile away, is absent at this site, even though other fen indicators are common to both locations.

Gentiana flavida and *Habenaria flava* var. *herbiola,* along with *Habenaria lacera, Scleria trigomerata, Asclepias hirtella,* and *Hypericum gentianoides,* are established on moist sand prairies and meadows in the old lakebed of Glacial Lake Oshkosh. Also associated with the extinct lake bed are disjunct species that are members of the Atlantic Coastal Plain element—*Aletris farinosa, Bartonia virginica, Panicum commonsianum* var. *euchlamydeum, Rhexia virginica, Scleria verticillata,* and *Xyris torta.* It is conceivable that they became established during post-glacial times via migrating waterfowl (Read 1976).

A single specimen of *Parthenium integrifolium* was observed in 1995 in an old field that is partly restored to upland prairie. It is possible that the seeds of *P. integrifolium* were present in a seed pool of the old field and did not germinate until after restoration efforts in 1983. The property owners are confident they did not knowingly or unknowingly introduce *P. integrifolium* to the site.

While most of the original oak openings in Green Lake County are gone, a few small remnants persist. Among the rarer species of oak openings in the county are *Arctostaphylos uva-ursi, Monotropa hypopithys,* and *Spiranthes lacera,* known from Pine Bluff; *Talinum rugospermum,* from a roadside opening north of Lake Puckaway; and *Polytaenia nuttallii,* which is exclusive to the Puchyan Prairie, a state natural area.

A native grass, *Muhlenbergia richardsonis,* previously unknown in Wisconsin, was discovered at the Berlin Fen, a state scientific natural area, in August 1989 (Eddy and Harriman 1992). I have botanized in fens and calcareous meadows that are floristically similar to the Berlin Fen but have not found *M. richardsonis* in any of them.

Natural Areas

Natural areas in the county that are regulated by the Wisconsin Department of Natural Resources comprise wildlife areas, refuges and scientific natural areas. The White River Wildlife Area, Grand River Marsh, and the Fox River Public Access are among the larger management and refuge areas. In addition, four Wisconsin Natural Areas are established in the county: Puchyan Prairie, section 1, T16N, R12E; Fountain Creek Prairie, sections 8 and 17, T14N, R11E; and Berlin Fen, section 12, T17N, R13E. In 1994 the Green Lake Chapter Izaak Walton League deeded approximately 18 acres of high quality fen, low prairie, and sedge meadow habitats to the Department of Natural Resources. This property, section 14, T16N, R12E, was dedicated as a state natural area in 1995 and is named the Snake Creek Wetlands.

On a county level, natural areas that are part of any one of the six parks are protected. The largest, Dodge County Park, encompasses a wetlands complex and the lower branch of Roy Creek, a tributary of Green Lake at section 15, T15N, R12E.

Private organizations have also taken measures to protect natural areas. The Green Lake Chapter Izaak Walton League owns and manages approximately 15 acres of wetlands within the Snake Creek corridor in sections 13, 14 and 15, T16N, R12E. The Snake Creek Wetlands Trail, a public hiking trail, is established on an abandoned railroad embankment. In addition, the Green Lake Chapter owns and manages more than 100 acres of wetlands in sections 17 and 18, T17N, R13E. This property, called the Mascouten Fox River Wetlands, is protected from development by a conservation easement.

Other private lands that feature quality natural areas include the Mitchell's Glen area, section 35, T16N, R13E; Pine Bluff, section 1, T17N, R11E; and the Upper Fox River area southwest of Princeton, T15N, R11E.

Catalog Sources

The catalog of species is a list of vascular plants that grow or have grown without cultivation in Green Lake County, Wisconsin. Cultivars that may have escaped and are reproducing spontaneously are included.

A "record" in the context of this paper refers to any herbarium voucher that verifies the existence of a plant that is, or has been, a member of the county flora. Plant records are based mainly on specimens in the University of Wisconsin-Oshkosh herbarium (OSH) that were collected from 1979 to 1996.

Some records include specimens that are represented in the herbaria at UW-Madison and UW-Milwaukee, while others, notably from the Potamogetonaceae, are supported by vouchers that are part of a teaching collection at Ripon College, Ripon, Wisconsin. All Green Lake County specimens cited in the catalog have been examined and verified.

Species mapped for Green Lake County in the "Preliminary Reports on the Flora of Wisconsin," but for which vouchers were not located, *are not* included in the catalog. These include *Lycopodium tristachyum* and *Cheilanthes feei* (Peck 1982); *Panicum columbianum* (Fassett 1951); *Viburnum rafinesquianum* var. *rafinesquianum* (Salamun 1979); *Silene stellata* (Schlising and Iltis 1961); *Vaccinium macrocarpon* (Fassett 1929); *Acalypha gracilens* (Richardson et al. 1987); *Petalostemum candidum* (Fassett 1961); *Gentiana rubricaulis* (Mason and Iltis 1965); *Epilobium leptophyllum* (Ugent 1962); *Lysimachia lanceolata* (Iltis and Shaughnessy 1960); *Salix rigida (S. eriocephala)* (Argus 1964); and *Agalinis gattingeri* and *Penstemon hirsutus* (Salamun 1951).

Species reported in the Natural Areas Inventory, but which are not supported with herbarium vouchers, *are not* listed in the catalog. Among those species regarded as possible sightings are *Carex haydenii, Bromus kalmi, Apocynum cannabinum, Asclepias ovalifolia, Asclepias viridiflora, Aster ptarmicoides (Solidago ptarmicoides),* and *Utricularia intermedia* (Wis. Dep. Nat. Res. 1977–1979).

Asclepias lanuginosa, a state threatened species, is among the plants listed in a Bureau of Endangered Resources publication entitled *Rare, Threatened and Endangered Species and Natural Communities in Green Lake County* (Wis. Dep. Nat. Res. 1994). Since *A. lanuginosa* is not supported by a herbarium specimen, it is not included in the catalog. The plant, which was identified during field surveys for the Natural Heritage Inventory, appears in the publication based solely on reports submitted by a reliable observer and a 1986 photograph (Elizabeth Simon, personal communication, 27 June 1996). I have been unable to locate a specimen of *A. lanuginosa* in the county, despite explicit directions and detailed field notes that were generously provided for me (Richard Barloga, personal communication, 28 June 1996).

Catalog Design

Plant families are alphabetized within the major plant groups, as are the genera and species within a family. Nomenclature strictly follows Gleason and Cronquist (1991). Due to the magnitude of this study, the treatment of narrowly defined species and most infraspecific taxa are avoided, as well as a listing of synonyms.

For most species a brief habitat description and the frequency of occurrence are stated. Mention of specific locations are mostly avoided to ensure privacy for private landowners and dissuade indiscriminate botanizing by overzealous plant collectors. Section, township and range locations, however, are included on herbarium labels for each species in the catalog.

The collectors and collection numbers are cited for all species listed in the catalog, with most of these represented by specimens at OSH. Catalog records not represented by vouchers at OSH are cited with the respective herbaria from which specimens have been examined and verified. These include WIS (UW-Madison) and UWM (UW-Milwaukee). RIP denotes records for specimens that are part of a teaching collection at Ripon College, Ripon, Wisconsin.

State threatened and endangered plants in the catalog are based on the most recently published list prepared by the Wisconsin Bureau of Endangered Resources (Wis. Dep. Nat. Res. 1993).

Summary of Taxa

Presently, the county flora comprises 921 cataloged species. A summary of the number of families, genera, and species for the major plant groups is shown in Table 2.

The monocots are largely represented by the Poaceae and Cyperaceae, which, when combined, account for 66.8% of the total number of monocots. Nearly one-fifth, or 18.4%, of the dicots are represented by a single family, the Asteraceae. A comparison of the three largest monocot and dicot families is presented in Table 3.

Table 2. Summary of major plant taxa in Green Lake County

Plant Group	*Families*	*Genera*	*Species*
Pteridophytes	10	17	31
Gymnosperms	2	4	8
Monocotyledons	21	103	283
Dicotyledons	85	305	599
TOTALS	118	429	921

Table 3. Comparison of the three largest Monocot and Dicot Families

Monocots	*Genera*	*Species*	*% of total Green Lake County Flora*
Poaceae	46	107	11.6%
Cyperaceae	9	82	8.9%
Liliaceae	16	20	2.2%
Dicots			
Asteraceae	50	110	11.9%
Rosaceace	15	40	4.3%
Fabaceace	18	34	3.7%

CATALOG OF SPECIES

Division Lycopodiophyta

LYCOPODIACEAE (Clubmoss Family)

Lycopodium digitatum Dillen. Oak woods. Rare. (Eddy 4110)

L. lucidulum Michx. Rare, known from one site; moist oak woods. (Harriman 1255)

SELAGINELLACEAE (Selaginella Family)

Selaginella rupestris (L.) Spring. Local on rhyolite outcrops. (Harriman 1249; Underwood 232)

Division Equisetophyta

EQUISETACEAE (Horsetail Family)

Equisetum arvense L. Roadsides, railroad cinders, old fields. Common. (Eddy 2207; Trotter 229)

E. x *ferrissii* Clute. (Eddy 409, 509)

E. fluviatile L. Marshes, wet ditches. (Eddy 207, 349, 1678)

E. hyemale L. var. *affine* (Engelm.) A. A. Eaton. (Peters 005, WIS)

E. laevigatum A. Braun. (Eddy 1531; Harriman 793, 18292; Kohlman 673)

E. x *litorale* Kuhlewein *ex* Rupr. (Fassett 8799, WIS)

Division Polypodiophyta

ADIANTACEAE (Maidenhair Fern Family)

Adiantum pedatum L. ssp. *pedatum.* Deciduous woods. Uncommon. (Harriman 734; Hockman s.n.; Galster s.n.)

Pellaea glabella Mettenius. Shaded dolomitic cliffs. Uncommon. (Eddy 2218; Harriman 16680)

ASPLENIACEAE (Spleenwort Family)

Asplenium rhizophyllum L. Local on moist, shaded cliffs. (Rill 7071)

Athyrium filix-femina (L.) Roth. var. *michauxii* Mettenius. Deciduous woods. Common. (Eddy 176, 1525, 1728, 1873, 1928; Harriman 1252, 1253; Weinkauf 1050; Underwood 236)

Cystopteris bulbifera (L.) Bernh. Shaded dolomitic outcrops. Uncommon. (Eddy 180, 181, 2412)

C. fragilis (L.) Bernh. var. *fragilis.* Shaded dolomitic outcrops. Uncommon. (Eddy 2205; Harriman 16681A; Hockman s.n.)

Dryopteris carthusiana (Villars) H. P. Fuchs. Swamps, wet woods. Common. (Eddy 1514, 2703; Harriman 821)

D. cristata (L.) A. Gray. Swamps. Common. (Eddy 1729, 2389, 2704; Harriman 2071)

D. intermedia (Muhl.) A. Gray. Moist woods. (Eddy 1747; Shaver 047)

Thelypteris palustris Schott. var. *pubescens* (Lawson) Fern. Common in wetlands. (Eddy 1761, 1931, 2025)

Woodsia ilvensis (L.) R. Br. Local on rhyolite outcrops. (Cochrane et al. 6109; Eddy 1505, 1799; Underwood 235)

W. obtusa (Sprengel) Torr. Local on rhyolite outcrops. (Eddy & Sonntag 2103; Harriman 16681)

DENNSTAEDTIACEAE (Bracken Family)

Pteridium aquilinum (L.) Kuhn. var. *latiusculum* (Desv.) Underw. Wooded openings, roadsides. Common. (Pucker 1433)

ONOCLEACEAE (Sensitive Fern Family)

Matteuccia struthiopteris (L.) Todaro. Swamps, wet woods, escape from plantings. (Eddy 4208)

Onoclea sensibilis L. Common in wetlands. (Eddy 1560)

OPHIOGLOSSACEAE (Adder's Tongue Family)

Botrychium dissectum Spreng. Uncommon. (Underwood 1320)

B. multifidum (S. G. Gmelin) Rupr. (Pratt s.n., WIS)

B. virginianum (L.) Swartz. Moist oak woods. (Buchholtz 1243; Eddy 168, 1755, 2053; Harriman 733; Hockman s.n.)

OSMUNDACEAE (Royal Fern Family)

Osmunda cinnamomea L. Moist woods. (Harriman 823)

O. claytoniana L. Moist open woods, swamps, wet ditches. Uncommon. (Eddy 1463, 1875)

O. regalis L. var. *spectabilis* (Willd.) A. Gray. Swamps, sedge meadows, wet ditches. (Eddy 532; Harriman 776; Hockman 038)

POLYPODIACEAE (Polypody Family)

Polypodium virginianum L. Local on moist shaded rock outcrops. (Eddy 1788, 2169; Harriman 16682; Shaver 049; Underwood 234)

Division Pinophyta

CUPRESSACEAE (Cypress Family)

Juniperus communis L. Dry rocky woods. Common. (Krysiak 011)

J. virginiana L. Disturbed woods and dry hillsides. Common. (Buchholtz 1360; Burbey 006; Eddy 2632; Kampa 033; Krysiak 012; Kuen 026; Schroeder 005; Schultz 067)

Thuja occidentalis L. (Pichette 044)

PINACEAE (Pine Family)

Larix laricina (Duroi) K. Koch. Dominant tree of conifer swamps. (Eddy 708; Hockman 123; Kampa 021)

Pinus banksiana Lambert (Eddy 4200)

P. resinosa Aiton. Originally native to the county, now occasionally spreading from pine plantings, along with *P. strobus.* (Eddy 4199)

P. strobus L. See *P. resinosa.* (Kyrsiak 009; Schultz 061)

P. sylvestris L. Planted and occasionally escaped. (Kampa 032)

Division Magnoliophyta

Class Magnoliopsida (Dicotyledons)

ACERACEAE (Maple Family)

Acer negundo L. Disturbed woods, fencerows, roadsides. Common. (Draheim 006; Nyman 062; Shaver 044)

A. rubrum L. Moist woods. Common. (Weinkauf 1230)

A. saccharinum L. A dominant tree of low forests. (Pinchette 047)

A. saccharum Marshall. Rich woods; co-dominant tree with *Tilia americana* in climax forest. (Eddy 4210)

AMARANTHACEAE (Amaranth Family)

Amaranthus albus L. Common weed. (Underwood 223)

A. hybridus L. Common weed. (Draheim 117)

A. retroflexus L. Common weed. (Draheim 062; Pucker 094; Zeitler 199)

A. tuberculatus (Moq.) Sauer. Wetlands. (Eddy 2637, 2723)

ANACARDIACEAE (Cashew Family)

Rhus aromatica Aiton var. *aromatica.* Known from one site; a prairie restoration site at the Green Lake Center. Probably an escaped cultivar. (Eddy 4191)

R. copallinum L. Local in dry woods and oak openings at Pine Bluff, a rhyolite rock outcrop. (Eddy 1801; Underwood 860)

R. glabra L. Roadsides, railroads, wooded openings. Common. (Draheim 023; Nyman 068; Krauth 140; Pucker 080)

R. typhina L. Roadsides, wooded openings. Less common than *R. glabra.* (Bennett 229)

Toxicodendron radicans (L.) Kuntze. Disturbed woods, paths, clearings. Locally abundant. (Eddy 1813; Gorsuch 121; Harriman 735; Nyman 066)

T. vernix (L.) Kuntze. Local in *Larix* swamps. (Eddy 039)

APIACEAE (Carrot Family)

Angelica atropurpurea L. Marshes, wet ditches, sedge meadows. Common. (Eddy 130; Harriman 513; Nelson s.n.)

Carum carvi L. Garden escape. (Draheim 011; Pucker 622)

Cicuta bulbifera L. Marshes, sedge meadows, wet ditches. Common. (Chier 1169; Eddy 974)

C. maculata L. Marshes, sedge meadows, wet ditches. (Habighorst 045)

Cryptotaenia canadensis (L.) DC. Moist woods. (Eddy 2329)

Daucus carota L. Roadside weed. (Eddy 4163)

Heracleum lanatum Michx. Moist ditches, low thickets. (Draheim 017)

Osmorhiza claytonii (Michx.) C. B. Clarke. Woods. Common. (Eddy 1744; Hockman s.n.)

O. longistylis (Torr.) DC. Woods. (Eddy 196; Harriman 772)

Oxypolis rigidior (L.) Raf. Low prairies, sedge meadows, marshes, wet ditches. Common. (Eddy & Rill 2022; Kohlman 1293)

Pastinica sativa L. Common weed. (Eddy & Harriman s.n.)

Polytaenia nuttallii DC. Known from one site; Puchyan Prairie, a state scientific natural area. STATE THREATENED (Eddy 2358)

Sanicula gregaria E. Bickn. Woods. (Eddy 010, 2321)

S. marilandica L. Woods. (Eddy 009, 516; Pucker 632)

Sium suave Walter. Sedge meadows, marshes, swamps. (Eddy 1688)

Zizia aptera (A. Gray) Fern. Known from one site; remnant dry prairie. (Eddy & Harriman 19689)

Z. aurea (L.) Koch. Mesic prairies. Common. (Eddy 2139; Pucker 631; Underwood 494, 854)

APOCYNACEAE (Dogbane Family)

Apocynum androsaemifolium L. Roadsides, railroads, oak openings. Common. (Draheim 027; Eddy 275; Harriman 1117; Hockman s.n.)

A. sibericum Jacq. Roadsides. Uncommon. (Eddy 2647)

Vinca minor L. Garden escape. (Burbey 061; Dubester 059; Rohlfs 039)

AQUIFOLIACEAE (Holly Family)

Ilex verticillata (L.) A. Gray Swamps. (Eddy 1601; Harriman 1246, 18930; Kohlman 1322)

ARALIACEAE (Ginseng Family)

Aralia nudicaulis L. Woods. Common. (Harriman 684)

A. racemosa L. Rich woods. Uncommon. (Eddy 1876, 2469; Harriman 18934)

Panax quinquefolium L. Moist wooded slopes. Rare. (Galster 1196; Misterek 131)

ARISTOLOCHIACEAE (Birthwort Family)

Asarum canadense L. Moist woods. Locally abundant. (Eddy 1399)

ASCLEPIADACEAE (Milkweed Family)

Asclepias amplexicaulis J. E. Smith. Dry prairies, oak openings. Uncommon. (Eddy 2421, 2669; Hockman 072)

A. exaltata L. Woods, openings. Uncommon. (Eddy 1972; Hockman s.n.)

A. hirtella (Pennell) Woodson. Sand prairies. Rare. (Eddy 2645, 3068; Underwood 815)

A. incarnata L. Wetlands. Common. (Draheim 059; Eddy 637; Harriman 1169; Jennings 265; Lindvall 159)

A. syriaca L. Roadsides, fields, disturbed soils. Common. (Harriman 1163)

A. tuberosa L. Mesic prairies, roadsides. Common. (Harriman 1162; Laurent 029)

A. verticillata L. Roadsides, waste places. Common. (Eddy 747; Harriman 1208, 1259; Kasierski 004; Weber 039)

ASTERACEAE (Aster Family)

Achillea millefolium L. Roadsides, prairies, old fields. Common. (Eddy 132; Harriman 779; Nelson s.n.; Pucker 213; Weiss 176; Zeitler 231)

Ambrosia artemisiifolia L. Common weed. (Draheim 073; Lindvall 166; Pucker 067; Supple 215; Underwood 240)

A. trifida L. Common weed. (Eddy 1857;

Manthei 203; Manthei & Bennett 222; Salzman 076; Zietler 212)

Anaphalis margaritacea (L.) Benth. & Hook. Dry openings. Common. (Harriman 1233)

Antennaria neglecta Greene. Forming dense patches in dry openings, on lawns. Common. (Eddy 233, 263; Schroeder 004)

A. plantaginifolia (L.) Richardson. Dry openings, fields. (Eddy 13, 252; Hockman s.n.)

Anthemis cotula L. Common weed. (Draheim 064; Eddy 827)

Arctium minus Schk. Common weed. (Draheim 052; Zeitler 215)

Artemisia biennis Willd. (Zeitler 222)

A. campestris L. Sandy soils. (Eddy 2175)

A. ludoviciana Nutt. Upland prairies, roadsides. (Eddy 2639)

Aster borealis Prov. Low prairies, fens, sedge meadows. Locally abundant. (Eddy 1943; Galster 1075; Underwood 1178)

A. ciliolatus Lindley. Woods. (Misterek 146)

A. ericoides L. Prairies, roadsides. Common. (Bennett 220; Jennings 260)

A. firmus Nees. Low prairies. (Draheim 111; Nyman 059; Habighorst 158)

A. hesperius A. Gray. Low prairies, sedge meadows. Uncommon. (Eddy 1911)

A. laevis L. Prairies. Common. (Eddy 2059; Pucker 093; Macfarlane 113)

A. lanceolatus Willd. var. *lanceolatus.* Prairies, fields, roadsides. Common. (Breitlow 201; Eddy 1777, 1905; Salzman 074; Underwood 1190; Weiss 160; Zeitler 224)

A. lateriflorus (L.) Britton. Oak openings, prairies. Common. (Briscoe s.n.; Draheim 096; Jansen 222; Supple 194; Wepner 003; Zeitler 207)

A. linariifolius L. Dry sandy openings. Rare. (Harriman 1240)

A. novae-angliae L. Low prairies, sedge meadows, roadsides. Common. (Bennett 213; Eddy 2176; Gorsuch 122; Jennings 233; Mateyka 059; Underwood 221; Weiss 169; Zeitler 221)

A. oolentangiensis Riddell. Upland prairies, oak openings. Common. (Bennett 205; Buchholtz 1142; Draheim 205; Harriman 1231; Lindvall 158; Mittelstaedt 243; Taves 905)

A. pilosus Willd. Dry sandy openings. (Coburn s.n.; Jansen 222)

A. puniceus L. Larix swamps. (Whinney s.n.)

A. sagittifolius Willd. Oak openings, prairies, roadsides. Common. (Mittelstadet 238; Turner 013)

A. sericeus Vent. Oak openings, prairies. (Harriman 1206; Weiss 070)

A. umbellatus Miller. Low prairies, sedge meadows, fens. Locally abundant. (Eddy & Rill 1024; Eddy 1989; Underwood 1186; Whirry 774)

Bidens aristosa (Michx.) Britton. Marshes, sedge meadows. (Habighorst 040)

B. cernua L. Wet ditches, shores, marshes. Common. (Draheim 140; Eddy 784, 2172; Jennings 241; Krauth 146; Nyman 063; Weiss 167)

B. connata Muhl. Moist or wet waste places. (Zeitler 229)

B. coronata (L.) Britton. Marshes, sedge meadows. Common. (Buchholtz 1366; Harriman 18972; Weiss 154)

B. frondosa L. Marshes, sedge meadows. Common. (Brudnicki 134; Harriman 1247, 18980)

Cacalia suaveolens L. Local on sandy flats on Lake Puckaway. (Harriman 13214; Underwood 1166)

Carduus nutans L. Old pastures. (Eddy 4215; Eddy & Harriman s.n.)

Centaurea maculosa Lam. Common roadside weed. (Eddy 2635)

Chrysanthemum leucanthemum L. Common weed. (Draheim 022)

Chrysopsis villosa (Pursh) Nutt. var. *angustifolia* (Rybd.) Cronq. Dry sandy openings. Uncommon. (Jansen 220)

Cichorium intybus L. Roadside weed. (Eddy 4172)

Cirsium altissimum (L.) Sprengel. Open woods. (Harriman 18998)

C. arvense (L.) Scop. Common weed. (Eddy 4162)

C. muticum Michx. Sedge meadows, low prairies, fens. Common. (Eddy 766, 1934, 2161; Underwood 211, 1183; Weiss 148; Zeitler 227)

C. vulgare (Savi) Tenore. Uncommon weed. (Jennings 270; Misterek 127; Turner 040)

Conyza canadensis (L.) Cronq. Common weed. (Bennett 194; Jansen 216; Pucker 068)

Coreopsis palmata Nutt. Prairies. Common. (Eddy 749, 2102; Harriman 2085)

Crepis tectorum L. Common weed. (Eddy 2545, 2557)

Erechtites hieraciifolia (L.) Raf. Various habitats recently burned over. (Harriman 13209)

Erigeron annuus (L.) Pers. Common weed. (Eddy 2372)

E. philadelphicus L. Roadsides, openings. Common. (Draheim 018; Eddy 1566; Nelson s.n.; Pucker 619; Taves 445)

E. pulchellus Michx. Open woods. Uncommon. (Draheim 019; Harriman 727)

E. strigosus Muhl. Common weed. (Harriman 1244)

Eupatorium maculatum L. Low prairies, sedge meadows, damp thickets. Common. (Habighorst 068; Nyman 054; Zeitler 219)

E. perfoliatum L. Low prairies, sedge meadows. Common. (Habighorst 171; Kasierski 008; Zeitler 228)

E. purpureum L. Openings, thickets. Uncommon. (Davis s.n.)

E. rugosum Houttuyn. Woods, thickets. (Davis s.n.; Draheim 093; Harriman 16679; Wepner 004)

Euthamia graminifolia (L.) Nutt. Mesic prairies. (Weiss 161)

Gaillardia pulchella Foug. Sandy oak openings. (Draheim 037)

Galinsoga quadriradiata Ruiz & Pavon. Common weed. (Eddy 616; Turner 213)

Gnaphalium obtusifolium L. Dry openings, pastures. (Draheim 091; Galster 811; Harriman 1263; Mittelstaedt 110, 236; Supple 189; Weber 037)

Grindelia squarrosa (Pursh) Dunal. var. *squarrosa.* Roadsides. Uncommon. (Eddy 1829; Harriman 4189)

Helenium autumnale L. Low prairies, sedge meadows, fens. Common. (Breitlow 200; Draheim 069; Jennings 255; Misterek 126; Supple 270; Underwood 216, 1193; Weiss 146; Whirry 1081; Zeitler 226)

Helianthus annuus L. (Breitlow 204)

H. decapetalus L. Oak openings, thickets. Common. (Davis s.n.)

H. giganteus L. Roadsides, thickets. Common. (Draheim 068; Eddy 783, 2149; Habighorst 048)

H. grosseserratus Martens. Roadsides. (Eddy 4166)

H. hirsutus Raf. Dry woods, openings. (Berlowski 039; Turner 043).

H. occidentalis Riddell. Oak openings, upland prairies. Common. (Eddy 1910, 2119; Harriman 1236)

H. strumosus L. Openings, roadsides. (Buchholtz 1016; Eddy 1886; Harriman 1257; Jennings 1237)

H. tuberosus L. Roadsides, waste places. (Breitlow 202)

Heliopsis helianthoides (L.) Sweet. var. *scabra* (Dunal.) Fern. Openings, prairies. (Davis s.n.; Harriman 1174)

Hieracium aurantiacum L. Common weed. (Draheim 016; Eddy 266; Harriman 510, 1892)

H. caespitosum Dumort. Common weed. (Draheim 015; Eddy 012, 709, 1516)

H. kalmii L. Dry openings. (Eddy 408, 1105; Harriman 18977)

H. longipilum Torr. Dry openings. Uncommon. (Eddy 1956, 2627; Harriman 2071)

H. scabrum Michx. Dry openings. Common. (Eddy 1919, 1947, 2684; Harriman 1235)

H. umbellatum L. Openings, thickets. Uncommon. (Eddy 1912, 1919-A, 2056; Harriman 1238)

Krigia biflora (Walter) S. F. Blake. Mesic prairies. Uncommon. (Eddy 690, 2136; Harriman 794, 1848; Underwood 830)

K. virginica (L.) Willd. Sandy openings. Uncommon. (Harriman 18293)

Kuhnia eupatorioides L. var. *corymbulosa* T. & G. Dry sandy openings. (Eddy 835; Harriman 1205, 1256)

Lactuca biennis (Moench) Fern. Thickets. (Draheim 098; Eddy 4153; Harriman & Rill s.n.)

L. canadensis L. Common weed. (Davis s.n.; Eddy 2584; Harriman & Rill s.n.; Kuen 020; Underwood 828)

L. ludoviciana (Nutt.) DC. (Harriman & Rill s.n.)

Lapsana communis L. Uncommon weed of rhyolite outcrops. (Eddy 1754)

Liatris aspera Michx. Mesic prairies. Common. (Bennett 225; Habighorst 161; Harriman 1260; Kasierski 006; Underwood 237; Wiest 071)

L. ligulistylis (A. Nels.) K. Schum. Mesic prairies. Rare. (D. Chier 1077)

L. pycnostachya Michx. Mesic prairies. Common. (Eddy 050, 1945, 1949)

Matricaria matricarioides (Less.) Porter. Common weed. (Eddy & Harriman s.n.)

Parthenium integrifolium L. Rare, known from one site; old field restored, in part, as upland prairie. (The property owners are confident they did not introduce *P. integrifolium* to the site.) A single specimen observed and conservatively top-picked. STATE THREATENED. (Eddy & Schultz 4218)

Prenanthes alba L. Woods, thickets. (Buchholtz 1011; Eddy 2158, 2721; Habighorst 064; Kasierski 007; Kohlman 1300)

P. racemosa Michx. Mesic prairies. Less common than *P. alba.* (J. Linde 1375)

Ratibida pinnata (Vent.) Barnhart. Upland prairies. (Eddy 4157)

Rudbeckia hirta L. Upland prairies. Common. (Eddy 515; Harriman 1168, 1881)

Senecio pauperculus Michx. Peaty soils. Common. (Dean 023; Eddy 131, 2137)

S. plattensis Nutt. Dry prairies. Uncommon. (Harriman 809, 1845)

Silphium terebinthinaceum Jacq. Mesic prairies, roadsides. Common. (Eddy 2624; Pucker 1139)

Solidago canadensis L. Prairies, old fields, roadsides. Common. (Anderson s.n.; Habighorst 053; Harriman 1166; Underwood 226; Weiss 162; Zeitler 210)

S. flexicaulis L. Woods, openings. Common. (Eddy 818; Misterek 132)

S. gigantea Aiton. Openings. (Eddy 1916; Michels 022; Pucker 1064)

S. nemoralis Aiton. Oak openings. Common. (Eddy 1103, 1869; Jennings 265; Mittelstaedt 240; Underwood 243; Weber 030)

S. riddellii Frank. Fens, calcareous seepages in low prairies, sedge meadows. Locally abundant. (D. Chier 1061; Eddy 2150, 3063; Weber 035)

S. rigida L. Dry prairies, oak openings. (Bennett 215)

S. speciosa Nutt. Openings, prairies. Uncommon. (Bennett 221; Manthei 189; Wiest 066, 067)

S. uliginosa Nutt. Local in boggy meadows, fens. (Dean 042; Eddy 1921, 2151, 2163; Galster 1058, 1068)

S. ulmifolia Muhl. Openings. Common. (Wepner 001; Wiest 062)

Sonchus oleraceus L. Common weed. (Davis s.n.; Eddy 4206)

Tanacetum vulgare L. Garden escape. (Harriman 1047)

Taraxacum officinale Weber *ex* Wiggers. Ubiquitous weed. (Jennings 268; Supple 214)

Tragopogon dubius Scop. Common roadside weed, open habitats. (Eddy, 4213)

T. pratensis L. Common roadside weed, open habitats. (Davis s.n.; Eddy 4214)

Vernonia fasciculata Michx. Low prairies. Common. (Harriman & Kasierski 010; Salzman 079; Underwood 1210)

Xanthium strumarium L. Common weed of disturbed sites. (Bennett 208)

BALSAMINACEAE (Touch-Me-Not Family)

Impatiens capensis Meerb. Shores, wetlands. Common. (Davis s.n.; Eddy 1837)

BERBERIDACEAE (Barberry Family)

Berberis thunbergii DC. Escape on edge of oak woods. (Eddy 4152)

Caulophyllum thalictroides (L.) Michx. Maple-basswood forests. Common. (Eddy 2199)

Podophyllum peltatum L. Forming dense patches in forests. Common. (Draheim 020; Pucker 564)

BETULACEAE (Birch Family)

Alnus incana (L.) Moench. Larix swamps, sedge meadows. Common. (Eddy 1775; Harriman 18938; Weinkauf 1222)

Betula alleghaniensis Britton. Known from one site; Green Lake Center. (Eddy 2345)

B. glandulosa Michx. Larix swamps, sedge meadows, fens. Locally common. (D. Chier s.n.; Eddy 345, 1580; Underwood 837)

B. papyrifera Marshall. Various habitats. Common. (Eddy 511, 712; Harriman 523)

Corylus americana Walter. Forming dense thickets in woods and some low prairies. (Eddy 2406; Hockman s.n.; Harriman 2074)

C. cornuta Marshall. Thickets, openings. (Eddy 2204)

Ostrya virginiana (Miller) K. Koch. Rich wood. Common. (Eddy 4211)

BORAGINACEAE (Borage Family)

Hackelia virginiana (L.) I. M. Johnst. Upland forests. Common. (Eddy 1663, 1743)

Lappula squarrosa (Retz.) Dumort. One specimen collected between 1900 and 1908. (Davis s.n.)

Lithospermum canescens (Michx.) Lehm. Oak openings, upland prairies. Common. (Eddy 1475; Harriman 687, 738; Shaver 046; Taves 878)

L. caroliniense (Walter) MacMillan. Mesic prairies. Less common than *L. canescens.* (Eddy 705)

Mertensia paniculata (Aiton) G. Don. Open woods, roadside ditches. (Berlowski 044)

M. virginica (L.) Pers. Garden escape. (Eddy 1446)

Myosotis scorpioides L. Occasional weed along shorebanks in the southern half of the county. (Eddy 1647)

M. verna Nutt. Known from one site; rhyolite quarry. (Eddy & Harriman 19687)

BRASSICACEAE (Mustard Family)

Alliaria petiolaris (Bieb.) Cavara & Grande. Weed in disturbed woods. (Harriman 18904)

Arabis canadensis L. Known from one location; rhyolite quarry. (Eddy & Harriman 19686)

A. glabra (L.) Bernh. Dry soils. (Eddy 1504, 2755; Harriman 780, 2039)

A. hirsuta (L.) Scop. var. glabrata T. & G. Rocky ledges. Uncommon. (Eddy 1529)

A. lyrata L. Dry openings, old fields. Common. (Harriman 688, 795)

A. missouriensis Greene. (Eddy & Harriman s.n.)

Armoracia lacustris (A. Gray) Al-Shehbaz & V. Bates. Quiet waters and muddy shores. The last record for Green Lake County was collected from Green Lake in 1921 (Patman & Iltis, 1961), and it is uncertain whether this lake macrophyte is still extant in the county. STATE ENDANGERED. (Rickett s.n., WIS)

Barbarea vulgaris R. Br. Common weed. (Eddy 260)

Berteroa incana (L.) DC. Common weed. (Buckstaff 40-15; Habighorst 178; Harriman 1176; Kasierski 005; Supple 184)

Brassica nigra (L.) Common weed. (Buchholtz 1388)

Capsella bursa-pastoris (L.) Medikus. Ubiquitous weed. (Eddy & Harriman s.n.)

Cardamine concatenata (Michx.) O. Schwartz. Moist woods. (Burbey 062; Eddy 1401; Kampa 029; Rohlfs 040; Schultz 063)

C. douglassii Britton. Wet woods. Uncommon. (Eddy 4091)

C. parviflora L. (Eddy & Harriman s.n.)

C. rhomboidea (Pers.) DC. Wetlands. Common.

(Eddy 197, 357; Harriman 676; Taves 887; Underwood 497)

Descurainia pinnata (Walter) Britton var. *brachycarpa* (Richards.) Fern. Weed on railroad cinders. (Eddy 3065)

Hesperis matronalis L. Common roadside escape. (Eddy 4228)

Lepidium densiflorum Schrader. Common weed. (Bennett 185; Eddy 4156; Harriman 778)

L. virginicum L. Common weed. (Harriman 762; Zeitler 202)

Raphanus raphanistrum L. Weed. (Hockman 069; Misterek 148; Taves 617)

Rorippa nasturtium-aquaticum (L.) Hayek. An Old World species thoroughly naturalized in spring streams and spring-fed ponds. (Eddy 603; Harriman 781; Weiss 149)

R. palustris (L.) Besser. var. *palustris* (Eddy 1695, 1840, 2540)

R. sylvestris (L.) Besser. (Fassett & Sperry 18388, WIS)

Sisymbrium altissimum L. Weed. (Draheim 137; Harriman 680, 740, 789, 2084, 2095; Pucker 635)

S. officinale (L.) Scop. Weed. (Eddy 1670; Harriman 761; Supple 210)

Thlaspi arvense L. Common weed. (Harriman 678, 759)

CACTACEAE (Cactus Family)

Opuntia humifusa (Raf.) Raf. Dry sand prairies. Rare. (Shinners s.n., WIS; Fassett 9203, WIS)

O. fragilis (Nutt.) Haw. STATE THREATENED (Pratt s.n., WIS)

CAMPANULACEAE (Bellflower Family)

Campanula americana L. (Eddy 4205)

C. aparinodes Pursh. Wetlands. (Davis s.n.; Harriman 2263)

C. glomerata L. Garden escape. (Eddy 2368)

C. rapunculoides L. Common along roadsides. (Davis s.n.)

C. rotundifolia L. Gravely soils. (Davis s.n.; Kohlman 1035)

Lobelia inflata L. Open woods. (Davis s.n.; J. Linde 1025; Supple 191; Whirry 830)

L. kalmii L. Fens, calcareous seepages in low prairies, sedge meadows. Locally common. (Eddy 104; Galster 081; Hockman 127; Kuen 002; Taves 901; Underwood 220; Whirry 1079)

L. siphilitica L. Marshes, stream banks, wet shores. Common. (Briscoe s.n.; Davis s.n.; Draheim 086, 102; Galster 812; Jennings 269)

L. spicata Lam. var. *spicata*. Upland prairies, oak openings, roadsides. Common. (Crosswhite s.n.; Eddy 1622, 1881, 2408; Harriman 1886; Hockman 073; Kohlman 675)

Triodanis perfoliata (L.) Nieuwl. Local on thin soils of rhyolite outcrops. (Eddy & Harriman s.n.; Harriman 801)

CANNABACEAE (Indian Hemp Family)

Cannabis sativa L. Common weed; cultivated during the 1940s as a source of hemp fiber. (Harriman 1239; Hockman 115; Weiss 147)

CAPPARACEAE (Caper Family)

Polanisia dodecandra (L.) DC. Sandy oak openings within the Central Plain. Common. (Eddy 078, 097; Rill 4073)

CAPRIFOLIACEAE (Honeysuckle Family)

Diervilla lonicera Miller. Oak wooded openings. Uncommon. (Eddy 1506; Hockman 041)

Lonicera x *bella* Zabel. (Doll s.n., WIS)

L. tartarica L. A cultivar, widely escaping and appearing naturalized in open woods. Common. (Berlowski 003; Eddy 267, 270)

Sambucus canadensis L. Woods, thickets, moist roadside ditches. Common. (Eddy 441; Supple 212)

S. racemosa L. ssp. *pubens* (Michx.) House. Woods. Less common than *S. canadensis*. (Eddy 1443, 2203; Harriman 820)

Triosteum perfoliatum L. Low woods. (Misterek 133)

Viburnum acerifolium L. Woods. Uncommon. (Harriman 1258)

V. lentago L. Woods, fencerows. Common. (Harriman 18926)

V. opulus L. var. *americanum* Aiton. Woods. Uncommon. (Eddy 1847)

CARYOPHYLLACEAE (Pink Family)

Arenaria lateriflora L. Woods, openings. Common. (Eddy 1434, 2320)

A. stricta Michx. var. *stricta.* Limestone outcrops. (Harriman 689, 725)

Cerastium arvense L. Lawns, fields, roadsides. Common. (Sadler X34)

C. nutans Raf. (Hockman s.n.)

C. vulgatum L. Common weed. (Davis s.n.; Dean 009; Eddy 018; Linde 015; Walker 244)

Dianthus armeria L. Garden escape. (Eddy 4184)

Gypsophila paniculata L. Garden escape. (Hockman 102; Redmond 142)

Saponaria officinalis L. Common weed. (Harriman 1175)

Silene antirrhina L. Sandy soils. (Harriman 815, 2041)

S. dichotoma Ehrh. Dry sandy soils. (Eddy 481)

S. latifolia Poir. (Eddy 1656; Harriman 817; Pucker 091; Zeitler 211)

S. vulgaris (Moench) Garcke. Roadsides, fields, railroads. Common. (Eddy 1812, 2167)

S. aquatica (L.) Scop. Moist sands on edge of White River. (Underwood 833)

Stellaria graminea L. Sedge meadows. (Harriman 777)

S. longifolia Muhl. Sedge meadows. (Eddy 1581, 2478)

CELASTRACEAE (Staff-Tree Family)

Celastrus orbiculatus Thunb. Garden escape. (Eddy 2182; Grim s.n.)

C. scandens L. Woods, thickets, openings. (Dean 020; Eddy 2458, 2722; Hansen 063; Kuen 032)

CERATOPHYLLACEAE (Hornwort Family)

Ceratophyllum demersum L. Rivers, streams, lakes, ponds. Common. (Bumby 62, 1214, RIP)

CHENOPODIACEAE (Goosefoot Family)

Chenopodium album L. Common weed. (Eddy 2547; Zeitler 223)

C. urbicum L. Waste places. (Eddy 2713)

Cycloloma atriplicifolium (Spreng.) J. M. Coulter. Railroad gravels. Common. (Bennett 204; Breitlow 196)

Kochia scoparia (L.) Schrader. Disturbed sôils. (Brudnicki 144)

Salsola kali L. Disturbed soils. (Breitlow 179)

CISTACAE (Rock-rose Family)

Helianthemum bicknellii Fern. Dry sandy soils. (Eddy 678; Kohlman 1042)

H. canadense (L.) Michx. Oak openings. (Davis s.n.; Eddy 1596; Harriman 1850; Supple 183)

Hudsonia tomentosa Nutt. Sandy roadside near Princeton Locks. (Dean 019)

Lechea intermedia Leggett. Dry sandy soils, blowouts. Locally abundant. (Eddy 1959, 4186; Harriman 1232)

CLUSIACEAE (Mangosteen Family)

Hypericum canadense L. Wetlands. (Eddy 2686; Harriman 18979; Linde 1371)

H. gentianoides (L.) BSP. Local on moist sand prairies. Rare. (Eddy 2660; Underwood 246, 861)

H. kalmianum L. Local in fens, calcareous seepages in sedge meadows. (Eddy 1944, 2496; Underwood 826)

H. majus (A. Gray) Britton. Sedge meadows. (Buchholtz 787; Eddy 1756, 2658; Kohlman 842; Weber 032)

H. perforatum L. Common weed of roadsides, pastures, fields. (Eddy 4220; Harriman 1046)

H. punctatum Lam. Oak openings, dry prairies, roadsides. Common. (Brudnicki 145)

H. pyramidatum Aiton. Moist soils. (Draheim 115; Eddy 4221)

Triadenum fraseri (Spach) Gleason. Marshes, sedge meadows. (Eddy 4207)

CONVOLVULACEAE (Morning-glory Family)

Calystegia sepium (L.) R. Br. Common weed. (Breitlow 194; Davis s.n.; Draheim 135; Harriman 509, 2044)

Convolvulus arvensis L. Common weed. (Anderson s.n.; Eddy 2695)

CORNACEAE (Dogwood Family)

Cornus amomum Miller var. *schuetzeana* (C. A. Meyer) Rickett. Low woods, stream banks.

(Dean 011; Eddy 1738; Harriman 18935; Krauth 147)

C. racemosa Lam. Sedge meadows, thickets, woods. Common. (Draheim 055; Eddy 1579; Harriman 1887)

C. rugosa Lam. Sandy or rocky soils. Common. (Draheim 028; Eddy 530)

C. sericea L. Wetlands, thickets. Co-dominant with *Salix* species in shrub-carr communities. (Eddy 1680; Harriman 520; Hockman s.n.; Underwood 219, 488)

CUCURBITACEAE (Gourd Family)

Echinocystis lobata (Michx.) T. & G. Thickets, damp openings. Common. (Draheim 083; Eddy 802, 4154; Harriman 2243; Underwood 222; Zeitler 205)

CUSCUTACEAE (Dodder Family)

Cuscuta coryli Engelm. Twining on vegetation. (Weinkauf 767)

C. cuspidata Engelm. (Harriman 13216)

C. pentagona Engelm. (Eddy 2006)

DIPSACACEAE (Teasel Family)

Dipsacus laciniatus L. Introduced and spreading. Known from one site; grassy old field. (Eddy 4118)

DROSERACEAE (Sundew Family)

Drosera intermedia Hayne. Boggy habitats. Uncommon. (Kuen 050)

D. rotundifolia L. Boggy habitats. Uncommon. (Eddy 2502)

ERICACEAE (Heath Family)

Arctostaphylos uva-ursi (L.) Sprengel. Rare, known from one site; Pine Bluff oak opening on rhyolite outcrop. (Eddy & Brooks 4183)

Gaultheria procumbens L. Woods. Uncommon. (Eddy 1620)

Gaylussacia baccata (Wangenh.) K. Koch. Woods. Uncommon. (Eddy 1455; Harriman 732)

Vaccinium angustifolium Aiton. Oak openings. Common. (Eddy 412)

EUPHORBIACEAE (Spurge Family)

Acalypha rhomboidea Raf. Common weed. (Eddy 2054)

Euphorbia corollata L. var. *corollata*. Dry prairies, roadsides, waste places. Common. (Davis s.n.; Dean 043; Draheim 143; Kasierski 001)

E. cyparissias L. Garden escape. (Davis s.n.; Eddy 2378; Sadler X32)

E. maculata L. Common weed. (Eddy 4225)

FABACEAE (Pea or Bean Family)

Amorpha canescens Pursh. Upland prairies, oak openings. Common. (Davis s.n.; Eddy 437; Kasierski 002)

Amphicarpaea bracteata (L.) Fern. Woods, thickets. Common. (Eddy 828)

Apios americana Medikus. Moist woods, thickets. Uncommon. (Eddy 1879, 1978)

Baptisia lactea (Raf.) Thieret. *(B. leucantha).* Mesic prairies. Uncommon. (Davis s.n.; Eddy 1510)

B. bracteata Elliott var. *glabrescens* (Larisey) Isley *(B. leucophaea).* Sand prairies. Less common than *B. lactea.* (Davis s.n.; Eddy 1469; Underwood 822)

Coronilla varia L. Planted to reduce bank erosion and commonly spreading on roadsides. (Eddy 1546; Weinkauf 1306)

Dalea purpurea Vent. Upland prairies, oak openings. Common. (Bennett 203; Harriman 1234; Manthei 180)

Desmodium canadense (L.) DC. Roadsides, thickets, openings. Common. (Eddy 2626)

D. glutinosum (Muhl.) A. Wood. (Davis s.n.; Draheim 208; Eddy 190, 1664; Harriman 1115; Mittlestaedt 242)

D. illinoense A. Gray. Woods. Uncommon. (Eddy 740)

D. nudiflorum (L.) DC. (Fassett 16785, WIS)

Glycine max (L.) Merrill. Escape crop plant; roadside collection. (Harriman 18946)

Lathyrus palustris L. Low prairies, sedge meadows, marshes, wet roadside ditches. Common. (Eddy 341, 2297)

L. venosus Muhl. var. *intonsus* Butters & St. John. Moist woods, thickets. Uncommon. (Eddy 2407)

Lespedeza capitata Michx. Upland prairies, oak openings, roadsides. Common. (Eddy 838, 1815, 1901; Harriman 1261; Lindvall 159; Supple 182)

Lotus corniculatus L. Planted to reduce bank erosion, commonly escaping to roadsides and clearings. (Eddy 141)

Lupinus perennis L. Sand prairies, oak openings. Common. (Warmbier 073)

Medicago lupulina L. Common weed. (Kasierski 003)

M. sativa L. Introduced. (Bennett 212; Salzman 073; Turner 044)

Melilotus alba Medikus. Introduced. (Eddy & Harriman s.n.)

M. altissima Thuill. Introduced. (Zeitler 242)

M. officinalis (L.) Pallas. Introduced. (Eddy & Harriman s.n.)

Robinia pseudoacacia L. Introduced. (Draheim 043; Eddy 4202; Kuen 033)

Tephrosia virginiana (L.) Pers. Local on dry-mesic prairies, oak openings, sandy roadsides. (Eddy 2569)

Trifolium arvense L. Weed. (Davis s.n.; Rill 5023)

T. aureum Pollich. Weed. (Davis s.n.; Eddy 506)

T. campestre Schreber. Common weed. (Eddy 2476)

T. hybridum L. Common weed. (Eddy 306, 2534)

T. pratense L. Common weed. (Habighorst 047; Jennings 259; Manthei 195; Zeitler 200)

T. repens L. Common weed. (Draheim 066; Eddy 310; Jennings 243)

Vicia americana Muhl. Roadsides, openings, thickets. Common. (Pucker 634; Underwood 510)

V. caroliniana Walter. Woods, thickets. Common. (Eddy 1476)

V. sativa L. (Eddy 1885)

V. villosa Roth. Weed. (Draheim 104; Eddy 2534; Harriman 521; Weinkauf 1337)

FAGACEAE (Beech Family)

Quercus alba L. Upland forests. Common. (Eddy 1896; Wiest 106)

Q. bicolor Willd. Bordering wetlands. (Eddy 18928)

Q. ellipsoidalis E. J. Hill. Dry openings, woods. (Eddy 1971, 4141; Eddy & Sonntag 2094; Hockman s.n.; Wiest 073)

Q. macrocarpa Michx. Oak openings, roadsides, woods. Common. (Buchholtz 1315)

Q. rubra L. Upland forests. (Eddy 1897; Michels 024)

Q. velutina Lam. Upland forests, oak openings. Common. (Mateyka 150; Wiest 065)

FUMARIACEAE (Fumitory Family)

Corydalis aurea Willd. Known from one site; rocky ground in clear-cut oak forest. (Davis s.n.; G. Linde 217)

C. sempervirens (L.) Pers. Local on rhyolite outcrops. (Davis s.n.; Harriman 1896; Hockman s.n.; Underwood 241)

Dicentra canadensis (Goldie) Walp. Known from one site; growing in dense patches at the Green Lake Center grounds. (Eddy 3079)

D. cucullaria (L.) Bernh. Maple-basswood forests. Common. (Eddy 1415)

GENTIANACEAE (Gentian Family)

Bartonia virginica (L.) BSP. Local on moist sand prairies and boggy meadows in the Central Plain. A rare Atlantic Coastal disjunct. (Eddy & Neil s.n.)

Gentiana andrewsii Griseb. Low prairies, sedge meadows, fens. Common. (Draheim 095; Harriman 18984; J. Linde 1374; Weiss 151)

G. flavida A. Gray. Known from one site; moist sand prairie-meadow complex. STATE THREATENED (Harriman 18985)

G. puberulenta J. Pringle Dry prairies, oak openings. Uncommon. (Anderson s.n.; J. Linde 1373; Underwood 230)

Gentianella quinquefolia (L.) Small. Upland woods. Uncommon. (J. Linde 1214)

Gentianopsis procera (Holm.) Ma. Local in fens, calcareous seepages in sedge meadows. (Eddy 2152; Galster 1062; Kuehn 005)

GERANIACEAE (Geranium Family)

Geranium bicknellii Britton. (Rill 7142)

G. carolinianum L. Known from one site; rhyolite quarry. (Eddy & Harriman 19688)

G. maculatum L. Woods, thickets, roadsides. Common. (Draheim 007; Hockman s.n.; Taves 883; Underwood 493)

G. pusillum L. Adventive weed in prairie garden at Green Lake Public School. (Eddy 4150)

GROSSULARIACEAE (Gooseberry Family)

Ribes americanum Miller. Woods. (Eddy 1893; Underwood 487)

R. cynosbati L. Woods. (Eddy 2229, 2418; Harriman 1825)

R. missouriense Nutt. Woods. (Eddy 533)

R. sativum Syme. Garden escape in oak woods. (Eddy 1420)

HALORAGACEAE (Water-Milfoil Family)

Myriophyllum sibiricum Komarov. *(Myriophyllum exalbescens).* (M. J. Bumby 123)

M. spicatum L. Common macrophyte of rivers, lakes. (M. J. Bumby 1244)

Proserpinaca palustris L. One collection from a water-filled ditch near the north shore of Lake Puckaway. (Eddy 2594)

JUGLANDACEACE (Walnut Family)

Carya cordiformis (Wangenh.) K. Koch. Known from one site; maple-basswood woods. Uncommon. (Eddy 4212)

C. ovata (Miller) K. Koch. Common throughout the county. (Eddy 4224)

Juglans cinerea L. (Eddy 4187)

J. nigra L. (Eddy 4161)

LAMIACEAE (Mint Family)

Galeopsis tetrahit L. var. *bifida* (Boenn.) Lej. & Courtois. Garden escape. (Eddy 2616)

Glechoma hederacea L. Common weed. (Pinchette 059)

Hedeoma hispidum Pursh. Dry sandy soils. (Harriman 806; Hockman 042)

H. pulegioides (L.) Pers. Upland woods. (Eddy 2049)

Isanthus brachiatus (L.) BSP. *(Trichostema brachiatus).* (Fassett 18379, WIS; Fassett & Wadmond 18394, WIS)

Leonurus cardiaca L. Common weed. (Davis s.n.; Draheim 040; Pucker 070)

Lycopus americanus Muhl. Wetlands. (Draheim 097; Eddy 2602; Hockman 126; Smith 040; Taves 443)

L. uniflorus Michx. Wetlands. (Taves 872; Underwood 1179)

Mentha arvensis L. Moist soils. (Eddy 4148; Harriman 2072)

Monarda fistulosa L. var. *fistulosa.* Prairies, oak openings, roadsides. Common. (Davis s.n.; Draheim 054; Hockman s.n.)

M. punctata L. var. *villicaulis* Pennell. Dry sandy openings. Common. (Harriman 1178; Hockman 124; Kasierski 012, 018)

Nepeta cataria L. Common weed. (Bennett 191; Eddy 1669)

Physostegia virginiana (L.) Benth. Sedge meadows, low prairies, marshes. Common. (Eddy 1899; Harriman 13213; Weber 033)

Prunella vulgaris L. Common weed of moist soils. (Eddy 1734)

Pycnanthemum flexuosum (Walter) BSP. Prairies. Common. (Eddy 2642)

P. virginianum (L.) Durand & B. D. Jackson. Prairies. Common. (Taves 903; Zeitler 225)

Scutellaria galericulata L. Wetlands. (Davis s.n.; Eddy 751, 2560; Harriman 2264; Hockman 063)

S. lateriflora L. Wetlands. (Eddy 2159)

S. leonardii Epling. Woods, openings, prairies. (Eddy 512, 1511, 4144)

Stachys hispida Pursh. Wetlands. (Eddy 449, 1690, 1891, 4165; Harriman 1170)

S. palustris L. Wetlands. (Eddy 4219)

Teucrium canadense L. var. *occidentale* (A. Gray) McClintock & Epling. Moist soils. (Davis s.n.; Eddy 087, 1697; Harriman 2257; Hockman 125)

LENTIBULARIACEAE (Bladderwort Family)

Utricularia vulgaris L. Shallow waters. Common. (Eddy 301)

LYTHRACEAE (Loosestrife Family)

Decodon verticillatus (L.) Elliott var. *laevigatus* T. & G. Marshes, swamps, river and lake shores. (Eddy 1823)

Lythrum alatum Pursh var. *alatum* Pursh. Loosestrife. Low prairies, sedge meadows, marshes, wet ditches. Common. (Davis s.n.; Eddy 052)

L. salicaria L. Aggressive exotic that is established and spreading in wetlands. (Cibik 180; Zeitler 208)

MALVACEAE (Mallow Family)

Abutilon theophrasti Medikus. Common field weed. (Eddy 2180; Misterek 151)

Hibiscus trionum L. (Jennings 268)

Malva neglecta Wallr. Common weed. (Pucker 065)

MELASTOMATACEAE (Melastome Family)

Rhexia virginica L. Rare, known from one wetlands site, north of Lake Puckaway; local on moist sands of the Central Plain. An Atlantic Coastal Plain disjunct. (Eddy 2578)

MENYANTHACEAE (Buckbean Family)

Menyanthes trifoliata L. (Thompson 82, WIS)

MOLLUGINACEAE (Carpet-Weed Family)

Mollugo verticillata L. Weed of sandy, sterile soils. (Draheim 136; Harriman 1230)

MONOTROPACEAE (Indian Pipe Family)

Monotropa uniflora L. Woods. Uncommon. (Davis s.n.; Eddy 1874, 2500; Harriman 1204)

M. hypopithys L. Rare, known from one site; Pine Bluff oak opening on rhyolite outcrop. (Eddy & Neil 4143)

MORACEAE (Mulberry Family)

Morus alba L. Roadsides, waste places, thickets. Common. (Ihrke 030; T. Whirry 1348)

MYRICACEAE (Bayberry Family)

Comptonia peregrina (L.) J. M. Coulter. Sandy soils of oak openings. (Eddy 1458)

NELUMBONACEAE (Lotus-Lily Family)

Nelumbo lutea (Willd.) Pers. Shallow waters. Locally abundant. (Eddy 1676; Harriman 13202)

NYCTAGINACEAE (Four-O'Clock Family)

Mirabilis nyctagineus (Michx.) MacMillan. Common weed. (Harriman 1241; Underwood 225)

NYMPHACEAE (Water-Lily Family)

Nuphur variegata Durand. Shallow waters. Locally abundant. (Campbell 053; Eddy 032; Harriman 13208)

Nymphaea odorata Aiton. Shallow waters. (Campbell 052; Eddy 1677, 1846)

OLEACEAE (Olive Family)

Fraxinus nigra Marshall. Swamps, wet woods. (Harriman 18925)

F. pennsylvanica Marshall. Woods. (Eddy 112)

Syringa vulgaris L. Garden escape. (Eddy 967)

ONAGRACEAE (Evening-Primrose Family)

Circaea alpina L. Known from one site; shaded sandstone outcrop. (Rill 7069)

C. lutetiana L. Moist woods. (Eddy 175, 1640, 1665, 1740; Hockman 080; Pucker 1072; Rill 7074)

Epilobium angustifolium L. Moist soils, notably common in burned over habitats. (Eddy 2475; Hockman 037)

E. ciliatum Raf. Sedge meadows, marshes, wet ditches. Common. (Harriman 2261; Weiss 150)

E. coloratum Biehler. Sedge meadows, marshes, wet ditches. Common. (Eddy 2717)

Ludwigia palustris (L.) Elliott. Muddy flats, shallow waters. (Eddy 2690; Harriman 18909)

Oenothera biennis L. Common along roadsides, waste places. (Jansen 227)

O. clelandii Dietrich, Raven & W. L. Wagner. Roadsides, fields. (Eddy 2569; Harriman 1051, 2093)

O. parviflora L. (Anderson s.n.; Pucker 088)

O. perennis L. Old fields, openings. (Eddy 1567, 1629, 2342; Underwood 825)

OXALIDACEAE (Wood Sorrel Family)

Oxalis stricta L. Common weed. (Draheim 089; Eddy 4171; Harriman 1847)

O. violacea L. Woods, oak openings. Uncommon. (Berlowski 006; N. Morton 226; Underwood 491)

PAPAVERACEAE (Poppy Family)

Eschscholzia californica Cham. Garden escape. (Grim s.n.)

Papaver orientale L. Garden escape. (Eddy 2379)

Sanguinaria canadensis L. Moist woods. Common. (Eddy 1404)

PHYTOLACCACEAE (Pokeweed Family)

Phytolacca americana L. Known from one site; shaded lane at the Green Lake Center. (Hockman s.n.)

PLANTAGINACEAE (Plantain Family)

Plantago lanceolata L. Common weed. (Eddy 2429)

P. major L. Common weed. (Hockman s.n.; Jennings 247)

P. patagonica Jacq. Railroad gravels. (Harriman 2092; Hockman 036)

P. rugelii Decne. Common weed. (Harriman 1165)

POLEMONIACEAE (Phlox Family)

Phlox paniculata L. Garden escape. (Zeitler 203)

P. pilosa L. var. *fulgida* Wherry. Upland prairies, oak openings. Common. (Eddy 715, 1582; Harriman 726; Warmbier 072)

Polemonium reptans L. var. *reptans.* Moist woods, thickets. (Eddy 1464; Underwood 484)

POLYGALACEAE (Milkwort Family)

Polygala polygama Walter. Open sandy soils. (Eddy 504; Harriman 1884)

P. sanguinea L. Prairies, oak openings. Common. (J. Linde 1152; Underwood 245; Weber 028)

P. senega L. Low prairies. Uncommon. (Eddy 1591, 2411; Taves 888)

P. verticillata L. (Shinners s.n., WIS)

POLYGONACEAE (Smartweed Family)

Polygonella articulata (L.) Meissner. Dry sandy openings. Locally abundant. (Eddy 4195)

Polygonum amphibium L. Shallow waters, mud flats. Common. (B. A. & T. S. Cochrane 7417; Davis s.n.; Eddy 214, 826, 2147; Eddy & Rill 2040; Harriman 16687; Kasierski 013; J. Linde 1389; Kohlman 1127; Underwood 1162)

P. aviculare L. Common weed. (Eddy 2549)

P. convolvulus L. Common weed. (Harriman 1172; Zeitler 201)

P. cuspidatum Sieb. & Zucc. Escape. (Eddy s.n.)

P. lapathifolium L. Moist soils. Common. (Eddy & Rill 2042; Harriman 2255, 13207; Supple 185)

P. pensylvanicum L. Moist waste places. Common. (Anderson s.n.; Bennett 205; Davis s.n.; Draheim 076; Eddy & Rill 2017; Harriman 1118; Lindvall 162; Salzman 072)

P. persicaria L. Common weed. (Eddy 1878; Eddy & RIll 2019)

P. punctatum Elliott. Marshes, swamps, sedge meadows, wet ditches. Common. (Eddy 995, 2664)

P. sagittatum L. Marshes, sedge meadows. Common. (Harriman 1251, 2262)

P. scandens L. Moist woods, thickets. (Davis s.n.; Eddy 1994)

P. tenue Michx. Dry sandy soils. (Eddy 831, 1800, 2007; Harriman 18941)

P. virginianum L. Moist woods. (Harriman 18933)

Rumex acetosella L. Common weed on lawns, old fields, pastures. (Harriman 764)

R. crispus L. Common weed of moist waste places. (Draheim 042)

R. maritimus L. Wet soils. (Eddy 2622)

R. obtusifolius L. (Eddy & Harriman s.n.)

R. orbiculatus A. Gray. Marshes, swamps, sedge meadows. Common. (Habighorst 177; Zeitler 217)

R. salicifolius J. A. Weinm. Wet soils. (Eddy 2623)

PORTULACACEAE (Purslane Family)

Claytonia virginica L. Moist woods. Common. (Eddy 1398)

Portulaca oleracea L. Common weed. (Eddy 4158)

Talinum rugospermum Holzinger. Dry sandy openings. Rare. (Eddy 1798, 2571; Harriman 18893; Underwood 233)

PRIMULACEAE (Primrose Family)

Dodecatheon meadia L. Upland prairies, oak openings. (Harriman 768; Hockman 076; Underwood 504)

Lysimachia ciliata L. Marshes, sedge meadows, low prairies. Uncommon. (Eddy 2533; Hockman 081)

L. nummularia L. Escape. (Eddy 4170)

L. quadrifolia L. (Eddy 1621)

L. quadriflora Sims. Low prairies, sedge meadows. Common. (Davis s.n.; Eddy 1705, 1942, 2603; Harriman 1167; Taves 876)

L. terrestris (L.) BSP. Swamp openings. Uncommon. (Eddy 2586; Hockman 039)

L. thyrsiflora L. *Larix* swamps, wet woods, marshes. Common. (Eddy 4227; Taves 858)

Trientalis borealis Raf. Local in *Larix* swamps, moist pine plantations and oak openings. (Eddy 421; Harriman 729)

PYROLACEAE (Shinleaf Family)

Chimaphila umbellata (L.) Barton. Oak woods. Uncommon. (Eddy & Harriman s.n.)

Pyrola elliptica Nutt. Oak woods. Uncommon. (Eddy 248)

RANUNCULACEAE (Buttercup Family)

Actaea alba (L.) Miller. Moist woods. Uncommon. (Eddy 1877)

A. rubra (Aiton) Willd. Woods. Common. (Draheim 049; Eddy 249, 1442; Hockman s.n.)

Anemone canadensis L. Low prairies, roadsides. Common. (Davis s.n.; Harriman 519)

A. cylindrica A. Gray. Upland prairies, oak openings. Common. (Draheim 204; Taves 433)

A. patens L. var. *multifida* Pritzel. Dry prairies and openings. Uncommon. (Harriman 792; Kraus 007; Krysiak 040; Shcroeder 003; Tanner 015)

A. quinquefolia L. Moist woods. Common. (Burbey 067; Eddy 245; Kampa 034)

A. virginiana L. Woods, openings. (Davis s.n.; Eddy & P. Sonntag 2101)

Anemonella thalictroides (L.) Spach. Woods. Common. (Underwood 507)

Aquilegia canadensis L. Woods. Common. (Draheim 014; Harriman 774; Taves 324)

Caltha palustris L. Swamps, wet ditches, sedge meadows, shallow marshes. (Eddy 665; Kampa 020; Pichette 056, 061; Shaver 042; Stalker 077; Underwood 501)

Clematis occidentalis (Hornem.) DC. Known from one site; rocky woods on south shore of Green Lake. (Eddy 1421, 1866)

C. virginiana L. Fencelines, thickets. Common. (Eddy 2177)

Hepatica americana (DC.) Ker Gawler. Moist woods. (Eddy 240)

Isopyrum biternatum (Raf.) T. & G. Moist woods. (Dubester 048)

Ranunculus abortivus L. Woods. Common. (Eddy 320; Harriman 760)

R. acris L. Weed of roadsides, old fields. (Anderson s.n.)

R. fascicularis Muhl. Roadsides, old fields, pastures. (Hockman s.n.; Schroeder 001; Shaver 045; Trotter 644)

R. flabellaris Raf. Quiet waters, muddy shores. (Eddy 417)

R. hispidus Michx. var. *nitidus* (Elliott) T. Duncan. Woods. (Eddy 1405)

R. longirostris Godron. Shallow waters. (Davis s.n.)

R. pensylvanicus L. f. Sedge meadows, wet ditches, marshy habitats. (Eddy 1699; Kohlman 844)

R. recurvatus Poiret. Moist woods. (Eddy 2276)

R. rhomboideus Goldie. Prairies, openings. (Burbey 063; Krysiak 039)

R. sceleratus L. (Eddy & Harriman s.n.)

Thalictrum dasycarpum Fischer & Avé-Lall. Low prairies, sedge meadows, roadsides. Common. (Harriman 522; Nelson s.n.)

T. dioicum L. Moist woods. Common. (Harriman 686; Hockman s.n.)

RHAMNACEAE (Buckthorn Family)

Ceanothus americanus L. var. *pitcheri* T. & G. Low prairies. (Davis s.n.; Eddy 187; Hockman 101)

Rhamnus cathartica L. Common escape and appearing naturalized in woods and openings. (Eddy 2090)

R. frangula L. Escape from cultivation and appearing naturalized. Moist woods, thickets. (Eddy 037, 477, 1781; Harriman 825, 1245; Whirry 109)

ROSACEAE (Rose Family)

Agrimonia eupatoria L. Introduced. (Davis s.n.)

A. gryposepala Wallr. Wood, openings. Common. (Eddy 4168)

Amelanchier arborea (Michx. f.) Fern. Rocky woods. (Eddy 2191)

A. sanguinea (Pursh) DC. var. *sanguinea.* Oak woods. (Eddy 1419)

A. spicata (Lam.) K. Koch. Dry woods, openings, old fields. (Draheim 024; Hockman s.n.)

Aronia melanocarpa (Michx.) Elliott. Roadsides, openings, old fields. (Eddy 2263; Harriman 827)

Crataegus coccinea L. (Eddy 2258)

C. punctata Jacq. (Draheim 092; Misterek 129)

Filipendula rubra (Hill) B. L. Robinson. Rare, known from one site in the city of Green Lake; remnant population at edge of wet thicket in the city of Green Lake. (Eddy 4117)

Fragaria virginiana Duchesne. Upland prairies, oak openings, railroad gravels. Common. (Underwood 964)

Geum aleppicum Jacq. var. *strictum* (Aiton) Fern. Woods, roadsides. Common. (Davis s.n.; Eddy 640, 1763)

G. canadense Jacq. Woods. Common. (Eddy 1730)

G. triflorum Pursh. Dry prairies and openings. Uncommon. (Harriman 810, 1843)

Physocarpus opulifolius (L.) Maxim. Sedge meadows, wet thickets. Common. (Eddy 340, 2387)

Potentilla anserina L. Moist sandy soils. Common. (Underwood 213)

P. argentea L. Common weed. (Eddy 347; Harriman 802, 1851; Hockman s.n.)

P. arguta Pursh. Dry prairies and openings. (Harriman 799, 1888; Hockman s.n.)

P. fruticosa L. Fens, calcareous seepages in sedge meadows and low prairies. Common. (Underwood 212)

P. norvegica L. Roadsides, waste places. (Harriman 767; Weiss 144)

P. palustris (L.) Scop. Marshy shores, wet ditches. Common. (Harriman 18937)

P. recta L. Common weed. (Davis s.n.; Harriman 507)

P. simplex Michx. Roadsides, waste places, old fields. Common. (Eddy 329; Harriman 731)

Prunus americana Marshall. (Eddy 1410)

P. pensylvanica L. f. (Eddy 2188)

P. serotina Ehrh. Woods. Common. (Eddy 269, 330; Harriman 1834)

P. virginiana L. Woods, thickets. Common. (Harriman 682)

Pyrus ioensis (A. Wood) L. Bailey. (Eddy 2257, 4201)

Rosa blanda Aiton. Prairies, roadsides. (Eddy 2405; Krauth 139)

R. carolina L. Roadsides, old pastures. Common. (Draheim 013; Nelson s.n.; Rill 4315)

R. multiflora Thunb. Escape from cultivation. (Eddy 1527)

R. palustris Marshall. Swamps, marshes, low prairies. (Eddy 2598)

Rubus allegheniensis T. C. Porter. Varied habitats. Common. (Eddy 140, 1572)

R. recurvicaulis Blanchard. (Eddy 2333)

R. hispidus L. Woods, thickets, openings. Common. (Harriman 1940, 1828)

R. idaeus L. Openings, thickets. Common. (Eddy 2630; Harriman 763)

R. pubescens Raf. *Larix* swamps, wet woods. (Eddy 350, 510, 2708; J. Walker 220)

R. setosus Bigel. (Eddy 2681)

Sorbaria sorbifolia (L.) A. Braun. (Hockman 046)

Spiraea alba Duroi var. *alba.* Sedge meadows, marshes, low prairies. Common. (Davis s.n.; Hockman 033)

S. tomentosa L. var. *tomentosa. Larix* swamps, boggy meadows. Less common than *S. alba.* (Harriman 1248; Kasierski 021; J. Linde 791; Weber 029)

RUBIACEAE (Madder Family)

Cephalanthus occidentalis L. Shorebanks of White and Fox rivers. Uncommon. (Eddy 4229)

Galium aparine L. Woods. Common. (Harriman 819; Weinkauf 1057)

G. boreale L. Low prairies, sedge meadows. Common. (Draheim 034; Eddy 618; Harriman 518; Hockman s.n.)

G. labradoricum (Wieg.) Wieg. (Fassett 18955, WIS)

G. obtusum Bigelow. Moist soils. (Eddy & Rill 2043; Underwood 818)

G. trifidum L. Marshy habitats. (Eddy 095, 1689; Weinkauf 1131)

G. triflorum Michx. Woods. (Eddy 1737; Harriman 18931)

G. verum L. Garden escape. (Eddy 1666, 1926)

Hedyotis longifolia (Gaertner) Hook. Local on rhyolite outcrops. (Eddy 1502; Harriman 1889)

Mitchella repens L. Moist woods. Uncommon. (Eddy 172)

RUTACEAE (Rue Family)

Zanthoxylum americanum Miller. Forming dense thickets in disturbed woods, openings. Common. (Eddy 2357; Harriman 18929)

SALICACEAE (Willow Family)

Populus alba L. Escape. (Eddy 4155)

P. deltoides Marshall. River bottoms, disturbed sites. Common. (Trotter 965)

P. grandidentata Michx. (Eddy 4209)

P. tremuloides Michx. Old fields, disturbed sites. Common. (Krauth 151; Krysiak 013)

Salix bebbiana Sarg. Wetlands. Common. (Eddy 704; Trotter 593; Underwood 490)

S. candida Fluegge. Fens, calcareous sedge meadows. (Eddy 694; Underwood 502, 843)

S. discolor Muhl. Various wetlands. Common. (Underwood 486)

S. exigua Nutt. Wet ditches, shores, sandbars. Common. (Eddy 480; Pucker 249)

S. fragilis L. Shores, wet ditches, riverbanks. Common. (Eddy 612; Harriman 508; Pucker 427)

S. humilis Marshall. Low prairies. Uncommon. (Underwood 495)

S. lucida Muhl. Wetlands. Uncommon. (Eddy 276)

S. nigra Marshall. Alluvial soils. Common. (Eddy 304)

SANTALACEAE (Sandlewood Family)

Comandra umbellata (L.) Nutt. var. *umbellata.* Upland prairies, oak openings, railroad gravels. Common. (Eddy 662, 1588; Harriman 805)

SARRACENIACEAE (Pitcher-Plant Family)

Sarracenia purpurea L. Boggy meadows and fens. Locally abundant. (Eddy 706)

SAXIFRAGACEAE (Saxifrage Family)

Heuchera x *hirsuticaulis* (Wheelock) Rydb. Woods, openings. (Eddy 521, 1583; Harriman 875, 1894)

H. richardsonii R. Br. Prairies, oak openings. Common. (Davis s.n.; Eddy 1509)

Mitella diphylla L. Rich woods. Rare. (Eddy 1432)

Parnassia glauca Raf. Local in fens, calcareous seepages in sedge meadows. (Eddy 2164; Kuen 018; Whirry 776)

Penthorum sedoides L. Marshes, sedge meadows, muddy flats. Locally common. (Eddy 753, 2622)

Saxifraga pensylvanica L. Low prairies, boggy meadows. (Davis s.n.; Eddy 404; Harriman 694)

SCROPHULARIACEAE (Figwort Family)

Agalinis purpurea (L.) Pennell var. *parviflora* (Benth.) B. Boivin. Moist sand prairies, railroad gravels. (Eddy 2683; Underwood 229)

A. tenuifolia (M. Vahl) Raf. Low prairies, openings. (D. Chier 1064; Eddy 1907; Harriman 2250, 13217; Jansen 223; Kasierski 011; J. Linde 761; Taves 904)

Aureolaria grandifolia (Benth.) Pennell. var. *pulchra* Pennell. Wooded openings. (Harriman 1254)

A. pedicularia (L.) Raf. var. *ambigens* (Fern.) Farw. Dry woods, openings. (Harriman 1237; Kohlman 847)

Castilleja coccinea (L.) Sprengel. Low prairies. Rare. (Eddy 720, 2140; Rill 5908)

Chaenorrhinum minus (L.) Lange. Railroad gravels. (Kohlman 646)

Chelone glabra L. Low prairies, sedge meadows, wet ditches. (C. Buchholtz 1150; Underwood 215, 1158)

Digitalis lutea L. Garden escape. (Eddy 2511)

Gratiola neglecta Torr. Wet soils. (Eddy 2689)

Linaria canadensis (L.) Dum.-Cours. Open sandy soils. (Harriman 826, 2078)

L. vulgaris Miller. Common weed. (Davis s.n.; Jennings 226; Kasierski 009)

Lindernia dubia (L.) Pennell. Muddy or sandy flats. Locally common. (Harriman 18978)

Mimulus ringens L. Marshes, sedge meadows, wet ditches. Common. (Eddy 429; Harriman 2248)

Pedicularis canadensis L. Mesic prairies, openings. Common. (Eddy 405, 1462)

P. lanceolata Michx. Marshes, fens, boggy meadows. (Harriman 2260; Taves 906)

Penstemon digitalis Nutt. Oak openings, roadsides. (Crosswhite s.n.)

P. gracilis Nutt. Dry prairies and openings. (Eddy 513; Harriman 798, 1846)

Scrophularia lanceolata Pursh. Openings, roadsides. (Davis s.n.)

Verbascum thapsus L. Common weed. (Weber 031)

Veronica peregrina L. var. *xalapensis* (HBK.) St. John & Warren. Moist soils. (Harriman 679, 693)

V. serpyllifolia L. Common lawn weed. (Eddy 649; Underwood 482)

Veronicastrum virginicum (L.) Farw. Prairies, wooded openings. Common. (Davis s.n.; Draheim 050; Eddy 431)

SOLANACEAE (Nightshade Family)

Physalis heterophylla Nees. Open sandy soils. Common. (Eddy 159)

P. longifolia Nutt. (Eddy 2531)

P. virginiana Miller. (Harriman 1885)

Solanum dulcamara L. Common. (Eddy 4160)

S. nigrum L. Common. (Eddy 4159)

TILIACEAE (Linden Family)

Tilia americana L. Rich woods; co-dominant tree with *Acer saccharum* in climax forest. (Eddy 1887)

ULMACEAE (Elm Family)

Celtis occidentalis L. Moist woods. Uncommon. (Eddy 1643; Harriman 18896)

Ulmus americana L. Low woods, residential yards. (Eddy 4151)

U. pumila L. Introduced. (Ihrke 029)

URTICACEAE (Nettle Family)

Boehmeria cylindrica (L.) Swartz. *Larix* swamps, sedge meadows, marshes. Common. (Eddy 609; Whirry 1174)

Parietaria pensylvanica Muhl. Woods. Uncommon. (Eddy 188, 1742; Eddy & P. Sonntag 2088)

Pilea fontana (Lunell) Rydb. Wet soils. (Jansen 226; Kohlman 1121; Underwood 1205)

P. pumila (L.) A. Gray. Wet soils. (Eddy 971, 2173)

Urtica dioica L. var. *procera* (Muhl.) Wedd. Common weed. (Bennett 228; Draheim 074; Pucker 092)

VALERIANACEAE (Valerian Family)

Valeriana edulis Nutt. var. *ciliata* (T. & G.) Cronq. Fens, low prairies. Locally common. (Eddy 719, 1590; Underwood 489)

VERBENACEAE (Vervain Family)

Phryma leptostachya L. Woods. Common. (C. Buchholtz 1002; Davis s.n.; Eddy 1662, 1811; Harriman 1116; Hockman s.n.)

Phyla lanceolata (Michx.) Greene. River bottoms. (Rill 4075)

Verbena bracteata Lagasca & Rodriquez. Upland prairies, roadsides, waste places. (Harriman 806, 811)

V. hastata L. Sedge meadows, marshes, wet ditches, low prairies. Common. (Anderson s.n.; Davis s.n.; Draheim 046; Habighorst 145; Harriman 1177; Kasierski 014)

V. stricta Vent. (Hockman 079)

V. urticifolia L. Thickets, waste places. Uncommon. (J. Linde 1154)

VIOLACEAE (Violet Family)

Viola lanceolata L. Known from one site; damp sand prairie. (Eddy 4226)

Viola palmata L. var. *pedatifida* (G. Don) Cronq.

Dry prairies, oak openings. Uncommon. (Eddy 222)

V. pedata L. Upland prairies, oak openings. Locally abundant. (Harriman 797; Taves 325)

V. pubescens Aiton. Moist woods. Common. (Pichette 046)

V. sagittata Aiton. Low prairies, sedge meadows. Uncommon. (Harriman 1841)

V. sororia Willd. Woods. (Eddy 1460, 2216; Hockman s.n.)

V. tricolor L. Garden escape. (Eddy s.n.)

VITACEAE (Grape Family)

Parthenocissus vitacea (Knerr) A. Hitchc. Woods, thickets. Common. (Draheim 078; Pucker 075)

Vitis riparia Michx. Woods, thickets, fencerows. Common. (Pucker 071)

Class Liliopsida (Monocotyledons)

ACORACEAE (Sweet Flag Family)

Acorus calamus L. Marshy shores. Common, notably along south shore of Lake Puckaway. (Eddy 1679, 4142; Harriman 2075; Warmbier 1082)

ALISMATACEAE (Water Plantain Family)

Alisma plantago-aquatica L. Shallow waters, marshy shores. Common. (Eddy 1758; Jennings 244)

Sagittaria cuneata Sheldon Shallow waters, marshy shores. (Eddy 4203)

S. latifolia Willd. (Jansen 228)

ARACEAE (Arum Family)

Arisaema triphyllum (L.) Schott. Deciduous woods. Common. (Jansen 233)

Symplocarpus foetidus (L.) Nutt. Swamps, bottomland forest, low stream banks. Common. (Eddy 4178)

COMMELINACEAE (Spiderwort Family)

Commelina communis L. Garden escape. (Eddy 2699)

Tradescantia ohioensis Raf. Prairies, oak openings, roadsides. Common. (Davis s.n.; Harriman 517, 1849; Hockman 035)

CYPERACEAE (Sedge Family)

Bulbostylis capillaris (L.) C. B. Clarke. Moist sands and gravels, especially on railroad beds. Common. (Eddy 093, 4142, 4185; Underwood 231)

Carex alopecoidea Tuckerman. Wet woods, sedge meadows, marshes. Common. (Eddy 362, 564, 2539)

C. aquatilis Wahlenb. Marshes, sedge meadows, wet ditches. Common. (Draheim 021; Eddy 355, 907, 1674, 2593)

C. arctata W. Boott. Woods. (Eddy 2299)

C. atlantica L. Bailey (Eddy 562)

C. aurea Nutt. Dolomitic outcrops. (Eddy 192; Underwood 799)

C. bebbii (L. H. Bailey) Fern. Wet prairies, sedge meadows, marshes. Common. (Eddy 207, 276, 567, 585, 2146, 2580, 4169)

C. bicknellii Britton. Wet prairies, sedge meadows. Common. (Eddy 003, 546; Harriman 730, 1895)

C. brevior (Dewey) Mackenzie. Sedge meadows. (Eddy 552; Harriman 1890)

C. buxbaumii Wahlenb. Wet prairies, sedge meadows. (Eddy 699, 1584, 2581; Harriman 784)

C. castanea Wahlenb. Dry thickets. (Eddy 2219)

C. cephalophora Muhl. Dry open woods. (Eddy 126, 1503, 1724)

C. communis L. Bailey Woods. (Eddy 2265)

C. comosa F. Boott. *Larix* swamps. (Eddy 1649, 1782; Harriman 2254; Turner 226)

C. conoidea Schk. Low prairies, sedge meadows. (Eddy 4090A)

C. crawfordii Fern. Sedge meadows. (Eddy 449, 1683, 1749, 2587; Harriman 2040)

C. cristatella Britton. Sedge meadows, swamps. (Eddy 1691)

C. cryptolepis Mackenzie. Fens, low prairies with calcareous seepages. (Eddy 2562)

C. debilis Michx. Woods. (Eddy 1617; Harriman 829)

C. deweyana Schwein. *Larix* swamps. (Eddy 396, 581)

C. echinata Murray Boggy meadows, fens. (Eddy 560, 2401)

C. festucacea Schk. Upland prairies, oak openings. (Eddy 2011, 2354)

C. foenea Willd. Dry, wooded openings. (Eddy 089, 1595, 1667)

C. gracillima Schwein. Low woods. (Eddy 1765)

C. granularis Muhl. (Eddy 4180)

C. gravida L. Bailey. Dry openings. (Eddy 1766)

C. hystericina Willd. Marshes, stream banks. Common. (Eddy 568, 573, 695, 1786, 2599; Harriman 786; Turner 225)

C. interior L. Bailey. Sedge meadows. Uncommon. (Eddy 360, 389, 418, 563, 1563, 4047)

C. lacustris Willd. *Larix* swamp. (Eddy 1474, 2398)

C. lasiocarpa Ehrh. var. *americana* Fern. Swamps, sedge meadows, marshes, shores. (Eddy 362, 1597; Hockman 040)

C. laxiflora Lam. Low woods. (Eddy 2555)

C. leptalea Wahlenb. Boggy meadows. (Eddy 583, 589, 1553)

C. limosa L. Known from one site; Snake Creek Wetlands fen, a state scientific natural area. (Eddy 4111)

C. muhlenbergii Schk. Sandy soils. (Eddy 398; Harriman 800, 1852; Underwood 835)

C. muricata L. var. *laricina* (Mackenzie) Gleason. Wetlands. (Eddy 1626, 3082, 4042)

C. normalis Mackenzie. Woods and low prairies. (Eddy & Busse 2454)

C. pensylvanica Lam. Woods, openings. Common. (Harriman 1829)

C. pseudocyperus L. Wetlands. Common. (Eddy 365)

C. retrorsa Schweintz. (Eddy 4167, 4179)

C. rosea Schk. Woods. (Eddy 2259, 2322)

C. rostrata Stokes. Marshes. (Eddy 1693)

C. sartwellii Dewey. Marshes, shores. Common. (Eddy 590, 1592, 1614, 2399)

C. scoparia Schk. Low prairies, sedge meadows. (Eddy 2088; Harriman 286, 1627)

C. sparganioides Muhl. Woods, thickets. Common. (Eddy 004, 1671)

C. sprengelii Dewey. Moist woods. Uncommon. (Eddy 2415)

C. stipata Muhl. Open swamps, sedge meadows. Uncommon. (Eddy 381)

C. stricta Lam. Sedge meadows. Common. (Eddy 4176)

C. tenera Dewey. Sedge meadows, thickets. (Eddy 1731, 2289)

C. tetanica Schk. Wet woods, sedge meadows. (Eddy 1471, 1491, 2350, 2401, 4045)

C. trisperma Dewey. *Larix* swamps. Uncommon. (Eddy 2400)

C. umbellata Schk. Local on rock outcrops. Uncommon. (Eddy 2184, 2223)

C. vulpinoidea Michx. Sedge meadows, stream banks, wet ditches. (Eddy 067, 292, 1685, 1722, 1757; Harriman 516, 2042; Turner 222)

Cladium mariscoides (Muhl.) Torr. Local in Snake Creek Wetlands fen, a state scientific natural area. (Eddy 3092)

Cyperus bipartitus Torr. Sedge meadows, shores. Common. (Eddy 1721, 2659; Harriman 18982; Underwood 1206)

C. diandrus Torr. (Fassett 13233, WIS)

C. erythrorhizos Muhl. Mud flats. (Eddy 1841; Harriman 13218; Rill 4469; Smith 043)

C. esculentus L. (Hansen 002)

C. filiculmis Vahl. Dry woods, fields. (Eddy 2625)

C. houghtonii Torr. Dry open woods. (Eddy 492)

C. odoratus L. Edge of gravel road in White River Marsh. (Eddy 1784; Harriman 13203, 18940)

C. schweinitzii Torr. Sandy stream banks. (Eddy 059, 2162; Harriman 1050, 2073, 2087, 2094; Weiss 168)

C. strigosus L. Sedge meadows, *Larix* swamps. (Anderson s.n.; Eddy 1099; Harriman 2246)

Eleocharis acicularis (L.) Roemer & Schultes. Muddy shores. Uncommon. (Eddy 4090)

E. compressa Sullivant. Sedge meadows. Common. (Eddy 692, 1578; Underwood 832)

E. intermedia (Muhl.) Schultes. Sand-muck shores, mud flats, drying ponds. (Eddy 2515)

E. ovata (Roth) Roemer & Schultes. Shallow marshes, mucky shores. (Eddy 2606, 2656)

E. palustris L. Sedge meadows, ditches. Common. (Eddy 065, 461, 586, 2552; Harriman 2076)

E. rostellata (Torr.) Torr. Rare, known from one site; Snake Creek Wetlands fen, a state scientific natural area. (Eddy 3086)

Eriophorum angustifolium Honckeny. Sedge meadows, fens. Common. (Eddy 703)

Rhynchospora alba (L.) Vahl. Local in Snake Creek Wetlands fen, a state scientific natural area. (Eddy 2277, 3091; Underwood 500)

R. capillacea Torr. Local in Snake Creek Wetlands fen, a state scientific natural area. (Eddy 3090)

R. capitellata (Michx.) Vahl. Boggy meadows, fens. Rare. (Eddy 1937, 2493)

Scirpus acutus Muhl. Marshes, shores. Common. (Eddy 280; Harriman 13212; Zietler 213)

S. atrovirens Willd. Marshes, shores, sedge meadows, swamps. Common. (Draheim 053; Eddy 491; Habighorst 106)

S. cespitosus L. var. *callosus* Bigel. Locally abundant in Snake Creek Wetlands fen, a state scientific natural area. STATE ENDANGERED (Eddy 4041)

S. cyperinus (L.) Kunth. Marshes, shores. (Eddy 1681; Habighorst 120; Kasierski 022; Weiss 158)

S. fluviatilis (Torr.) A. Gray. Shallow waters. Common. (Harriman 13210)

S. pendulus Muhl. (Eddy 2368)

S. pungens Vahl. (Harriman 16683)

S. validus Vahl. Marshes, shores, wet ditches. Common. (Eddy 475, 1746, 1844, 2541; Harriman 2043; Jennings 235; Turner 223; Weiss 159)

Scleria triglomerata Michx. Local on moist sand prairies. Rare. (Eddy 1902, 1948, 2492)

S. verticillata Muhl. Local in Snake Creek Wetlands fen, a state scientific natural area. A rare Atlantic Coastal Plain disjunct. (Eddy 3084; Harriman & Underwood 18945)

DIOSCOREACEAE (Yam Family)

Dioscorea villosa L. Moist woods. Uncommon. (Eddy 2466; Harriman 18936)

HYDROCHARITACEAE (Frog's-Bit Family)

Elodea canadensis Michx. Quiet waters. Common. (Grim, s.n.)

Vallisneria americana L. Submersed in shallow waters. Common. (Bumby 7, 26, 46, 1211, 1239, RIP; Cozart 19, RIP)

IRIDACEAE (Iris Family)

Iris pseudacorus L. Shores; introduced. (Eddy 4217)

I. versicolor L. Shores, wet ditches, various wetlands. Common. (Eddy 129; Harriman 512)

Sisyrinchium angustifolium Miller. Prairies, oak openings. Common. (Eddy 520, 522)

S. campestre E. Bickn. Prairies, oak openings. (Eddy 256, 416, 660, 2280; Harriman 765, 790, 1833, 1840)

JUNCACEAE (Rush Family)

Juncus acuminatus Michx. Moist sandy soils. Uncommon. (Eddy 2657)

J. alpinus Vill. Local in Snake Creek Wetlands fen, a state scientific natural area. Harriman 2259, 2579; Weiss 166)

J. brachycephalus (Engelm.) Buchenau. Local in Snake Creek Wetlands fen, a state scientific natural area. (Eddy 3087)

J. bufonius L. Wet ditches, old lanes. Uncommon. (Harriman 2245; Hockman s.n.)

J. canadensis J. Gay. Fens, low prairies, sedge meadows, wet ditches. Common. (Eddy 1913; Whirry 771)

J. dudleyi Wieg. Moist soils of various habitats. Common. (Harriman 2038, 2258; Underwood 800, 1171)

J. effusus L. Widespread on wet ground. Common. (Eddy 464, 2601; Harriman 2082, 2249)

J. greenei Oakes & Tuckerman. Moist, sandy habitats. Uncommon. (Eddy 815, 1805; Harriman 1228, 2086; Weber 040)

J. marginatus Rostk. Local on wet sandy shores. Uncommon. (Eddy 2663, 2716)

J. nodosus L. Wetlands. (Eddy 587, 864;

Harriman 2578; Underwood 1207; Weiss 165)

J. tenuis Willd. Widespread on disturbed moist soils. (Eddy 291, 580; Harriman 1883, 2080, 2244; Hockman 075; Weiss 170)

J. torreyi Cov. Wet ditches, sedge meadows. Uncommon. (Eddy 066; Harriman 2252)

Luzula multiflora (Retz.) Lej. Woods, clearings. Common. (Eddy 387, 553)

L. campestris (L.). (Eddy 489, 683; Underwood 508)

JUNCAGINACEAE (Arrow-Grass Family)

Triglochin maritimum L. Local in Snake Creek Wetlands fen, a state scientific natural area. (Eddy 001, 3089)

T. palustre L. Same habitat as *T. maritima.* (Eddy 3088)

LEMNACEAE (Duckweed Family)

Lemna minima Philippi. Floating on quiet waters. (Eddy 1973, 1833, 2148)

L. minor L. Most commonly occurring duckweed species in the county. Stagnant waters of ditches, ponds, slow streams. (Jansen 225)

L. trisulca L. Quiet surface waters. (Hockman 065)

Spirodela polyrhiza (L.) Schleiden. Quiet surface waters. (Eddy 2621; Grim s.n.; Harriman 16690)

Wolffia punctata Griseb. Stagnant waters. Uncommon. (Hockman 064)

LILIACEAE (Lily Family)

Aletris farinosa L. Rare, known from one site; moist sand prairie. An Atlantic Coastal Plain disjunct. (Eddy 1950, 2491)

Allium canadense L. Low prairies, low woods. Common. (Hockman 074)

A. tricoccum Aiton. Deciduous woods. Common. (Eddy 1764; Misterek 138)

Asparagus officinalis L. Garden escape. Common along roadsides, wooded clearings. (Harriman 768, 1832; Pucker 072; Sandler X27)

Convallaria majalis L. Garden escape. (Sandler X29)

Erythronium albidum Nutt. Moist woods. Common. (Eddy 1396; Kampa 038)

E. americana Ker Gawler. Similar habitat, but less common than *E. albidum.* (Burbey 057; Kampa 024; Stalker 056)

Hemerocallis fulva (L.) L. Garden escape common along roadsides, abandoned farm sites. (Eddy 620)

Hypoxis hirsuta (L.) Cov. Prairies, oak openings. Common. (Eddy 661, 1439, 1600; Harriman 796, 1826, 1842; Pucker 6161; Taves 867; Underwood 498)

Lilium superbum L. Wetlands. Common. (Eddy 054, 1648, 2576; Underwood 839)

L. lancifolium Thunb. Garden escape. (Eddy 2633)

Maianthemum canadense Desf. Common in woods. (Harriman 728, 1827; Underwood 509)

Polygonatum biflorum (Walter) Elliott. Fencerows, roadsides, clearings. Common. (Pucker 076; Taves 885)

Scilla sibirica Andrews. Spreading from gardens. (Eddy 1411)

Smilacina racemosa (L.) Desf. Deciduous woods, thickets, roadsides. Common. (Eddy 251; Hockman 100)

S. stellata (L.) Desf. Deciduous woods, thickets, roadsides. Common. (Eddy 254; Harriman 690; Misterek 135; Underwood 492)

Tofieldia glutinosa (Michx.) Pers. Local in Snake Creek Wetlands fen, a state scientific natural area. STATE THREATENED (Eddy 3060; Taves 874)

Trillium grandiflorum (Michx.) Salisb. Deciduous woods. Common. (Draheim 002; Hockman s.n.)

Uvularia grandiflora J. E. Smith. Deciduous woods. Common. (Harriman 691; Hockman s.n.)

Zigadenus elegans Pursh. Rare, known from one site in wooded opening along south shore of Green Lake. (Eddy 2482, 2524)

NAJADACEAE (Water-Nymph Family)

Najas flexilis (Willd.) Rostkov & Schmidt. (DNR 2261; Harriman 16689; Molter s.n.)

ORCHIDACEAE (Orchid Family)

Cypripedium acaule Aiton. Known from three sites; at one, locally abundant on sterile, sandy soil of a red pine plantation. (Eddy 1480)

C. calceolus L. var. *pubescens* (Willd.) Correll. Rare, known from two sites; oak woods. (Eddy 1482; Harriman 736)

C. candidum Muhl. Rare, known from one site; Snake Creek Wetlands fen, a state scientific natural area. STATE THREATENED (Eddy 3093)

Goodyera pubescens (Willd.) R. Br. Oak woods, pine plantation. Rare. (Harriman 2294)

Habenaria flava (L.) R. Br. var. *herbiola* (R. Br.) Ames & Correll. Rare, known from two sites; shrubby meadows with peaty soils interspersed with fine loamy sands. STATE THREATENED (Crosswhite s.n.; Eddy 2490, 3066)

H. lacera (Michx.) Lodd. Rare, known from one site; associated with *H. flava.* (Eddy 3067)

H. psycodes (L.) Sprengel. Wet ditches, wet open woods, thickets. The most commonly occurring *Habenaria* species in the county. (Eddy 2591, 2652)

Liparis lilifolia (L.) Rich. Oak woods, pine plantations. Local. (Eddy 002, 1523)

L. loeselii (L.) Rich. Rare, known from one site; fen with calcareous seepages. (Eddy & Harriman 4188)

Orchis spectabilis L. Rare, known from one site; maple-basswood forest. (Eddy 4181)

Spiranthes cernua (L.) Rich. Fens, boggy meadows, *Larix* swamps. Locally abundant. (Eddy 760, 2109; Whirry 772)

S. lacera (Raf.) Raf. var *lacera.* Rare, known from one site; Pine Bluff oak opening on rhyolite outcrop. (Eddy 3006)

POACEAE (Grass Family)

Agrostis capillaris L. (Eddy 524)

A. gigantea Roth. Wetlands, woods, openings. Common. (Eddy 2527)

A. hyemalis (Walter) BSP. Open sandy habitats. Uncommon. (Eddy 548, 2589, 4145)

A. perennans (Walter) Tuckerman. Moist open woods. (Eddy 471, 573)

A. stolonifera L. var. *palustris* (Hudson) Farw. Appearing naturalized in wetlands. (Eddy 1653, 2447, 2462)

A. tenuis Sibth. (Eddy 524)

Alopecurus aequalis Sobol. Wetlands. (Eddy 1750, 2692; Harriman 722)

A. pratensis L. Sedge meadows. Uncommon. (Eddy 145, 363; Linde 757)

Andropogon gerardii Vitman. Prairies, oak openings, recovering roadsides, railroad gravels. Common. (Eddy 999; Underwood 214)

Aristida basiramea Engelm. var. *basiramea.* Railroad gravels, sandy openings. (Eddy 2008, 4196; Fassett & Shinners 20657; Harriman 1227)

A. basiramea Engelm. var. *curtissii* (A. Gray) Shinners. Thin soil on rhyolite outcrops. Uncommon. (Eddy 2171)

A. longespica Poiret. var. *geniculata* (Raf.) Fern. Railroad cinders. (Eddy 2156)

A. oligantha Michx. Dry sand prairies. Uncommon. (Eddy 4140)

Avena sativa L. Escape from cultivation. (Jennings 229)

Bouteloua curtipendula (Michx.) Torr. Dry prairies. Uncommon. (Harriman 1207)

B. hirsuta Lagasca. Dry prairies. Uncommon. (Eddy 1964; Harriman 1227, 18894)

Bromus ciliatus L. Prairies, sedge meadows. Common. (Eddy 578, 2648)

B. inermis Leysser. Roadsides, disturbed sites. Common. (Harriman 816; Nelson s.n.)

B. pubescens Muhl. Woods. (Eddy 193)

B. secalinus L. (Fassett 1951, UWM)

B. tectorum L. Roadsides, disturbed sites. Common. (Eddy 633, 724)

Calamagrostis canadensis (Michx.) P. Beauv. Wetlands. Common. (Eddy 821, 1687, 2510)

C. stricta (Timm) Koeler. (Shinners s.n., WIS)

Cenchrus longispinus (Hackel). Fern. Roadsides, disturbed sites. Common weed. (Brudnicki 146; Eddy 837; Harriman 1173, 1229; Kohlman 1044)

Cinna arundinacea L. Low woods, thickets. (Harriman 18900)

Dactylis glomerata L. Roadsides, disturbed sites. Common weed. (Eddy 459, 1864; Pucker 629)

Danthonia spicata (L.) P. Beauv. Dry woods, oak openings. (Eddy 555, 1745, 2095)

Digitaria ischaemum (Schreber) Muhl. (Eddy 4197)

D. sanguinalis (L.) Scop. Roadsides, lawns, disturbed sites. Common weed. (Bennett 138; Eddy 1849)

Echinochloa crusgalli (L.) P. Beauv. Disturbed sites. Common. (Bennett 210; Habighorst 148; Zeitler 214)

E. muricata (P. Beauv.) Fern. (Eddy 1003, 1723, 1857)

E. occidentalis (Wieg.) Rydb. (Draheim 061)

E. walteri (Pursh) Heller. Wet shores, ditches, marshes. Uncommon. (Harriman 13205, 18939)

Elymus canadensis L. Prairies, oak openings. Common. (Eddy 062, 069; Jennings 266; Mateyka 152; Weiss 164)

E. hystrix L. *(Hystrix patula).* Woods, openings. (Eddy 1659; Harriman 16686)

E. riparius Wieg. Fountain Creek Prairie Scientific Area. (Underwood 1200)

E. trachycaulus (Link) Gould. Low prairies. (Eddy 2641; Harriman 2090; Underwood 839, 853)

E. villosus Muhl. Dry woods. (Harriman 16685)

E. virginicus L. Moist woods, prairies. (Eddy 1714, 2091)

Elytrigia repens (L.) Nevski. Lawns, fields, disturbed sites. Common. (Eddy 191, 1860)

Eragrostis capillaris (L.) Nees. Dry sandy soils. (Eddy & Sonntag 2086)

E. cilianensis (All.) Janchen. Common weed. (Eddy 2178)

E. hypnoides (Lam.) BSP. Forming dense tufts on mud flats. Uncommon. (Eddy 2698; Rill 4096)

E. pectinacea (Michx.) Nees. Various habitats. (Harriman 1171)

E. spectabilis (Pursh) Steudel. Dry roadsides, fields, open woods. Common. (Eddy 2672; Harriman 1262; Linde 1027; Mateyka 151; Mittelstaedt 237)

Festuca elatior L. Roadsides, pastures. (Eddy 2554)

F. obtusa Biehler. Moist woods. Uncommon. (Eddy 1769)

F. ovina L. Roadsides, fields, waste places. (Eddy 2303, 2369, 2758)

F. rubra L. Various habitats. (Eddy 2522; Eddy & Harriman s.n.; Michaels 032)

Glyceria borealis (Nash) Batchelder. Sedge meadows. (Eddy 2655)

G. canadensis (Michx.) Trin. Marshes, sedge meadows, low prairies. Common. (Eddy 2563, 4193; Harriman 2081)

G. grandis S. Wats. Marshes, sedge meadows, low prairies. Uncommon. (Eddy 2607)

G. striata (Lam.) A. Hitchc. Various wetlands. Common. (Eddy 565, 1556, 1645; Harriman 785)

Hierochloe odorata (L.) P. Beauv. Low prairies, sedge meadows. Common. (Eddy 146, 368, 1431; Underwood 483, 499)

Hordeum jubatum L. Roadsides, waste places. Common. (Harriman 783; Hockman 078)

Koeleria pyramidata (Lam.) P. Beauv. Dry prairies, sandy roadsides. Common. (Eddy 1668, 2574; Harriman 803)

Leersia oryzoides (L.) Swartz. Colonizing wet ditches. (Eddy 2687)

L. virginica Willd. Common along Shore Drive at the Green Lake Center. (Harriman 18901)

Leptoloma cognatum (Schultes) Chase. Open sandy ground. Uncommon. (Eddy 1100, 1741; Harriman 1049)

Lolium perenne L. Lawns, waste places, roadsides. Common. (Eddy 2691)

Miscanthus sacchariflorus (Maxim.) Hackel. Introduced. (Eddy 4222)

Muhlenbergia frondosa (Poiret) Fern. Low woods, thickets. (Eddy & Sonntag 2084, 2087)

M. glomerata (Willd.) Trin. Wetlands. Common. (Eddy 1980)

M. mexicana (L.) Trin. Railroad cinders. Uncommon. (Eddy 972, 1983, 2166; Eddy & Rill 2016; Harriman 13215; Underwood 1192; Weiss 153)

M. racemosa (Michx.) BSP. Low prairies, sedge meadows. Common. (Eddy & Rill 2033)

M. richardsonis (Trin.) Rydb. Known only from the Berlin Fen, a state scientific natural area. *M. richardsonis,* a native grass, was first discovered in Wisconsin in August 1989. (Harriman & Underwood 18944)

M. sylvatica (Torr.) Torr. Shore of Little Green Lake. Uncommon. (Harriman 16684)

Panicum capillare L. Common weed of waste places, fields, gardens. (Eddy 2001, 2165; Jennings 242; Zeitler 204)

P. commonsianum Ashe. var. *euchlamydeum* (Shinners) Pohl Open sandy habitats; prairies, dunes, blowouts. Uncommon Atlantic Coastal Plain disjunct. (Eddy 2338, 2693)

P. dichotomiflorum Michx. (Eddy 2154)

P. flexile (Gattinger) Scribn. Known only from the Berlin Fen, a state scientific natural area. (Harriman 18969)

P. lanuginosum Elliot var. *implicatum* (Scribn.) Fern. (Eddy 4115)

P. latifolium L. Woods and thickets. Common. (Eddy 183)

P. leibergii (Vasey) Scribn. Sandy prairies, oak openings. (Eddy 2049, 2361; Eddy & Harriman 19685; Harriman 1892)

P. linearifolium Scribn. Sandy oak opening. (Eddy s.n., 3081; Eddy & Harriman 19684; Harriman 18970)

P. miliaceum L. Recurrent introduction. (Eddy 1856; Harriman 16677)

P. oligosanthes Schultes. Sandy prairies, openings. (Eddy 2338.5; Harriman 788, 874; Hockman 088; Underwood 834)

P. villosissimum Nash. (Eddy 088, 550, 576)

P. virgatum L. Prairies, oak openings. (Eddy 4223)

Paspalum setaceum Michx. var. *ciliatifolium* (Michx.) Vasey. Sandy roadsides, oak openings. (Harriman 18895)

Phalaris arundinacea L. Becoming a monoculture in some wetlands. Mostly introduced from Europe as a forage crop, but the species is likely native. (Draheim 030)

Phleum pratense L. Roadsides, pastures, waste places. (Nelson s.n.)

Phragmites australis (Cav.) Trin. *(P. communis).* Marshes, wet ditches. (Harriman 13206; Jansen 234)

Poa annua L. Lawns, disturbed sites. Common. (Eddy & Harriman s.n.)

P. compressa L. Roadsides, fields. (Eddy 1641, 1694, 2546)

P. palustris L. Sedge meadows. Uncommon. (Eddy 790, 2371)

P. pratensis L. Lawns, roadsides, waste places. Common. (Draheim 010)

Puccinellia distans (Jacq.) Parl. (Eddy & Harriman s.n.)

Schizachyrium scoparium (Michx.) Nash var. *scoparium.* Same habitats as *A. gerardii.* Common. (Bennett 209; Eddy 834, 1107; Manthei 187; Underwood 244)

Secale cereale L. Escape from cultivation. (Eddy 384; Harriman 739)

Setaria glauca (L.) P. Beauv. Common weed. (Pucker 079)

S. viridis (L.) P. Beauv. Common weed. (Breitlow 195; Eddy 1859; Pucker 079; Turner 045)

Sorghastrum nutans (L.) Nash. Prairies. (Eddy 1995, 2115; Underwood 228)

Sorghum halepense (L.) Pers. Escape from cultivation. (Jennings 225)

Spartina pectinata Link. Wet prairies. (Eddy 075; Jennings 234; Pucker 211; Smith 044)

Sphenopholis obtusata (Michx.) Scribn. var. *major* (Torr.) K. S. Erdman Moist woods. Uncommon. (Eddy 006)

Sporobolus cryptandrus (Torr.) A. Gray. Open, sandy habitats. Uncommon. (Eddy 061; Harriman s.n.)

S. heterolepis A. Gray. Low prairie. Uncommon. (Eddy & Rill 2027)

S. vaginiflorus (Torr.) A. Wood. Railroad gravels. (Eddy 2009)

Stipa comata Trin. & Rupr. Dry prairie. Uncommon. (Harriman 876)

S. spartea Trin. (Shinners & Shaw 4384, WIS)

S. viridula Trin. Known from one site, dry sand prairie. (Eddy 4140)

Triplasis purpurea (Walter) Chapman. Dry sandy soil. (Eddy 073)

Triticum aestivum L. Escape from a bird seed mixture. (Eddy 4156)

Vulpia octoflora (Walter) Rybd. Sandy soils. (Eddy 2441)

Zizania aquatica L. var. *aquatica* (Eddy 4204; Harriman & Eddy s.n.; Fassett & McLaughin 12181, WIS). Very common in waterways during presettlement times.

Z. palustris L. var. *interior* (Fassett) Dore. *(Z. aquatica* L. var. *interior* Fassett) (Fassett & McLaughin 1536, WIS)

Z. palustris L. var. *palustris.* (Fassett & Warren 9629, WIS)

PONTEDERIACEAE (Water-Hyacinth Family)

Zosterella dubia (Jacq.) Small. (Bumby 1219)

POTAMOGETONACEAE (Pondweed Family)

Potamogeton amplifolius Tuckerman. (Bumby 60, RIP)

P. crispus L. Common macrophyte of lakes and streams. (Eddy 2487; Harriman 16688)

P. filiformis Pers. (Grim s.n.)

P. foliosus Raf. (Bumby 1222, 1235, RIP)

P. friesii Rupr. (Bumby 33, 34, 52, RIP)

P. gramineus L. (Bumby 12, 36, RIP)

P. illinoensis Morong. (Tracy 1, RIP)

P. natans L. Common lake macrophyte. (Harriman 1892)

P. nodosus Poiret. (Grim s.n)

P. pectinatus L. (Bumby 1232; Molter, s.n.)

P. praelongus L. Wulfen. (Nhler & McLaughin 374, WIS)

P. pulsillus L. (Bumby 67, 1241, 1234, RIP)

P. richardsonii (Ar. Bennett) Rydb. (Bumby 5, 47, 57, 1237, RIP)

P. zosteriformis Fern. Locally abundant. (Bumby 1207)

SMILACACEAE (Catbrier Family)

Smilax herbacea L. Damp woods. (Eddy 1598)

S. hispida Muhl. Fencerows, thickets, roadsides. Common. (Eddy 1804)

S. illinoensis Mangaly. Woods. (Underwood 506)

S. lasioneura Hooker. Woods. (Draheim 075; Eddy 109; Hansen 539; Kohlman 1340; Whirry 1357)

SPARGANIACEAE (Bur-Reed Family)

Sparganium chlorocarpum Rydb. Marshes, stream banks. (Eddy 2654)

S. eurycarpum Engelm. Marshes, wet shores. Common. (Campbell 051; Harriman 511, 13211; Nelson s.n.; Zeitler 240)

TYPHACEAE (Cat-Tail Family)

Typha angustifolia L. Marshes, wet ditches, shallow waters. (Eddy 4164)

T. latifolia L. Marshes, wet ditches, shallow waters. (Pucker 195; Turner 224)

XYRIDACEAE (Yellow-Eyed Grass Family)

Xyris torta J. E. Smith. Rare, known from two sites; local on moist sand prairies. An Atlantic Coastal Plain disjunct. (Eddy 2661)

ZANNICHELLIACEAE (Horned Pondweed Family)

Zannichellia palustris L. (Bumby 20, 99, RIP)

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James O. Evrard and Richard A. Lillie

Flora and fauna of northwest Wisconsin Waterfowl Production Areas

Abstract *Biological inventories are becoming increasingly important in our rapidly changing world. This study documents the occurrence and, to some extent, relative abundance of plant and animal species on Waterfowl Production Areas (WPAs) in northern St. Croix and southern Polk Counties, Wisconsin. Former prairie uplands have undergone drastic landscape changes but wetlands have been impacted to a lesser degree. Over 200 vertebrate animal species, 54 terrestrial invertebrate animal taxa, and over 200 aquatic invertebrate species have been recorded in the WPA wetlands and surrounding uplands during 1982–91. Vegetation surveys have recorded 169 terrestrial species and 96 aquatic species. The plant and animal communities are dynamic over time, changing in response to a changing environment. The drought of 1987–88 provided a dramatic example of these changes.*

Today's environment, threatened by massive land use changes due to a burgeoning, human population, justifies the need to acquire baseline biological data to measure impacts of future landscape changes. Information obtained from biological inventories is valuable for a variety of managerial, economic, political, and judicial uses. This study was part of a much larger research project to evaluate management techniques for increasing waterfowl and ring-necked pheasant *(Phasianus colchicus)* production in the pothole region of northwest Wisconsin (Evrard and Lillie 1987).

The objective of this study was to document the occurrence and, to a limited extent, relative abundance of terrestrial and aquatic animals and plants on federal and state Waterfowl Production Areas (WPAs) in northern St. Croix and southern Polk Counties, Wisconsin. The WPAs, consisting of wetlands and adjacent grassy uplands, were established in the early 1970s. Although acquired primarily with federal duck stamp funds, WPAs were managed by the Wisconsin Department of Natural Resources (WDNR) until 1993. Many WPAs protected relatively undisturbed wetland habitats, which may have served as refugia for various flora and fauna that previously were quite common. Most surrounding uplands, however, were greatly disturbed by past agricultural practices, and very little native vegetation remains.

Study Area

Field research was conducted in the 1,300 km^2 study area in northern St. Croix and southern Polk Counties, Wisconsin (Figure 1). Approximately 2,800 ha or 2.2% of the study area were in WPAs. The study area lies entirely within the North Central Hardwood Forests ecoregion of Omernik (1987).

The landscape was formed by a terminal moraine of the Superior lobe of the Wisconsin glaciation (Langton 1978). Up to 30 m of glacial till overlies sandstone and dolomitic limestone bedrock. Soils are mainly sandy loams of the Santiago-Jewett-Magnor Association with topography level to gently sloping. The study area is about 86% uplands, 13% wetlands, and 1% water.

The area has a continental climate with warm, humid summers and cold, snowy winters (Langton op. cit.). Mean precipitation is 75 cm with 65% falling from May to September, and mean temperature is 44.1°F. The growing season averages 135 days with average last spring frost occurring on 14 May and the average first frost on 26 September.

At the time of settlement, about 58% of the study area was wooded, 27% was in tall grass prairie, and 15% in wetlands and water (Langton op. cit.). Since settlement, the prairie and much of the woodland was converted to agriculture. Today, most of the land area is used for agricultural crops and pasture. Corn, oats, and hay are the main crops, with emphasis on dairy and livestock production. Only about 11% of the county is now wooded, but the wetland losses have been minimal and still make up 13% of the area. Although total wetland acreages are not substantially reduced, the types of wetlands found today may differ to some extent from historic wetlands.

WPA wetlands range from small (< 1 ha), shallow (< 1 m), slightly acidic (pH < 6.0), kettle-hole, surface-water depressions to moderately large (> 8 ha), deep-water (up to 3 m), slightly alkaline (pH > 9.0), ground-water flow through wetlands (hydrologic class based on Novitzki 1979). Under the Cowardin et al. (1979) wetland classification system, the majority of wetlands in Wisconsin's prairie pothole region are temporary, seasonal, semipermanent, and permanent palustrine systems, while some of the larger wetlands are classed as permanent lacustrine systems. Annual water level fluctuations range from less than 0.1 m during stable periods (i.e., wet years) to as much as 1.0 m during transition periods (onset of drought). Many of the smaller seasonal and semipermanent wetlands were entirely dry during the drought of 1987–88. Productivity, measured either in terms of nutrient concentrations or biological production, ranged from generally low in the smaller, precipitation-dominated, kettle-hole wetlands to high in the larger ground-water dominated, deep-water marshes. Differences in land use and vegetative cover of surrounding watersheds contributed to marked differences in water quality as expressed by turbidity and chlorophyll (i.e., algae) concentrations. Many wetland margins and bottoms have been disturbed by cultivation during dry periods.

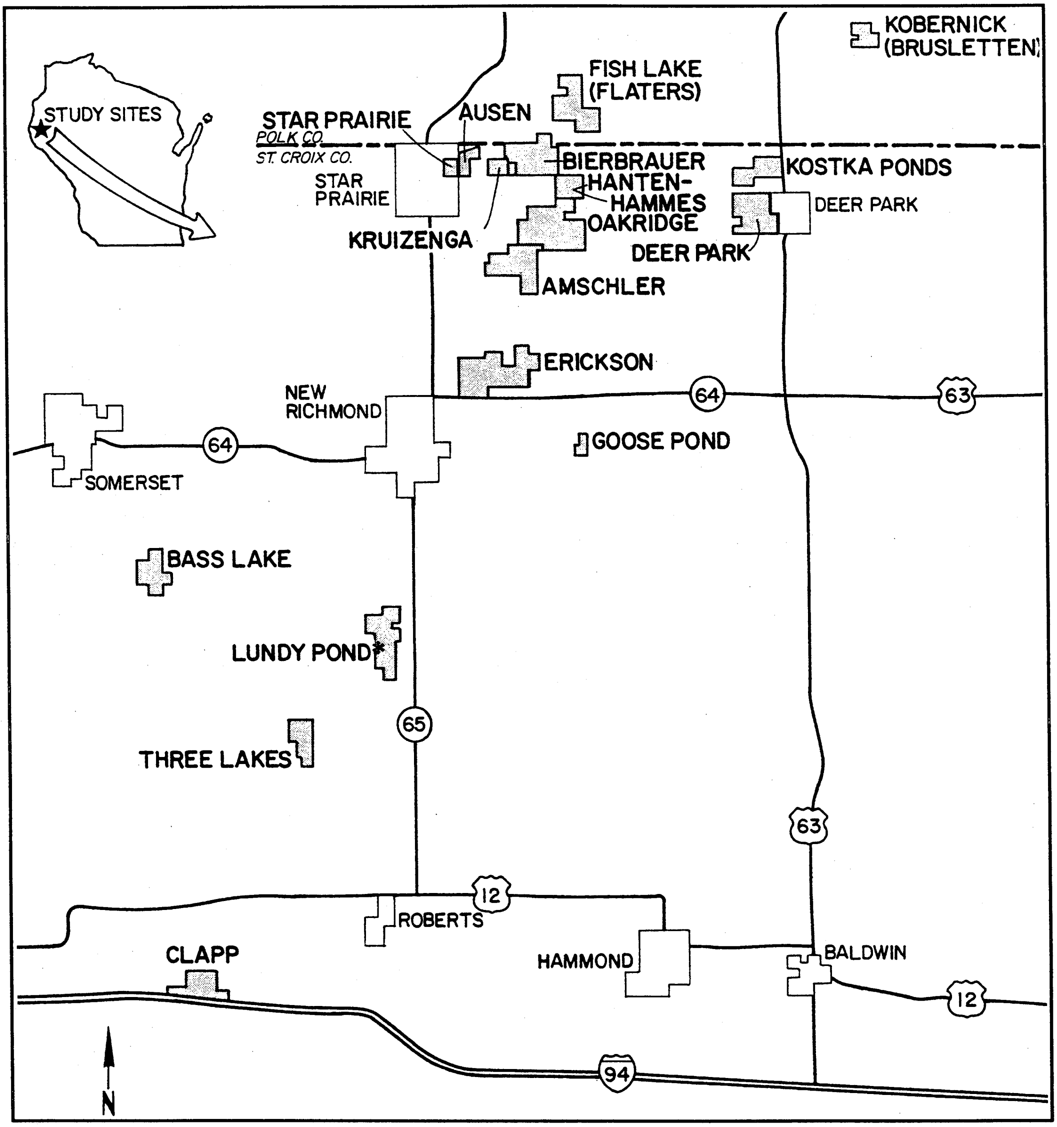

Figure 1. Location of waterfowl production areas within study area.

Methods

A broad combination of sampling methods and sampling protocols was employed in this study (Table 1). A field notebook was used to record the presence of wildlife on the public properties. All personnel involved in this study carried field notebooks in which significant wildlife observations were recorded from 1982 through 1991. Observational data recorded included species, numbers, sex, activity, location, weather, time, and date. However, many abundant animal species such as the red-winged blackbird *(Agelaius phoeniceus),* thirteen-lined ground squirrel *(Cittellus tridecemlineatus),* and the painted turtle *(Chrysemys picta)* are underrepresented in this study.

Additional wildlife observations were obtained from wildlife and vegetation surveys described in detail in Evrard and Lillie (1987); graduate research by Mauser (1985) and McDowell (1989); and from research project reports written by student interns (Kjolhaug 1982, Fassbender 1983, Lueth 1983, Cordray 1984, Kreis 1984, Elert 1985, Thilleman 1985, Giudice 1986, Seppi 1986, Sweitzer 1989, Brua 1987, Balzer 1988, Fleming 1989, Richter 1989, Dianich 1990, Johnson 1990, Wier 1990). Fish observation records, supplemented with field notes, were provided by H. Bolton and J. Milligan, U.S. Fish & Wildlife Service, Winona, MN and Genoa, MN, respectively. Records of occurrence of macro- and microinvertebrates (and those plants requiring microscopic examination for identification) were based on laboratory identifications using currently acceptable taxonomic keys and nomenclature. Lists of taxonomic keys used are available from the authors upon request. Voucher specimens of representative specimens are available for many flora and fauna at the WDNR Research Center, Monona, WI.

Results

Over 200 vertebrate species have been observed on the WPAs in northern St. Croix and southern Polk Counties. These include 162 bird, 30 mammal, 10 amphibian, 5 turtle, 1 lizard, 3 snake, and 11 fish species (Table 2). Evidence of breeding (eggs, nests, or young) was found for 42 bird species (Table 3). The status or relative abundance and seasonal occurrence of each species was determined from miscellaneous observations (Table 1). Bird species observed during the survey of Oakridge Lake were also assumed to be breeding in the area (Table 3). Most mammal, amphibian, turtle, lizard, snake and fish species were also assumed to be breeding in the WPAs.

Invertebrates were also observed and recorded in the WPA uplands and wetlands. At least 54 taxa, representing 44 terrestrial arthropod families or orders were found in the surrounding uplands (Table 4), and nearly 200 aquatic invertebrate species were found in the study area wetlands. Aquatic taxa included over 167 insect species (Table 5), 20 zooplankton species, and representatives of 12 other aquatic invertebrate orders (Table 6).

Vegetation surveys accounted for a minimum of 169 terrestrial plant species (Table 7) and 96 aquatic plant species (Table 8). More detailed information regarding wetland plant distribution is available in Evrard and Lillie (1987).

Discussion

Earlier workers (Robbins 1961, Robbins 1968, Goddard 1975, Robbins 1969, Faanes and Goddard 1976, Faanes 1981, Petersen et al. 1982) recorded bird species present on and adjacent to WPA wetlands in St. Croix and Polk Counties. Temporal and spatial changes in bird distribution and numbers have occurred.

The rare and local red-necked grebe *(Podiceps grisegena)* was first found breeding in St. Croix County on Twin Lakes in 1973 and on Oakridge Lake in 1976 (Faanes 1981). By 1978, it had abandoned Twin Lakes and by 1982, was found only on Oakridge Lake (Evrard 1988). The common loon *(Gavia immer)* reestablished itself as a breeding species in St. Croix County in 1986 after an absence of decades (Evrard 1987). The trumpeter swan *(Cygnus buccinator)* again became a breeding species in St. Croix County in 1990 following release of birds in adjacent Minnesota (Evrard 1990, 1991). Despite Faanes (1981) reporting brood records for redhead ducks *(Aythya americana),* canvasback *(Aythya valisneria),* and lesser scaup *(Aythya affinis)* in the mid-1970s, we never observed a single brood of these species on these same wetlands during our 10-year study.

Temporal and spatial changes have occurred with mammal species also. Coyotes *(Canis latrans)* and black bears *(Ursus americanus),* more common north of the study area, were seen with increasing frequency during this study. Opossum *(Didelphis marsupialus),* which have been extending their range northward in Wisconsin, were first seen in a WPA in 1990. Since the study area was formerly both prairie and woodland, it was not surprising to find both the meadow vole *(Microtus pennsylvanicus)* and the prairie vole *(M. ochrogaster)* and both the woodland deer mouse *(Peromyscus maniculatus gracilis)* and the prairie deer mouse *(P. m. bairdii)* (Long 1990).

This study also added to the knowledge of the occurrence and distribution of little-known wildlife groups such as the amphibians and reptiles. When compared to distribution records published by Vogt (1981), new county records or county locations were recorded for 2 salamander, 4 turtle, 1 lizard, and 3 snake species (Wier 1990).

The short list of fish species inhabiting WPA wetlands is not too surprising considering the dynamic hydrologic fluctuations experienced by most wetlands in the study region. During the severe drought of 1987–88, some wetlands formerly classed as permanent dried up completely, while those that retained water experienced severe winterkill conditions. Most of the WPA wetlands are landlocked, thus further delaying recolonization after a total winterkill. It is believed that some wetlands have been stocked by neighboring landowners with game and pan fish (in violation of state laws), while others have been illegally stocked with minnows by bait dealers. Many of the smaller wetlands are fishless, while intermediate-sized wetlands contain populations of the hardy fathead minnow and central mudminnow. Only the largest, deepest wetlands contain complex fish communities.

The list of insects and associated arthropods of terrestrial habitats (Table 4) undoubtedly represents only a small fraction of the total inventory present on WPAs in northwest Wisconsin. Much more intensive efforts would be required to provide a complete inventory.

Time constraints, financial support, and the objectives of the major study, under which the aquatic invertebrate data reported herein were collected, precluded species level determinations among all groups. Beetles and bugs were identified to species, while identification of other taxa was limited to genus or higher. Therefore, the lists in Tables 5 and 6 are unbalanced taxonomically and incomplete. However, because the data represent a composite collection from a wide range of wetland types and sizes, the lists do provide a good indication of what may be considered typical inhabitants of WPA wetlands in northwestern Wisconsin. Relative abundance of the various taxa differ dramatically among the individual wetlands. Small, temporary wetlands (fishless) generally contain an assemblage of species quite distinct from assemblages in the larger, more permanent wetlands. Small kettle-hole wetlands had assemblages dominated by dragonflies (Odonates), beetles (Coleoptera), and caddisflies (Trichoptera). Most large wetlands contained a diverse assemblage of generally, smaller-bodied forms, including flies (Diptera), beetles (a different group of beetles than in the smaller wetlands - see Lillie 1991), and bugs (Heteroptera). Zooplankton assemblages likewise were quite distinct among wetlands. Fairy shrimp (Anostraca), *Daphnia minnehaha*, and *Aglaodiaptomus leptopus* only were found on the small, temporary, fishless wetlands. No endangered or threatened species of insects were collected; however, several specimens represent new distributional records for Wisconsin.

In addition to an already published note concerning beetles (Lillie 1991), the following records are worth mentioning. Two adult specimens of *Euhrychiopsis lecontei* were collected on Bierbrauer WPA (Sect. 4, T31N, R17W, St. Croix Co.). This weevil is believed to have potential as a naturally-occurring biocontrol agent of the nuisance aquatic plant, Eurasian watermilfoil, *Myriophyllum spicatum* (Creed et al. 1992; Newman and Maher 1995). As such, its existence and knowledge concerning its distribution in Wisconsin is important. The record of a single specimen of the water scavenger beetle, *Cercyon* (nr.) *roseni*, from Deer Park WPA (Sect. 7, T31N, R16W, St. Croix Co.) is believed to be the first report of this species in Wisconsin. This species appears to be terrestrial or semiaquatic, associated with wet areas near water (Smetana 1988) and, due to its small size, may be often overlooked in most collections. A single specimen of the water boatman, *Cenocorixa dakotensis*, was captured from Erickson WPA (Sect. 30, T31N, R17W, St. Croix Co.). This species is listed as a taxon of "special concern" by the WDNR, Bureau of Endangered Species (Wis. Misc. Rare Invert. Working List). Only two other specimens have been collected from Wisconsin (pers. com. W. Hilsenhoff, UW-Madison).

Few components of the presettlement terrestrial plant communities remain (Table 7). Most upland plant communities surrounding study area wetlands are either old fields or grasses planted specifically for duck and ring-necked pheasant nesting cover. Exotic and weedy herbaceous plant species dominate with woody plants represented by trees and shrub seedlings invading the grass-forb communities. The handful of prairie species such as the bluestem grasses *(Andropogon gerardii, Schizachyrium scoparium)* are classed as uncommon and rare (Table 7). Aquatic plant communities varied among wetlands based primarily on size and position in the landscape. The smaller, precipitation-dominated, surface-depression wetlands mostly were of the sedge meadow type (Curtis 1959), dominated by sedges (*Carex* spp.) and grasses (Table 8). Some wetlands contained components of fens or bogs. The majority of larger wetlands represented either emergent or submerged aquatic communities (of Curtis 1959). Emergent wetlands were dominated by cat-tails (*Typha* spp.), arrowheads (*Sagittaria* spp.), or various grasses and spikerushes (*Eleocharis* spp.). Submerged and floating-leafed communities were dominated by pondweeds (*Potamogeton* spp.) and duckweeds (*Lemna* spp. and *Spirodela polyrhiza*). No endangered or threatened species were encountered.

Table 1. Compilation of sampling methodologies employed in this survey.

Flora or Fauna	*Sampling Methods*	*Sampling Period*	*Sampling Frequency*
Fauna:			
Waterfowl	Field notes	1982–91	continuous
	Nest searches	1982–91	3 yr^{-1}; May–June
	Breeding pair surveys	1982–91	2 yr^{-1}; May
Mammals	Field notes	1982–91	continuous
Amphibians	Field notes	1982–91	continuous
Fish	AC & DC Electroshocking	1983–86, 88, 90	1–2 yr^{-1} $wetland^{-1}$; May–July
	Fyke-netting	1983–86, 88, 90	1–2 yr^{-1} $wetland^{-1}$; May–July
	Seining (20–40 ft)	1983–84	1–2 yr^{-1} $wetland^{-1}$; May–July
	Experimental gill-nets	1983–86, 88, 90	1–2 yr^{-1} $wetland^{-1}$; May–July
	Field notes	1983–91	continuous
Terrestrial insects and arthropods	Sweep nets	1986	see Brua 1987 for details
	Pitfall traps	1986	see Brua 1987 for details
	Activity traps	1985–86	see McDowell 1989 for details
	Misc. in aquatic samples	1983–92	see Evrard & Lillie 1987
Aquatic insects and other invertebrates	Sweep nets	1983	N 3–6 sites, 4 dates yr^{-1} $wetland^{-1}$; May–August
	Activity traps	1985–86	see McDowell 1989 for details
	Column samplers	1983–92	N 3–6 sites, 1–4 dates yr^{-1} $wetland^{-1}$; May–July
	Sediment corers	1983–92	N 3–6 sites, 1–4 dates yr^{-1} $wetland^{-1}$; May–July
Zooplankton	#20 mesh net	1983–84	N 1 site, 1–4 dates yr^{-1} $wetland^{-1}$; May–July
Flora:			
Terrestrial plants	Quadrat surveys	1982–91	1 yr^{-1}; August
Wetland plants	Column sampler	1983–92	N 3-6 sites, 1-4 dates yr^{-1} $wetland^{-1}$; May–July
	Transect surveys	1983–86, 88, 90–91	N 3-5 transects, 1 date yr^{-1} $wetland^{-1}$; June
Aquatic plants	Column sampler	1983–92	N 3-6 sites, 1–4 dates yr^{-1} $wetland^{-1}$; May–July
	Transect surveys	1983–86, 88, 90–91	N 3-5 transects, 1 date yr^{-1} $wetland^{-1}$; June
	Gridded surveys	1983–86, 88, 90	N 75-85 sites; 2 wetlands; June

Table 2. Wildlife occurrence[a] in waterfowl production areas in St. Croix and southern Polk Counties, 1982–91. Latin names and English names conform to usage in *Birds of North America,* 2nd ed., and are consonant with the most recent American Ornithologists' Union checklist.

Species	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*Status[b]*
Birds:											
Common loon *(Gavia immer)*	PM	PBM	M	PBM	PBM*	PM	PBM*	BM	PBM	PM	U SR,Mg
Western grebe *(Aechmophorus occidentalis)*		M							M		Ac
Red-necked grebe *(Podiceps grisegena)*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM	PBM*	PBM*	BM*	PM	A SR,Mg
Horned grebe *(Podiceps auritus)*	PM	M	P					PM	M		R Mg
Pied-billed grebe *(Podilymbus podiceps)*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	BM*	PBM*	A SR,Mg
Double-crested cormorant *(Phalacrocorax auritus)*	PM	PBM	PBM	PBM	PBM	PBM	PM	PM	PM	M	C SR,Mg
Tundra swan *(Cygnus columbianus)*	PM	M	M	PM	M	M	M	M	M	M	C Mg
Trumpeter swan *(Cygnus buccinator)*				M	PM	BM	PBM	PBM*	PBM*	PBM*	U SR,Mg
Whooper swan *(Cygnus c.)*						M					Ac
Canada goose *(Branta canadensis)*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	A PR
Greater white-fronted goose *(Anser albifrons)*								M	P		Ac
Snow goose *(Chen caerulescens)*	M		M	M	M	M	M	PM	M	M	C Mg
Mallard *(Anas platyrhynchos)*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	A PR
American black duck *(Anas rubripes)*	M	M	M	M	M	PM	M	M	M	PM	C Mg
Northern pintail *(Anas acuta)*	M	M	M	M	M	M*	M	PM	PM	M	C Mg,SR
Gadwall *(Anas strepera)*	PM	M	PBM	M	M	BM	PBM	M	PM	PM	C Mg,SR
American wigeon *(Anas americana)*	PM	PM	M	PM	M	M	PM	PM	PM	PM	A Mg,SR
Northern shoveler *(Anas clypeata)*	PM	PM	PM	PM	M	PM	PBM	PBM*	PM	PM	C SR,Mg
Blue-winged teal *(Anas discors)*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	A SR,Mg
Green-winged teal *(Anas crecca)*	PBM*	PM	PBM*	PBM*	BM	PBM	PBM	PBM	PBM	PBM	A SR,Mg
Wood duck *(Aix sponsa)*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	A SR,Mg
Redhead *(Aythya americana)*	PM	PM	PM	M	M	M	M	PBM	PBM	M	A Mg,SR

Species	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Status[b]
Canvasback *(Aythya valisineria)*	M	M	M	M	M	M	M	M	M	M	U Mg,SR
Ring-necked duck *(Aythya collaris)*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM	PBM*	A SR,Mg
Lesser scaup *(Aythya affinis)*	PM	PM	M	PM	M	M	PM	PM	PM	PM	A Mg,SR
Common goldeneye *(Bucephala clangula)*	M	M	M	PM	M	M	M	M	M	M	C Mg
Bufflehead *(Bucephala albeola)*	M	PM	PM	M	M	M	M	PM	PM	PM	A Mg
White-winged scoter *(Melanitta fusca)*				M							Ac
Ruddy duck *(Oxyura jamaicensis)*	PBM*	PBM*	PBM*	PM	M	M	BM*	PBM	PBM	PBM	A SR,Mg
Common merganser *(Mergus merganser)*	PM	M	M	M	M	M	M	M	M	PM	C Mg
Red-breasted merganser *(Mergus serrator)*	M	M	M	PM	M	M	PM		M	PM	U Mg
Hooded merganser *(Lophodytes cucullatus)*	M	PBM*	PBM*	BM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM*	A SR,Mg
Turkey vulture *(Cathartes aura)*	M	M	M	M	M	M	M	M		M	U SR,Mg
Northern harrier *(Circus cyaneus)*	PM	PM	PM	PM*	M*	M	PM	M*	PM	M	C SR,Mg
Northern goshawk *(Accipiter gentilis)*	M	M	M		M	M					R Mg,WV
Cooper's hawk *(Accipiter cooperii)*	M	M	M		M*	M	M	M			U SR,Mg
Sharp-shinned hawk *(Accipiter striatus)*	M	M	M	M	M	M	M	M	M	M	U SR,Mg
Rough-legged hawk *(Buteo lagopus)*		M	M	M	M		M	M			C Mg
Red-tailed hawk *(Buteo jamaicensis)*	M	M	M*	M*	M*	M*	M	M	M	M	C SR,Mg
Swainson's hawk *(Buteo swainsoni)*		M			M						Ac
Broad-winged hawk *(Buteo platypterus)*			M		M	M					R Mg,SR
Bald eagle *(Haliaeetus leucocephalus)*	M	M	M	M	M	M	PBM	M	PM	M	A Mg,SR
Osprey *(Pandion haliaetus)*		M		M	M	M		M	PM	P	R Mg,SR
Peregrine falcon *(Falco peregrinus)*								M		M	R Mg
Merlin *(Falco columbarius)*					M		M				R Mg
American kestrel *(Falco sparverius)*	M*	M	M	M*	M*	M*	M*	M*	M*	M*	A SR,Mg
Ruffed grouse *(Bonasa umbellus)*		M	M		M*		M		M*	M	U PR
Northern bobwhite *(Colinus virginianus)*					M						Ac
Ring-necked pheasant *(Phasianus colchicus)*	M*	M*	M*	M*	M*	M*	M*	M	M*	M	A PR

Table 2, continued.

Species	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Status[b]
Gray partridge *(Perdix p.)*	M	M			M	M	M	M	M		R PR
Great egret *(Casmerodius albus)*	M	PBM	PBM	PBM	PBM	M	PBM	PBM	BM	PBM	A SR,Mg
Great blue heron *(Ardea herodias)*	PM	PBM	PBM	PBM	PBM	PBM	PBM	PBM	PB	PBM	A SR,Mg
Green-backed heron *(Butorides virescens)*	PM	PBM*	PBM*	PBM	PBM	PBM	PBM	PBM	PM	PBM	C SR,Mg
Black-crowned night heron *(Nycticorax n.)*	M	PBM	PBM	BM	M	BM	M	M		M	R SR,Mg
American bittern *(Botaurus lentiginosus)*	M	PBM	BM	P	PM	M	M	M	PBM		R SR,Mg
Least bittern *(Ixobrychus exilis)*			M			P					R SR
Sandhill crane *(Grus canadensis)*		M	M	M	M	M	M	M			R Mg
Virginia rail *(Rallus limicola)*		M	B	B	M	B	B*		B	BM	R SR,Mg
Sora rail *(Porzana carolina)*	PM	PM*	PBM	PBM	PM	PM*	P	M	PM	PB	R SR,Mg
Common moorhen *(Gallinula chloropus)*				M							Ac
American coot *(Fulica americana)*	PBM*	PBM*	PBM*	PBM*	PM	PBM	PBM	PBM*	PBM*	PBM*	A SR,Mg
American avocet *(Recurvirostra americana)*							M		M		R Mg
American golden plover *(Pluvialis dominica)*						PM					R Mg
Black-bellied plover *(Pluvialis squatarola)*	M						PM				R Mg
Semipalmated plover *(Charadrius semipalmatus)*						M	P				R Mg
Killdeer *(Charadrius vociferus)*		M	M	M	M	M	PBM	M	M	M	U SR,Mg
Upland sandpiper *(Bartramia longicauda)*		M									R SR
Hudsonian godwit *(Limosa haemastica)*							P				R Mg
Solitary sandpiper *(Tringa solitaria)*		M			M		BM				R SR
Spotted sandpiper *(Actitis macularia)*		P	PB	M		PM	PB				R SR
Willet *(Catoptrophorus semipalmatus)*							M				R Mg
Greater yellowlegs *(Tringa melanoleuca)*					M	M	P	M			R Mg
Lesser yellowlegs *(Tringa flavipes)*	M	M	M	PM	M	PM	PM	PM	M		C Mg
Ruddy turnstone *(Arenaria interpres)*	M										R Mg

Species	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Status[b]	
Short-billed dowitcher *(Limnodromus griseus)*				M			P				R	Mg
Purple sandpiper *(Calidris maritima)*							M				R	Mg
Pectoral sandpiper *(Calidris melanotos)*		M		M	M		M				R	Mg
Dunlin *(Calidris alpina)*							M		M		R	Mg
Least sandpiper *(Calidris minutilla)*							PM				R	Mg
Semipalmated sandpiper *(Calidris pusilla)*							M				R	Mg
Wilson's phalarope *(Phalaropus tricolor)*	M		PM	M	M				M		U	R
American woodcock *(Scolopax minor)*		M	M		M						R	SR,Mg
Common snipe *(Gallinago gallinago)*	PM	M	B	PM	M	PM	PM	PM	PM	P	U	SR,Mg
Ring-billed gull *(Larus delawarensis)*	M	PBM	M	BM	M	BM	PBM	M	M	PBM	C	Mg,SR
Bonaparte's gull *(Larus philadelphia)*		M		M			M		M	M	R	Mg
Herring gull *(Larus argentatus)*		M									R	Mg
Forster's tern *(Sterna forsteri)*	M	PM	PM*	M	PM	BM	PM		M	PM	U	SR,Mg
Caspian tern *(Sterna caspia)*			M	M	BM	M			M		R	Mg
Black tern *(Chlidonias niger)*	PM*	PBM*	PBM*	PBM*	PBM*	PBM*	PBM	PBM*	PM*	PBM	A	SR
Mourning dove *(Zenaida macroura)*		M	M*	M			M				R	SR,Mg
Black-billed cuckoo *(Coccyzus erythropthalmus)*			M								R	SR
Great horned owl *(Bubo virginianus)*	M	M	M	M	M	M	M*	M	M*		U	PR
Long-eared owl *(Asio otus)*					M*						R	PR
Short-eared owl *(Asio flammeus)*				M				M	M		R	SR,Mg
Barred owl *(Strix varia)*			M			M					R	PR
Common nighthawk *(Chordeiles minor)*			M		M		M				R	SR,Mg
Chimney swift *(Chaetura pelagica)*					M				M		R	SR
Belted kingfisher *(Ceryle alcyon)*	M	BM	PBM	PM	PBM	PBM	PBM	BM	M	PBM	C	SR,Mg
Northern flicker *(Colaptes auratus)*		M	M*	M	M	M					R	SR,Mg
Pileated woodpecker *(Dryocopus pileatus)*	M	M	M	M	M	M	M		M	M	C	PR

Table 2, continued.

Species	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Status[b]
Red-headed woodpecker *(Melanerpes erythrocephalus)*		M			M	M					R SR,Mg
Red-bellied woodpecker *(Melanerpes carolinus)*			M								R SR,Mg
Hairy woodpecker *(Picoides villosus)*	M										R PR
Eastern kingbird *(Tyrannus t.)*	M*	M	M		M	M	M	M			C SR
Western kingbird *(Tyrannus verticalis)*								M			Ac
Great crested flycatcher *(Myiarchus crinitus)*				M*							R SR
Eastern phoebe *(Sayornis phoebe)*					M						R SR,Mg
Alder flycatcher *(Empidonax alnorum)*						M					R SR
Willow flycatcher *(Empidonax traillii)*	M	B				B	P		BM		R SR
Horned lark *(Eremophila alpestris)*			M		M						R WR,Mg
Barn swallow *(Hirundo rustica)*			M			M		M	M		R SR,Mg
Cliff swallow *(Hirundo pyrrhonota)*			M								R SR,Mg
Tree swallow *(Tachycineta bicolor)*	M	M	M	M	M	BM	M	BM*	BM	M	C SR,Mg
Purple martin *(Progne subis)*	M			M							R SR,Mg
Blue jay *(Cyanocitta cristata)*				M	M						R PR
American crow *(Corvus brachyrhynchos)*	M*	M						M			R PR
Black-capped chickadee *(Parus atricapillus)*		M	M								R PR
White-breasted nuthatch *(Sitta carolinensis)*				M							R PR
House wren *(Troglodytes aedon)*	M		M*		M		M				R SR,Mg
Sedge wren *(Cistothorus platensis)*		M		M	M			M	M		R SR
Marsh wren *(Cistothorus palustris)*					BM	M	M	M	M		U SR
Gray catbird *(Dumetella carolinensis)*		M*									R SR
Brown thrasher *(Toxostoma rufum)*	M	M	M	M		M	M	M			R SR,Mg
American robin *(Turdus migratorius)*			M	M	M		M			M	R SR,Mg

Species	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Status[b]	
Eastern bluebird *(Sialia sialis)*	M	M	M*	M	M	M	M	M*	M	M	U	SR,Mg
Cedar waxwing *(Bombycilla cedrorum)*					M						R	PR
Loggerhead shrike *(Lanius ludovicianus)*		M	M	M	M	M	M				R	SR,Mg
Northern shrike *(Lanius excubitor)*	M	M		M	M	M		M			U	WR
European starling *(Sturnus vulgaris)*			M*	M*	M	M*	M*				R	PR
Nashville warbler *(Vermivora ruficapilla)*	M		M								R	SR
Yellow warbler *(Dendroica petechia)*	M	PBM			M	M	PM	PM	M	BM	R	SR
Yellow-rumped warbler *(Dendroica coronata)*	M	M								M	R	Mg
Blackpoll warbler *(Dendroica striata)*			M								R	Mg
Palm warbler *(Dendroica palmarum)*		M			M					M	R	Mg
Common yellowthroat *(Geothlypis trichas)*	PM	B	PM		PM	BM	M	PBM	M	PBM	R	SR
House sparrow *(Passer domesticus)*						M		M*			R	PR
Bobolink *(Dolichonyx oryzivorus)*	M	M	M	M	M	M	M	M	M		C	SR
Eastern meadowlark *(Sturnella magna)*		M	M*	M		M			M	M	U	SR
Yellow-headed blackbird *(Xanthocephalus x.)*	PM	PBM	PBM	PM	PM	BM	PM	PM	PM	PM	U	SR,Mg
Red-winged blackbird *(Agelaius phoeniceus)*	M	M	M	M*	M*	M	M	M	M	M	U	SR,Mg
Common grackle *(Quiscalus quiscula)*			M	M	M						R	SR,Mg
Brown-headed cowbird *(Molothrus ater)*					M		M				R	SR,Mg
Northern oriole *(Icterus galbula)*	M				M						R	SR
Scarlet tanager *(Piranga olivacea)*					M						R	SR
Northern cardinal *(Cardinalis cardinalis)*					M						R	SR
Rose-breasted grosbeak *(Pheucticus ludovicianus)*					M	M					R	SR
Indigo bunting *(Passerina cyanea)*				M		M					R	SR
American goldfinch *(Carduelis tristis)*	M	M									R	SR,Mg
Dickcissel *(Spiza americana)*				M		M			M		R	SR
Savannah sparrow *(Passerculus sandwichensis)*		M	M		M		M	M	M		R	SR

Table 2, continued.

Species	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*Status*[b]
Vesper sparrow *(Pooecetes gramineus)*			M	M							R SR,Mg
Dark-eyed junco *(Junco hyemalis)*			M								R Mg
Grasshopper sparrow *(Ammodramus savannarum)*	M		M	M							R SR,Mg
American tree sparrow *(Spizella arborea)*		M	M	M							R Mg
Chipping sparrow *(Spizella passerina)*				M		M*					R SR,Mg
Clay-colored sparrow *(Spizella pallida)*		M	M*	M	M	M			M		U SR
Field sparrow *(Spizella pusilla)*									M		U SR
White-crowned sparrow *(Zonotrichia leucophrys)*		M									R Mg
Fox sparrow *(Passerella iliaca)*					M						R Mg
Swamp sparrow *(Melospiza georgiana)*						M	M	M	M	M	R SR
Song sparrow *(Melospiza melodia)*	M	M	M	M	M		M		M		R SR,Mg
Snow bunting *(Plectrophenax nivalis)*	M	M	M	M							R WR
Mammals:											
Opossum *(Didelphis marsupialus)*									M		R PR
Masked shrew *(Sorex cinereus)*	M	M	M	M	M	M	M	M	M		R PR
Short-tailed shrew *(Blarina brevicauda)*	M	M	M	M	M	M	M	M			C PR
White-tailed jackrabbit *(Lepus townsendii)*		M	M	M	M	M					U PR
Cottontail rabbit *(Sylvilagus floridanus)*	M	M	M		M	M		M	M	M	C PR
Woodchuck *(Marmota monax)*		M									R PR
Thirteen-lined ground squirrel *(Cittellus tridecemlineatus)*	M	M	M	M	M	M	M	M	M		C PR
Fox squirrel *(Sciurus niger)*	M	M			M					M	R PR
Gray squirrel *(Sciurus carolinensis)*		M		M							R PR
Pocket gopher *(Geomys bursarius)*	M	M	M	M	M	M	M	M	M	M	R PR
Beaver *(Castor canadensis)*		PM	P	M	M	P	P	BM	PM	BM	U PR

Species	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Status[b]
Meadow and prairie voles	M	M	M	M	M	M	M	M	M		R PR
(Microtus pennsylvanicus, M. ochrogaster)											
Muskrat *(Ondatra zibethicus)*	M	PM	M	PB	M	M	BM	B		B	U PR
Meadow jumping mouse *(Zapus hudsonius)*	M	M	M	M	M				M		UC PR
Deer and white-footed mice	M	M	M	M	M	M	M	M	M		C PR
(Peromyscus maniculatus, P. leucopus)											
House mouse *(Mus musculus)*					M						R PR
Eastern chipmunk *(Tamias striatus)*		M									R PR
Red fox *(Vulpes v.)*	M	M	M	M	M	M	M	M	M	M	A PR
Coyote *(Canis latrans)*					M	M					R PR
Black bear *(Ursus americanus)*							M				Ac
Raccoon *(Procyon lotor)*	M	M	M	BM	BM	M	M	PM	PM	P	A PR
Short-tailed weasel *(Mustela erminea)*	M				M		M				R PR
Long-tailed weasel *(Mustela frenata)*	M	M			M						R PR
Mink *(Mustela vison)*	M	M	M	PM	PM	M	M	M	M		A PR
Badger *(Taxidea taxus)*	M	M	M	M	M		M	M	M		C PR
Striped skunk *(Mephitis m.)*	M	M	M	M	M	M	M	M	M	M	A PR
Otter *(Lutra canadensis)*		M	M	M	M		PM	BM			U PR
White-tailed deer *(Odocoileus virginianus)*	M	M	M	M	M	M	M	M	M	M	A PR
Amphibians:											
Blue-spotted salamander *(Ambystoma laterale)*			M								R PR
Spotted salamander *(Ambystoma maculatum)*									M		
Eastern tiger salamander *(Ambystoma tigrinum)*	M		M		M	M			M	M	U PR
Eastern American toad *(Bufo americanus)*			M	M			M		M		R PR
Western chorus frog *(Pseudacris triseriata)*		M	M	M	M	M	M	M	M	P	C PR
Northern spring peeper *(Pseudacris crucifer)*		M	M	M	M		M		M	P	U PR

Table 2, continued.

Species	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Status[b]
Eastern gray tree frog *(Hyla versicolor)*			M			M			M		R PR
Green frog *(Rana clamitans)*			BM		PB			B	BM		R PR
Northern leopard frog *(Rana pipiens)*			P	BM	M	M	M		M		R PR
Wood frog *(Rana sylvatica)*		M	M	M		M	M	M	M		C PR
Turtles:											
Common snapping turtle *(Chelydra serpentina)*			M	M		M	M	M	M	M	C PR
Blanding's turtle *(Emydoidea blandingii)*					M				M		R PR
Western painted turtle *(Chrysemys picta)*		M	M	M	M		M	P	M		U PR
Map turtle *(Graptemys geographica)*									M		R PR
Eastern spiny shoftshell turtle *(Apalone spiniferus)*					M				M		R PR
Lizards:											
Northern prairie skink *(Eumeces septentrionalis)*									M		UC PR
Snakes:											
Western fox snake *(Elaphe vulpina)*									M		R PR
Eastern garter snake *(Thamnophis sirtalis)*	M		M						M		R PR
Red-bellied snake *(Storeria occipitomaculata)*					M	M					R PR
Fish:											
White sucker *(Catostomus commersoni)*	M	MF	MF	F	F		MF	M			C PR
Golden shiner *(Notemigonus crysoleucas)*	M	MF	F	MFD	FD		F	M	F		A PR
Fathead minnow *(Pimephales promelas)*		MF	F	FD	FD		F	M	F	M	A PR
Central mudminnow *(Umbra limi)*				D	D		M			M	U PR
Brook stickleback *(Culaea inconstans)*		F									R PR
Yellow perch *(Perca flavescens)*		MF	MF	F	F		F		F		C PR
Bluegill *(Lepomis macrochirus)*			M		M		M				R PR

Species	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*Status*[b]
Pumpkinseed *(Lepomis gibbosus)*		M	F	MFD	MFD	M	MF				C PR
Largemouth bass *(Micropterus salmoides)*					M		M				R PR
Black bullhead *(Ictalurus melas)*			F		M		M			M	U PR
Walleye *(Stizostedion vitreum vitreum)*			F								Ac PR

[a]Occurrence codes: P – observed during two waterfowl breeding pair counts each May (Dzubin 1969); B – observed during two to three waterfowl brood counts each July (Bennett 1967); D – graduate student studies on Oakridge WPA (McDowell 1989); F – Fisheries surveys conducted May and July various years by U.S. Fish & Wildlife Service (pers. com., H. Bolton, U.S.F & W.S., Winona, MN); M – miscellaneous observations and surveys including student intern reports, Oakridge Lake survey, and small mammal trapping (Zippen 1958).

*Nest, brood, or young seen.

[b]Status codes: A = abundant (81–100%), C = common (61–80%), U = uncommon (41–60%), R = rare (0–40%), Ac = accidental, SR = summer resident, Mg = migrant, WR = winter resident, PR = permanent resident.

Table 3. Breeding bird survey of Oakridge Lake, one count each June, 1987-91.

	Number of Birds				
Species	*1987*	*1988*	*1989*	*1990*	*1991*
Common loon	-	1	2	1	-
Red-necked grebe	3	4	5	2	1
Pied-billed grebe	4	8	7	7	7
Trumpeter swan	1	2	2	2	2
Canada goose	6	10	-	14	4
Mallard	2	29	11	1	27
Gadwall	-	1	-	-	-
American wigeon	-	-	-	-	1
Northern shoveler	-	1	-	-	-
Blue-winged teal	2	9	9	5	3
Green-winged teal	1	-	-	-	-
Wood duck	20	18	16	5	2
Ring-necked duck	-	-	1	2	12
Ruddy duck	-	2	8	-	6
Hooded merganser	-	1	1	1	-
Great egret	-	1	1	2	3
Great blue heron	3	2	1	-	3
Green-backed heron	4	6	3	2	2
Black-crowned night heron	-	-	1	-	-
American bittern	-	-	-	1	-
American coot	2	2	2	2	2
Killdeer	1	6	2	-	2
Spotted sandpiper	-	1	-	-	-
Forster's tern	-	-	-	1	-
Black tern	3	4	11	2	2
Belted kingfisher	1	-	-	1	1
Alder flycatcher	1	-	-	-	-
Willow flycatcher	-	-	-	1	-
Tree swallow	9	14	10	15	16
Marsh wren	3	6	2	1	4
Sedge wren	1	-	-	-	1
Yellow warbler	1	2	2	3	6
Common yellowthroat	2	7	3	4	8
Yellow-headed blackbird	21	-	64	36	49
Red-winged blackbird	53	37	59	39	75
Swamp sparrow	4	3	2	2	2

Table 4. Terrestrial insect and other arthropod[a] occurrence in selected Waterfowl Production Areas, St. Croix and southern Polk Counties, 1983–91.

Family or Order	*Species[b]*	*Common Name*
Acrididae		Grasshoppers
Anthicidae	*Anthicus* spp.	Antlike Flower Beetles
Aphididae		Aphids
Arachnida*		Spiders & mites
Asilidae		Robber Flies
Cantharidae	*Silis latilobus*	Blister Beetles
Cerambycidae		Long-horned Beetles
Cercopidae		Spittlebugs
Chrysomelidae*	*Altica* sp., *Donacia* sp., *Babia quadriguttata*	Leaf Beetles
Chrysopidae		Common Lacewings
Cicadellidae	*Draeculacephala* nr. *minerva* *Helochara communis* *Doratura stylata*	Leafhoppers
Coccinellidae	*Hippodamia 13-punctata* *Hyperaspis undulata* *Psyllobora 20-maculata* *Scymnus* nr. *creperus*	Ladybird Beetles
Collembola*		Springtails
Curculionidae*		Weevils
Delphacidae*		Delphacid Planthoppers
Diplopoda		Millipedes
Dictyopharidae		Planthoppers
Diptera*		Flies
Elateridae	*Agriotes* sp., *Limnonius* sp.	Plant Hoppers
Formicidae		Ants
Geometridae		Measuringworms (moths)
Gryllidae		Crickets
Hymenoptera*		Wasps
Hydrophilidae*	*Cercyon* (nr.) *roseni*	Water Scavenger Beetle
Ixodidae		Ticks
Lampyridae*	*Pyractomena linearis*	Lightning Beetles
Lygaeidae	*Cymus discors*	Seed Bugs
Miridae	*Lygus* sp.	Plant Bugs
Mordellidae	*Mordellistena* nr. *morula*	Tumbling Flower Beetles
Nabidae		Damsel Bugs
Nitidulidae	*Glischrochilus quadrasignatus*	Sap Beetles
Noctuidae*		Noctuid Moths
Pentatomidae	*Eushistus variolarius*	Stink Bugs
Phlaeothripidae	*Polyphemothrips* sp.	Thrips
Pieridae		Whites, Sulphurs, Orangetip Butterflies
Pyralidae		Snout Moths
Reduviidae		Assassin Bugs
Scarabaeidae	*Aphodius* spp., *Ataenius* sp.	Scarab Beetles
Scolytidae	*Lesperisinus aculeatus*	Bark Beetles
Silphidae		Carrion Beetles
Staphlynidae*	*Bledius* sp., *Stenus mammops*	Rove Beetles
Tettigoniidae	*Corimelaena* sp.	Meadow Grasshoppers
Thyreocorinae		Burrower Bugs
Tingidae		Lace Bugs

[a]Data from Brua 1987.
[b]Data from WDNR collections; identifications made by S. Krauth, Academic Curator, Insect Research Collection, UW-Madison; specimens placed in UW-Madison Insect Research Collection in 1988.
*Family or order containing some aquatic or semiaquatic taxa.

Table 5. Aquatic insect occurrence in WPA wetlands, late April to mid-August, 1983–92.

Order/ Suborder	*Common Name*	*Family*	*Species*	*Relative Abundance*
Ephemeroptera	Mayflies	Baetidae	*Calibaetis* spp.	Common
		Caenidae	*Caenis* sp.	Abundant
Odonata				
Anisoptera	Dragonflies	Aeshnidae	*Aeshna* sp.	Abundant
			Anax sp.	Common
		Corduliidae	*Epitheca* sp.	Common
			Somatochlora spp.	Rare
		Gomphidae	*Stylurus* spp.	Uncommon
		Libellulidae	*Celithemis* sp. cf.?	Rare
			Leucorrhina spp.	Common
			Libellula spp.	Common
			Plathemis spp.	Rare
			Sympetrum spp.	Common
Zygoptera	Damselflies	Lestidae	*Lestes* spp.	Abundant
		Coenagrionidae	*Enallagma* spp.	Abundant
			Ishnura spp.	Rare
			Nehalennia spp.	Common
Heteroptera/ Hemiptera	Bugs	Aphidae	unidentified aphids	Common
		Belostomatidae	*Belostoma flumineum*	Common
			Lethocercus americanus	Uncommon
	Water Boatman	Corixidae	*Cenocorixa dakotensis*	Rare*
			Hesperocorixa kennicottii	Uncommon
			Hesperocorixa michiganensis	Uncommon
			Hesperocorixa vulgaris	Uncommon
			Hesperocorixa scabricula	Rare
			Sigara alternata	Uncommon
			Sigara bicoloripennis	Common
			Sigara compressoidea	Rare
			Sigara conocephala	Rare
			Sigara decoratella	Rare
			Sigara defecta	Rare
			Sigara lineata	Rare
			Sigara mathesoni	Rare
			Sigara mullettensis	Rare
			Sigara signata	Rare
			Sigara solensis	Common
			Trichocorixa borealis	Uncommon
			Trichocorixa naias	Abundant
		Nepidae	*Ranatra* sp.	Uncommon
			Ranatra fusca	Rare
			Ranatra nigra	Rare
		Notonectidae	*Buenoa macrotibialis*	Rare
			Notonecta undulata	Uncommon
		Pleidae	*Neoplea striola*	Abundant
		Gerridae	unidentified nymphs	Common
			Gerris buenoi	Uncommon
			Gerris comatus	Rare
		Hebridae	*Hebrus burmeisteri*	Rare
			Merragata brunnea	Common
			Merragata hebroides	Uncommon
		Hydrometridae	*Hydrometra martini*	Uncommon

Table 5, continued.

Order	*Common Name*	*Family*	*Species*	*Relative Abundance*
		Mesoveliidae	*Mesovelia mulsanti*	Abundant
		Veliidae	*Microvelia* spp.	Common
			Microvelia hinei	Uncommon
			Microvelia pulchella	Common
Trichoptera	Caddisflies	Polycentropodidae	*Polycentropus* spp.	Common
		Hydroptilidae	*Agraylea* spp.	Uncommon
			Hydroptila spp.	Rare
			Ithyrichia spp.	Uncommon
			Orthotrichia spp.	Common
			Oxyethira spp.	Common
		Leptoceridae	*Ceraclea* spp.	Common
			Leptocerus spp.	Common
			Mystacides spp.	Common
			Nectopsyche spp.	Common
			Oecetis spp.	Common
			Triaenodes spp.	Common
		Limnephilidae	*Arctopora* spp.	Rare
			Limnephilus spp.	Common
			Platycentropus spp.?	Rare
		Phryganeidae	*Banksiola* sp.	Common
			Phryganea sp.	Common
		Molannidae	*Molanna* sp.	Uncommon
Lepidoptera	Moths	Pyralidae	*Paraponyx* sp.	Uncommon
Coleoptera	Beetles*	Chrysomelidae	*Donacia caerulea*	Rare
			Donacia porosicollis	Rare
			Neohaemonia melsheimeri[b]	Rare
			Plateumaris sulcicollis	Rare
			Plateumaris diversa	Rare
			Pyrrhalta nymphaeae*	Common
		Curculionidae	*Apion* sp. A	Rare
			Apion sp. B	Rare
			Bagous americanus	Rare
			Barypiethes pellucidus	Rare
			Euhrychiopsis lecontei	Rare
			Hypera meles	Rare
			Lissorhoptrus oryzophilus	Rare
			Listronotus delumbis	Uncommon
			Listronotus echinodori	Rare
			Lixellus filiformis	Common
			Lixellus hubbardi	Uncommon
			Lixellus lutulentus	Uncommon
			Onychylis nigrirostris	Abundant
			Sitona scissifrons	Rare
			Tanysphyrus lemnae	Abundant
			Tychius picirostris	Uncommon
			Tychius stephensi	Rare
		Dytiscidae	*Agabus anthracinus*	Rare
			Celina hubbelli	Uncommon
			Colymbetes sculptilus	Rare
			Coptotomus lenticus	Uncommon
			Coptotomus longulus	Uncommon
			Desmopachria convexa	Uncommon

Table 5, continued.

Order	*Common Name*	*Family*	*Species*	*Relative Abundance*
			Dytiscus dauricus	Rare
			Dytiscus verticalis	Rare
			Graphoderus liberus	Rare
			Graphoderus perplexus	Rare
			Hydroporus notabilis	Rare
			Hydroporus undulatus	Common
			Hydrovatus pustulatus	Abundant
			Hygrotus sayi	Abundant
			Ilybius fraterculus	Rare
			Laccophilus maculosus	Common
			Liodessus affinis	Rare
			Liodessus flavicollis	Abundant
			Stictotarsus griseostriatus	Rare
			Rhantus consimilis	Rare
			Uvarus granarius	Uncommon
		Gyriniidae	*Gyrinus maculiventris*	Uncommon
		Haliplidae	*Haliplus blanchardi*	Abundant
			Haliplus borealis	Abundant
			Haliplus canadensis	Rare
			Haliplus connexus	Rare
			Haliplus immaculicollis	Abundant
			Haliplus longulus	Rare
			Peltodytes edentulus	Abundant
			Peltodytes tortulosus	Rare
		Hydrophilidae	*Anacaena limbata*	Rare
			Berosus aculeatus	Rare
			Berosus striatus	Common
			Enochrus diffusus	Rare
			Enochrus hamiltoni	Uncommon
			Enochrus ochraceus	Rare
			Enochrus perplexus	Uncommon
			Helophorus orientalis	Uncommon
			Helophorus nitiduloides	Rare
			Hydrochara obtusata	Rare
			Hydrochus neosquamifer	Rare
			Hydrochus squamifer	Rare
			Tropisternus lateralis	Rare
			Tropisternus mixtus	Uncommon
		Lampyridae	unidentified larvae	Uncommon
		Scirtidae	unidentified larvae	Uncommon
Diptera	Flies, midges	Ceratopogonidae	*Culicoides* spp.	Common
			Palpomayia spp.	Rare
			other unidentified larvae	Common
		Chaoboridae	*Chaoborus* sp.	Common
		Chironomidaec	*Glyptotendipes* spp.	Abundant
			Cricotopus spp.	Common
			Tanytarsus spp.	Uncommon
			Endochironomus spp.	Common
			Paratanytarsus spp.	Rare
			Macropelopia spp.	Rare
			Lenziella sp.?	Rare
			Dicrotendipes spp.	Common
			Cladotanytarsus spp.	Uncommon

Table 5, continued.

Order	*Common Name*	*Family*	*Species*	*Relative Abundance*
			Micropsectra spp.	Rare
			Paracladopelma spp.	Uncommon
			Chironomus spp.	Abundant
			Kiefferulus spp.	Uncommon
			Polypedilum spp.	Common
			Einfeldia spp.	Common
			Nanocladius spp.	Uncommon
			Procladius spp.	Common
			Paratendipes spp.	Rare
		Culicidae	*Culex* spp.	Common
		Dolichopodidae		Uncommon
		Ephydridae		Common
		Stratiomyidae	*Euparyphus-Caloparyphus* sp.	Uncommon
		Tabanidae		Common
		Tipulidae		Uncommon
			Dicranota spp.	Rare

[a]See Lillie (1991) for more detailed information concerning distribution of beetles on WPA wetlands.
[b]Taxonomy after Askevold (1988).
[c]Based on a small random subsample of taxa present.

Table 6. Miscellaneous macro- and microinvertebrates found on WPA wetlands, 1983–92.

Phylum/ Subphylum	*Class*	*Order/ Suborder*	*Species*	*Common Name*
Annelida	Oligochaeta			Oligochaetes
	Hirudinea		*Helobdella* spp.[a]	Leeches
Sarcomastigophora			*Difflugia* sp.	Amoebas
Arthropoda				
Chelicerata	Arachnida	Araneae		Spiders
		Acarina		
		Hydracarina		Water mites
Mandibulata	Crustacea			
	Branchiopoda	Anostraca		Fairy Shrimps
		Diplostraca		
		Conchostraca		Clam Shrimps
		Cladocera	*Alona* spp.[a]	
			Alona guttata[a]	
			Alona rectangula[a]	
			Alonella spp.[a]	
			Alonella excisa[a]	
			Bosmina longirostris	
			Camptocercus sp.	
			Chydorus sphaericus	
			Ceriodaphnia spp.[a]	
			Daphnia spp.	
			Daphnia pulex-pulicaria	
			Daphnia minnehaha	
			Diaphanosoma spp.[a]	
			Eubosmina sp.	
			Graptoleberis sp.	
			Holopedium gibberum	
			Ilyocryptus spp.[a]	
			Kurzia latissima[a]	
			Latonopsis sp. ?	
			Macrothrix sp.	
			Pleuroxus spp.[a]	
			Pleuroxus procurvus[a]	
			Pleuroxus striatus[a]	
			Polyphemus pediculus	
			Scapholeberis spp.[a]	
			Simocephalus spp.[a]	
			Streblocerus serricaudatus[a]	
	Ostracoda			Seed Shrimps
	Copepoda	Calanoida		Calanoid Copepods
			Aglaodiaptomus leptopus	
			Leptodiaptomus siciloides	
			Onychodiaptomus sanguineus	
			Skistodiaptomus oregonensis	
		Harpactidoida		Harpactacoid Copepods
		Cyclopoida		Cyclopoid Copepods
			Acanthocyclops vernalis	
			Diacyclops b. thomasi	
			Mesocyclops edax	
			Tropocyclops sp.	
	Malacostraca	Isopoda		Isopods
		Amphipoda	*Hyallela azteca*	Amphipods/Scuds

Table 6, continued.

Phylum/ Subphylum	*Class*	*Order/ Suborder*	*Species*	*Common Name*
Mollusca				
	Gastropoda			Snails
			Physa spp.	
	Pelecypoda			Bivalves/clams
Rotifera				Rotifers
			Brachionus sp.	
			Conochilus sp.	
			Kellicottia sp.	
			Keratella sp.	
			Polyarthra sp.	
			Synchaeta sp.	
			Trichocerca sp.	

[a]After McDowell (1989).

Table 7. Terrestrial plant occurrence and relative abundance in Waterfowl Production Area nesting cover, St. Croix and southern Polk Counties, 1982–91.

Family	*Species*	*Common Name*	*Relative Abundance*
Trees:			
Aceraceae	*Acer negundo*	Box elder	common
	Acer rubrum	Red maple	rare
	Acer saccharinum	Silver maple	rare
	Acer saccharum	Sugar maple	rare
Anacardiaceae	*Rhus typhina*	Staghorn sumac	uncommon
Fagaceae	*Quercus alba*	White oak	rare
	Quercus spp.	Oaks	rare
Oleaceae	*Fraxinus* sp.	Ash	rare
Pinaceae	*Juniperus virginiana*	Red cedar	rare
	Picea glauca	White spruce	rare
	Pinus resinosa	Red pine	rare
	Pinus strobus	White pine	rare
	Pinus sylvestris	Scotch pine	rare
Betulaceae	*Betula papyrifera*	Paper birch	rare
Rosaceae	*Crataegus* spp.	Hawthorns	rare
	Prunus virginianus	Chokecherry	rare
	Pyrus malus	Apple	rare
Salicaceae	*Populus deltoides*	Cottonwood	rare
	Populus grandidentata	Large-toothed aspen	rare
	Populus tremuloides	Quaking aspen	uncommon
	Salix spp.	Willows	uncommon
Ulmaceae	*Ulmus americana*	American elm	uncommon
	Ulmus pumila	Chinese-Russian elm	uncommon
Sedges, Grasses & Rushes:			
Cyperaceae	*Carex* spp.	Sedges	common
	Scirpus cyperinus	Woolgrass	rare
	Scirpus spp.	Bullrushes	rare
Gramineae	*Agropyron repens*	Quack grass	common
	Agropyron spp.	Wheatgrasses	uncommon
	Agrostis alba	Redtop grass	uncommon
	Andropogon gerardii	Big bluestem	uncommon
	Schizachyrium scoparium	Little bluestem	rare
	Avena sativa	Oats	rare
	Bromus inermis	Smooth brome grass	common
	Dactylis glomerata	Orchard grass	common
	Digitaria ischaemum	Crabgrass	uncommon
	Elymus canadensis	Canada wild rye	rare
	Eragrostis cilianensis	Stinkgrass	rare
	Festuca spp.	Fescues	rare
	Koeleria cristata	Junegrass	rare
	Panicum virgatum	Switchgrass	common
	Panicum sp.	Ticklegrass	rare
	Phalaris arundinacea	Reed canary grass	rare
	Phleum pratensis	Timothy	common
	Phragmites australis	Giant reed grass	rare
	Poa compressa	Canada bluegrass	uncommon
	Poa pratensis	Kentucky bluegrass	common
	Setaria magna	Giant foxtail	rare
	Setaria spp.	Foxtails	common
	Spartina pectinata	Cordgrass	rare
Juncaceae	*Juncus* spp.	Rushes	rare

Table 7, continued.

Family	*Species*	*Common Name*	*Relative Abundance*
Forbs:			
Amaranthaceae	*Amaranthus retroflexus*	Green amaranth	rare
Anacardiaceae	*Rhus radicans*	Poison ivy	uncommon
Asclepiadaceae	*Asclepias incarnata*	Swamp milkweed	rare
	Asclepias syriaca	Common milkweed	common
	Asclepias verticillata	Whorled milkweed	rare
Campanulaceae	*Campanula rotundifolia*	Harebell	rare
Caprifoliaceae	*Lonicera* spp.	Honeysuckles	rare
	Sambucus pubens	Elderberry	rare
Caryophyllaceae	*Cerastium vulgatum*	Mouse-eared chickweed	uncommon
	Dianthus armeria	Deptford pink	rare
	Lychnis alba	Evening lychnis	common
	Saponaria officinalis	Bouncing bet	rare
	Silene vulgaris	White (Bladder) campion	uncommon
	Stellaria media	Common chickweed	rare
Chenopodiaceae	*Chenopodium album*	Lamb's quarter	common
	Chenopodium sp.	Goosefoot	rare
Compositae	*Achillea millefolium*	Yarrow	common
	Ambrosia artemisiifolia	Common ragweed	common
	Anaphalis margaritacea	Pearly everlasting	uncommon
	Antennaria sp.	Pussy Toes	rare
	Arctium minus	Common burdock	rare
	Artemisia stelleriana	Dusty miller	rare
	Artemisia sp.	Wormwood	rare
	Aster spp.	Asters	common
	Centaurea maculosa	Spotted knapweed	rare
	Chrysanthemum leucanthemum	Ox-eye daisy	uncommon
	Chrysopsis sp.	Golden aster	uncommon
	Cirsium arvense	Canada thistle	common
	Cirsium vulgare	Bull thistle	uncommon
	Cirsium spp.	Thistles	common
	Eupatorium dubium	Joe Pye Weed	rare
	Erigeron canadensis	Horseweed (Mare's tail)	common
	Erigeron strigosus	Daisy fleabane	common
	Eupatorium perfoliatum	Boneset	rare
	Helianthus divaricatus	Woodland sunflower	rare
	Helianthus petiolaris	Prairie sunflower	rare
	Hieracium aurantiacum	Orange hawkweed	rare
	Lactuca sp.	Wild lettuce	common
	Rudbeckia hirta	Black-eyed susan	rare
	Solidago spp.	Goldenrods	common
	Sonchus sp.	Sowthistle	common
	Tanacetum vulgare	Common tansy	rare
	Tragopogon dubius	Goatsbeard	uncommon
	Xanthium strumarium	Cocklebur (Clotbur)	rare
Convolvulaceae	*Convolvulus* spp.	Bindweeds	common
Cornaceae	*Cornus racemosa*	Gray dogwood	rare
Crassulaceae	*Sedum* sp.	Stonecrop (orphine)	rare
Cruciferae	*Barbarea vulgaris*	Yellow rocket	uncommon
	Berteroa incana	Hoary allyssum	common
	Brassica spp.	Mustards	uncommon
	Raphanus raphanistrum	Wild radish	rare

Table 7, continued.

Family	*Species*	*Common Name*	*Relative Abundance*
Equisetaceae	*Equisetum* sp.	Horsetail	rare
Euphoribiaceae	*Euphorbia corollata*	Flowering spurge	rare
	Euphorbia esula	Leafy spurge	rare
Guttiferae	*Hypericum perforatum*	St. Johnswort	rare
Iridaceae	*Iris versicolor*	Large blue flag	rare
Labiatae	*Monarda fistulosa*	Wild Bergamot (Horsemint)	rare
Labiatae	*Agastache* sp.	Hyssop	rare
	Leonurus cardiaca	Motherwort	rare
	Lycopus americanus	Cut-leaf water-horehound	rare
	Mentha spp.	Mints	uncommon
	Nepeta cataria	Catnip	rare
Leguminosae	*Lespedeza* sp.	Bush clover	rare
	Lotus corniculatus	Trefoil	rare
	Medicago sativa	Alfalfa	common
	Medicago lupulina	Black medick	rare
	Meliotus sp.	Sweet clover	common
	Dalea sp.	Prairie clover	rare
	Trifolium agrarium	Yellow hop clover	rare
	Trifolium pratense	Red clover	common
	Trifolium repens	White clover	common
	Trifolium hybridum	Alsike clover	common
	Trifolium sp.	Ladino clover	common
	Vicia angustifolia	Vetch	uncommon
Liliaceae	*Asparagus officinalis*	Asparagus	rare
	Lilium sp.	Lillies	rare
Lycopodiaceae	*Lycopodium complanatum*	Creeping jenny	rare
Malavaceae	*Abutilon theophrasti*	Velvetleaf	rare
	Malva sp.	Mallow	rare
Oleaceae	*Syringa vulgaris*	Common lilac	rare
Onagraceae	*Epilobium angustifolium*	Fireweed	rare
	Oenothera biennis	Evening primrose	uncommon
Oxalidaceae	*Oxalis* spp.	Wood sorrels	common
	Oxalis dillenii	Yellow wood sorrel	common
Plantaginaceae	*Plantago* spp.	Plantains	common
Polygonaceae	*Polygonum arifolium*	Halberd tear-thumb	rare
	Polygonum scandens	Climb. false buckwheat	uncommon
	Polygonum spp.	Smartweeds	uncommon
	Rumex acetosella	Red (Sheep) sorrel	common
	Rumex crispus	Curled dock	uncommon
Primulaceae	*Lysimachia quadrifolia*	Whorled loosestrife	rare
Ranunculaceae	*Anemone canadensis*	Canada anemone	rare
	Thalictrum dasycarpum	Meadow (Purple) rue	rare
Rosaceae	*Amelanchier* sp.	Serviceberry	rare
	Fragaria virginiana	Field strawberry	uncommon
	Fragaria vesca	Woodland strawberry	uncommon
	Potentilla argentea	Silver cinquefoil	uncommon
	Potentilla spp.	Cinquefoils	common
	Rosa carolina	Pasture (Carolina) rose	rare
	Rosa setigera	Prairie rose	rare
	Rubus idaeus	Red raspberry	uncommon
	Rubus sp.	Blackberry	uncommon
	Spiraea sp.	Spiraea	rare

Table 7, continued.

Family	*Species*	*Common Name*	*Relative Abundance*
Polypodiaceae	—	Ferns	rare
	Onoclea sensibilis	Sensitive fern	rare
	Pteridium aquilinum	Bracken fern	rare
Rubiaceae	*Galium* spp.	Bedstraws	rare
Scrophulariaceae	*Linaria vulgaris*	Butter-and-eggs	rare
	Verbascum thapsus	Common mullein	common
Solanaceae	*Solanum* sp.	Nightshade	rare
Typhaceae	*Typha* sp.	Cat-tail	rare
Umbelliferae	*Heracleum lanatum*	Cow parsnip	rare
Urticaceae	*Boehmeria cylindrica*	Hemp (Bog) nettle	rare
	Urtica urens	Stinging nettle	rare
Verbenaceae	*Verbena hastata*	Blue vervain	rare
Violaceae	*Violoa* spp.	Violets	uncommon
Vitaceae	*Parthenocissus* spp.	Virginia creeper	uncommon
	Vitis spp.	Grapes	rare

Table 8. Aquatic plant occurrence and relative abundance within WPA wetlands, St. Croix and southern Polk Counties, 1983–1992.

Family	*Species*	*Common Name*	*Relative Abundance*
Araceae	*Acorus calamus*[d]	Sweet Flag	Uncommon
Asclepiadaceae	*Asclepias incarnata*[d]	Swamp-milkweed	Common
Alismaceae	*Sagittaria spp.*	Arrowheads	Abundant
	Sagittaria latifolia[d]		Abundant
	Sagittaria rigida[d]		Abundant
Caryopyhllaceae	*Stellaria longifola*[e]	Starwort	Uncommon
Ceratophyllaceae	*Ceratophyllum demersum*[d]	Coontail	Common
Characeae	*Chara* spp.[e]	Muskgrass	Uncommon
Compositae	*Ambrosia* spp.	Ragweed	Uncommon
	Bidens spp.[c]	Beggar-ticks	Common
	Bidens cernua[e]		
Cyperaceae	*Carex* spp.	Sedges	Abundant
	Carex alopecoidea[e]		
	Carex atherodes[d]		Common
	Carex comosa[d]		Common
	Carex Haydenii[e]		
	Carex lasiocarpa[e]		Uncommon
	Carex lanuginosa[d]		Uncommon
	Carex rostrata[d]		Abundant
	Carex vesicaria[e]		
	Carex vulpinoides[d]		Uncommon
	Eleocharis spp.	Spike Rush	Abundant
	Eleocharis erythropoda[d]		Common
	Eleocharis Smallii[d]		Common
	Scirpus spp.	Bulrush	Abundant
	Scirpus cyperinus[d]	Wool Grass	Rare
	Scirpus fluviatilis[cd]	River Bulrush	Uncommon
	Scirpus heterochaetus		
	Scirpus validus[d]	Great bulrush	Common
	Dulichium arundinaceum[d]		Common
Equisetaceae	*Equisetum* spp.	Horsetail	Common
	Equisetum fluviatile[e]		Common
	Equisetum pratense[d]		Common
Gramineae	*Calamagrostis canadensis*[d]	Bluejoint	Abundant
	Phalaris arundinacea[e]	Reed Canary Grass	Common
	Dactylis glomerata[d]	Orchard Grass	Abundant
	Glyceria borealis[e]	Manna Grass	Common
	Glyceria canadensis[d]	Rattlesnake Grass	Common
	Glyceria grandis[d]		
	Glyceria septentrionalis		
	Leersia oryzoides	Cut Grass	Common
	Poa palustris[e]		Uncommon
	Poa pratensis[e]	Kentucky Bluegrass	Uncommon
	Spartina pectinata[d]	Cord Grass	Rare
Haloragidaceae	*Myriophyllum sibericum*[d]	Northern Milfoil	Uncommon
Hydrocharitaceae	*Elodea canadensis*[cd]	Waterweed	Uncommon
	Vallisneria americana	Wild Celery	Rare
Hypericaceae	*Hypericum* sp.[c]	St. John's-wort	Uncommon
Iridaceae	*Iris versicolor*[d]	Blue Flag	Uncommon

Table 8 continued.

Family	*Species*	*Common Name*	*Relative Abundance*
Juncaceae	*Juncus effusus*[d]	Rush	Common
	Juncus pelocarpus[e]	Rush	Uncommon
Labiatae	*Lycopus* spp.	Bugle-weed	Common
	Lycopus uniflorus[e]		Uncommon
	Mentha spp.	Mint	Common
	Scutellaria laterifora[e]	Skullcap	Uncommon
Lemnaceae	*Lemna minor*[d]	Lesser Duckweed	Abundant
	Lemna trisulca[d]	Star Duckweed	Uncommon
	Spirodela polyrhiza	Giant Duckweed	Common
	Wolffia columbiana	Water-meal	Common
Lentibulariaceae	*Utricularia* spp.	Bladderwort	Uncommon
	Utricularia vulgaris[d]		Uncommon
Musci	*Drepanocladus* spp.		Uncommon
Najadaceae	*Najas flexilis*[e]	Bushy Pondweed	Uncommon
	Potamogeton crispus[e]	Curly Pondweed	Common
	Potamogeton epihydrus[c]		Uncommon
	Potamogeton foliosus		Uncommon
	Potamogeton Friesii[a]		Uncommon
	Potamogeton gramineus[c]		Common
	Potamogeton natans[abe]	Floating-leafed Pondweed	Uncommon
	Potamogeton pectinatus[d]	Sago Pondweed	Abundant
	Potamogeton praelongus[d]		Uncommon
	Potamogeton pusillus[c]		Uncommon
	Potamogeton zosteriformis[d]	Flat-stemmed Pondweed	Abundant
Nymphaeaceae	*Brasenia Schreberi*[e]	Watershield	Uncommon
	Nuphar spp.	Yellow Water Lily	Common
	Nuphar variegatum[e]		Common
Polygonaceae	*Polygonum coccineum*[d]	Smartweed	Common
	Polygonum amphibium[d]	Smartweed	Abundant
	Polygonum sagittatum[e]	Tear-thumb	Common
Primulaceae	*Lysimachia* spp.	Loosestrife	Uncommon
	Lysimachia terrestris[e]		Uncommon
	Lysimachia thyrsiflora[e]		Uncommon
Ranunculaceae	*Ranunculus longirostris*[d]	White Water-crowfoot	Uncommon
	Ranunculus sceleratus[d]	Cursed Crowfoot	Uncommon
Ricciaceae	*Riccia fluitans*	Liverwort	Uncommon
Rosaceae	*Potentilla* spp.	Cinquefoil	Uncommon
Rubiaceae	*Galium* spp.	Bedstraws	Uncommon
	Galium tinctorium[e]		Uncommon
Salicaceae	*Populus* spp.[c]	Poplar	Common
	Salix spp.	Willow	Common
Sparganiaceae	*Sparganium eurycarpum*[d]	Bur-reed	Abundant
Typhaceae	*Typha* spp.	Cat-tail	Abundant
	Typha latifolia[e]		
Umbelliferae	*Cicuta bulbifera*[d]	Water-hemlock	Common
	Sium suave[d]	Water-parsnip	Common
Urticaceae	unidentified		Uncommon

[a]Mauser 1985.
[b]McDowell 1989.
[c]Verified by Dr. G. Smith, UW-Whitewater.
[d]Verified by T. Cochran, UW-Madison Herbarium.
[e]Voucher specimens at WDNR Research Center, 1350 Femrite, Monona, WI.

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William L. Hilsenhoff

Effects of a catastrophic flood on the insect fauna of Otter Creek, Sauk County, Wisconsin

Abstract *A catastrophic flood in Baxter's Hollow on 18 July 1993 rearranged substrates in Otter Creek, eliminating most silt, sand, gravel, pebbles, and organic debris from high gradient portions of the stream and leaving predominately larger rock substrates. Comparison of the insect fauna in the spring and early summer of 1994 with that previously documented showed it had been significantly altered by the flood. While the insect fauna of high gradient portions was most severely altered, it was also changed by the flood in lower gradient areas upstream. Some species of insects became more abundant, a few species remained relatively unaffected, other species became scarce, and several may have been eliminated from the stream.*

Otter Creek flows south out of the Baraboo Hills through Baxter's Hollow, which is located 8 km SSW of Baraboo, Wisconsin. It is known for its diverse insect fauna, which has been extensively studied in Baxter's Hollow; the lower gradient area south of Baxter's Hollow and Kings Corner Road has received less attention. Since 1963, students in the Aquatic Insects class at the University of Wisconsin-Madison have sampled the stream almost every year. In 1972 Richard Narf (Narf and Hilsenhoff 1975) completed a study of the stonefly fauna, and in 1982 Jeffrey Steven completed a study of the caddisfly fauna (Steven and Hilsenhoff 1984). In 1984 and 1985 three adjacent riffles (rapid, splashing water) in the high gradient portion of the stream were sampled every two weeks from mid-April to mid-November as part of a study of six streams to develop a correction factor for the biotic index

(Hilsenhoff 1988). On each date at least 100 insects were collected from each riffle for the purpose of determining the biotic index (Hilsenhoff 1987).

On 18 July 1993 thunderstorms produced very heavy rain in the Baraboo Hills and caused severe flooding. Baraboo reported 19.8 cm (7.78 inches) of rain, with unofficial reports of higher amounts nearby. In Baxter's Hollow the water level of Otter Creek rose at least 2 m, washing out the road at bridges and rearranging substrates in Otter Creek. The high gradient portion of Otter Creek adjacent of Stones Pocket Road was most affected. This portion of the stream had consisted of a series of riffles containing sand, gravel, pebbles, cobbles (64–256 mm diameter rocks), larger rocks, and organic debris. Interspersed between riffles were runs (rapid, deeper water) containing mostly cobbles, and pools of sand, silt, and debris beneath deep, slow-moving water. The flood carried with it all silt and debris and almost all exposed sand, gravel, and small pebbles; it eliminated pools and most riffles, leaving mostly cobbles and some larger rocks to form an almost continuous run. Samples of insects taken from the stream in late summer and autumn 1993 indicated most species were scarce and some had perhaps disappeared.

In 1990 a list of genera and species of insects inhabiting Otter Creek was compiled for the Department of Natural Resources and The Nature Conservancy, which now owns most property in Baxter's Hollow where Otter Creek is located; the list was updated in December 1992. Because this list and data from 96 samples collected from riffles in 1984 and 1985 document the preflood insect fauna, I initiated a sampling program to determine effects of the July 1993 flood by comparing the insect fauna in 1994 with previous collections.

Materials and Methods

Qualitative samples of insects were collected with a D-frame net on 14 March and 16 May 1994 and preserved in 70% ethanol. They were taken 300–400 m above the first bridge on Stones Pocket Road north of Kings Corner Road in Baxter's Hollow (lower Otter Creek) and above and below the fourth bridge (upper Otter Creek), the two areas of the stream sampled by Aquatic Insects classes. Collections were made in all available habitats. To duplicate samples collected in 1984 and 1985, I collected three samples of 100+ insects with a D-frame net from riffle areas on 18 April, 2 and 16 May, 10 and 27 June, and 26 July 1994. A set of three samples on 30 May was collected by a student who did not realize larval abundance had diminished due to emergence. As a result, only 156 insects were collected, which was less than half the numbers collected on similar dates in 1984 and 1985. Standard collecting procedures for evaluation of water quality with the biotic index were used (Hilsenhoff 1987). Samples were collected from upstream, middle, and downstream portions of an 18 m long riffle, the only one remaining in the high gradient portion of the stream that was similar to riffles sampled previously. This riffle is about 320 m upstream from the first bridge, 15 m below a paved parking area, and about 50 m downstream from riffles sampled in 1984 and 1985. It was relatively unaffected by the flood because it flows east toward the road at a sharp bend, and most floodwater had continued south out of the stream channel, rejoining it several meters downstream. Riffles upstream from the parking area from which samples were collected in 1984 and 1985 were severely altered, being less than 1 m long and containing only rocks and large cobbles.

Results and Discussion

Numbers and species of insects collected from riffles in 1994 were compared with collections made on similar dates in 1984 and 1985 (Table 1). Because only 156 insects were collected on May 30, numbers of each species were multiplied by 2.25 to make numbers in Table 1 comparable to collections of 369 and 334 insects on similar dates in 1984 and 1985. Degree day accumulations above 4.5°C (Hilsenhoff 1988) were used to compare the three years, because development and emergence of most species in the spring depend on warming of the stream. Temperatures in 1984 were slightly below the historic normal (State Climatologist), delaying emergence by perhaps 2 days, while in 1985 and 1994 temperatures were well above normal, causing insects to emerge several days early. The spring of 1994 was not as warm as 1985, especially from 14 May to 11 June, but was still 4–7 days ahead of normal; degree day accumulations in 1985 were 10–14 days ahead of normal. In 1994, 7% fewer insects (using adjusted 30 May samples) were collected than in 1984, and 2% more were collected than in 1985. This only slightly affects comparisons of numbers in Table 1.

Table 1 shows that substantial changes occurred in the insect fauna. Changes in relative abundance of various substrates are undoubtedly the reason for most alterations of insect abundance, especially an almost complete absence of the silt, sand, and gravel that occurred previously and was replaced by cobbles and rocks. Also important was an absence of moss on rocks and a lack of stream-side vegetation; both were prevalent before the flood and eliminated by its scouring effect. After October 1993 amounts of new allochthonous debris, especially leaves and sticks falling or washed into the stream, appeared similar to previous years and provided a stable food resource for larvae of many insects that emerge in the spring. Plecoptera and Diptera larvae (excluding Chironomidae) comprised a higher percentage of the riffle fauna in 1994 than in 1984 and 1985, while larvae of Megaloptera, Coleoptera, and Chironomidae made up a much lower percentage (Table 1). When making comparisons, it must be remembered that only 100+ insects were used from each sample (Hilsenhoff 1987), so unusual abundance of one species results in apparent reduced abundance of others. A summary of apparent changes in 1994 of species listed in Table 1 follows, along with mention of all species or genera known from Otter Creek and not listed in Table 1.

Ephemeroptera (Mayfly) Larvae: Larvae of *Baetis brunneicolor* and *B. tricaudatus* were found for the first time. Among other Baetidae, *Acerpenna macdunnoughi* larvae were more numerous, those of *B. flavistriga* were less numerous, and *Labiobaetis propinquus* larvae were not found. Numbers of *Ephemerella needhami* larvae were much lower than in 1984 and 1985, while larval numbers of closely related *E. subvaria* remained unchanged. *Leucrocuta hebe* larvae were more abundant than previously. Mature larvae of *Leptophlebia cupida* (Say) and/or *L. nebulosa* (Walker) were collected 14 March, but adults had emerged by mid-April. *Paraleptophlebia mollis* (Eaton) larvae remained abundant through June and were replaced by larvae of another species of *Paraleptophlebia* in July. Two *Stenacron interpunctatum* (Say) larvae were found 16 May in upper Otter Creek; this species was not reported previously.

Odonata (Dragonfly) Larvae: Odonata larvae are infrequent in riffles. *Calopteryx maculata* (Beauvois) larvae were collected from under banks in upper Otter Creek.

Table 1. Total number of each species or genus of insects collected in three samples from Otter Creek riffles on seven dates between 14 April and 30 July in each of three years, and total and percent occurring in each order.

	1984		*1985*		*1994*	
Ephemeroptera (Mayfly) Larvae						
Ameletus lineatus Traver	0		0		2	
Acerpenna macdunnoughi (Ide)	2		9		18	
Baetis brunneicolor McDunnough	0		0		6	
B. flavistriga McDunnough	175		108		77	
B. tricaudatus Dodds	0		0		1	
Labiobaetis propinquus (Walsh)	1		0		0	
Ephemerella needhami McDunnough	67		62		19	
E. subvaria McDunnough	218		151		148	
Eurylophella temporalis (McDunnough)	2		0		4	
Leucrocuta hebe (McDunnough)	57		126		212	
Stenonema vicarium (Walker)	41		37		28	
Paraleptophlebia spp.	287		412		444	
Total	**850**	34.2%	**905**	40.0%	**959**	41.5%
Odonata (Dragonfly) Larvae						
Boyeria vinosa (Say)	3		3		1	
Cordulegaster maculata Selys	0		3		1	
Total	**3**	0.1%	**6**	0.3%	**2**	0.1%
Plecoptera (Stonefly) Larvae						
Paracapnia angulata Hanson	0		0		2	
Leuctra spp.	28		54		124	
Amphinemura delosa (Ricker)	37		71		177	
Prostoia similis (Hagen)	0		4		17	
Acroneuria lycorias (Newman)	98		90		17	
Paragnetina media (Walker)	83		55		36	
Clioperla clio (Newman)	1		0		3	
Isoperla cotta Ricker	11		12		8	
I. dicala Frison	2		20		68	
Total	**260**	10.5%	**306**	13.5%	**452**	19.5%
Trichoptera (Caddisfly) Larvae						
Micrasema gelidum MacLachlan	0		1		0	
M. rusticum (Hagen)	26		9		0	
M. wataga Ross	11		17		8	
Glossosoma nigrior Banks	50		66		140	
Ceratopsyche alhedra (Ross)	16		11		0	
C. slossonae (Banks)	95		107		193	
C. sparna (Ross)	0		0		11	
Cheumatopsyche spp.	236		159		6	
Diplectrona modesta Banks	0		0		19	
Hydropsyche betteni Ross	0		0		2	
Lepidostoma costale (Banks)	20		11		8	
Pycnopsyche spp.	19		16		2	
Psilotreta indecisa (Walker)	0		2		0	
Chimarra aterrima Hagen	69		21		28	
Dolophilodes distinctus (Walker)	19		12		17	
Lype diversa (Banks)	2		0		0	
Neophylax spp.	123		33		6	
Total	**686**	27.6%	**465**	20.5%	**440**	19.0%
Megaloptera (Fishfly and Alderfly) Larvae						
Nigronia serricornis (Say)	92		48		13	
Sialis spp.	1		2		0	
Total	**93**	3.7%	**50**	2.2%	**13**	0.6%

Table 1, continued.

	1984		1985		1994	
Coleoptera (Stream) Beetles and Larvae						
Helichus striatus LeConte	0		7		0	
Optioservus fastiditus LeConte (A+L)	86		65		3	
Total	**86**	3.5%	**72**	3.2%	**3**	0.1%
Diptera: Chironomidae (Midge) Larvae						
Brillia spp.	0		0		1	
Cardiocladius spp.	1		0		0	
Conchapelopia spp.	46		86		57	
Cricotopus spp.	0		2		1	
Diamesa spp.	1		0		8	
Eukiefferiella spp.	2		6		12	
Micropsectra spp.	57		59		9	
Microtendipes spp.	10		5		0	
Nanocladius spp.	20		15		0	
Orthocladius spp.	5		5		0	
Parametriocnemus spp.	22		20		3	
Paraphaenocladius spp.	1		1		0	
Polypedilum spp.	79		65		27	
Rheocricotopus spp.	2		13		0	
Rheotanytarsus spp.	2		3		1	
Stempellina spp.	0		1		0	
Synorthocladius spp.	0		1		0	
Tanytarsus spp.	0		3		0	
Thienemanniella spp.	0		2		0	
Tvetenia spp.	1		2		0	
Xylotopus spp.	0		3		0	
Total	**249**	10.0%	**292**	12.9%	**119**	5.1%
Diptera: Other (Fly) Larvae						
Atherix variegata Walker	63		48		44	
Ceratopogon spp.	0		0		1	
Nilobezzia spp.	1		0		0	
Probezzia spp.	1		16		0	
Empididae spp.	1		0		0	
Pericoma spp.	9		9		0	
Prosimulium magnum Dyar & Shannon	5		7		0	
P. mixtum Syme & Davies	86		19		106	
P. multidentatum (Twinn)	0		2		0	
P. mysticum Peterson	26		0		19	
Simulium aureum Fries	0		0		1	
S. jenningsi-group	0		0		1	
S. latipes (Meigen)	0		1		0	
S. tuberosum (Lundstrom)	13		18		96	
S. venustum Say	0		0		2	
Chrysops spp.	5		0		1	
Antocha spp.	25		25		0	
Dicranota spp.	1		7		8	
Limnophila spp.	2		0		1	
Pilaria spp.	2		0		0	
Pseudolimnophila spp.	1		2		0	
Tipula spp.	15		13		45	
Total	**256**	10.3%	**167**	7.4%	**325**	14.1%
TOTAL	**2,483**		**2,263**		**2,313**	

Larvae of *Aeshna umbrosa* Walker, *Basiaeschna janata* (Say), and *Phanogomphus spicatus* (Hagen), which had been collected previously from low gradient areas north of Kings Corner Road, were not found. *Cordulegaster obliqua* Say larvae, which occur in small, headwater seeps, were also not collected. Both of these areas were not sampled in 1994.

Plecoptera (Stonefly) Larvae: Larvae of *Leuctra sibleyi* Claassen, *L. tenuis* (Pictet), *Amphinemura delosa*, *Prostoia similis*, and *Isoperla dicala*, all of which have a one-year life cycle, were distinctly more abundant than before the flood. Larvae of *Acroneuria lycorias* and *Paragnetina media*, which have a three-year life cycle, were distinctly less abundant; many large, older larvae were likely swept downstream by the flood. Several emerging adults of the winter stoneflies *Paracapnia angulata* and *Taeniopteryx nivalis* (Fitch) were collected 14 March. Larvae and adults of other winter stoneflies, *Allocapnia illinoensis* Frison, *A. nivicola* (Fitch), *A. pygmaea* (Burmeister), *A. rickeri* Frison, and *A. vivipara* (Claassen), were not found because all adults had probably emerged before sampling was initiated in mid-March. Since winter stoneflies spend the summer as diapausing larvae deep in the substrate, the effect of the flood on these species was probably limited. The rare *Zealeuctra narfi* Ricker & Ross also was not found.

Trichoptera (Caddisfly) Larvae: Absence or lower numbers of larvae of the three species of *Micrasema* probably reflects a lack of moss on rocks because of the flood. The increase in *Glossosoma nigrior* larvae likely resulted from an increase in cobbles on which they live. Larvae of *Neophylax concinnus* MacLachlan and *N. oligius* Ross also inhabit cobbles; the lower number in 1985 was probably due to warmer weather causing earlier emergence. The low number in 1994 may have resulted from young larvae having been scoured from the cobbles by the flood. The large decline in numbers of *Cheumatopsyche gracilis* (Banks) and/or *C. oxa* Ross larvae was probably caused by a lack of moss and filamentous algae on rocks and cobbles; apparently they were replaced by larvae of other net-spinning Hydropsychidae, namely *Diplectrona modesta* and *Ceratopsyche slossonae.* Larvae identified as *Ceratopsyche sparna* in 1994 were small and may be *C. alhedra.* Lower numbers of *Pycnopsyche guttifera* (Walker), *P. lepida* (Hagen), and *P. scabripennis* (Rambur) larvae, which are most numerous in slower water, probably resulted from changed habitat and from many larvae having been swept away by the flood. A decline in numbers of sand-dwelling *Psilotreta indecisa* larvae was noticed in 1992; efforts to collect them in 1994 were futile. One larva of *Molanna blenda* Sibley was found in a sandy area of upper Otter Creek, and one *Limnephilus* sp. larva was also collected. Larvae of several previously collected species of generally uncommon caddisflies were not found. This includes larvae of *Lepidostoma libum* Ross, *L. sackeni* (Banks), *L. vernale* (Banks), *Frenesia missa* Milne, *Pseudostenophylax sparsus* (Banks), and *P. uniformis* (Betten) that occur only in spring seeps, which were not sampled. Also included are larvae of *Lepidostoma bryanti* (Banks), *L. griseum* (Banks), *Mystacides sepulchralis* (Walker), *Anabolia consocia* (Walker), *Hydatophylax argus* (Harris), *Platycentropus radiatus* (Say), *Oligostomis ocelligera* (Walker), *Ptilostomis ocellifera* (Walker), *Paranyctiophylax moestus* (Banks), *Polycentropus centralis* Banks, *P. flavus* (Banks), *P. pentus* Ross, and *P. remotus* Banks, which occur in slow water and pools, a habitat eliminated by the flood. Also not found were larvae of *Phylocentropus placidus* (Banks), *Oecetis avara* (Banks), and

Hesperophylax designatus (Walker), which inhabit sandy habitats, *Psychomyia flavida* Hagen larvae, which occur in decaying wood, and *Ironoquia lyrata* (Ross) larvae, which live under banks; all of these habitats were greatly reduced by the flood. The uncommon larvae of *Hydroptila virgata* Ross and *Oxyethira anabola* Blickle may have been overlooked because of their small size. *Helicopsyche borealis* (Hagen) larvae, which previously occurred occasionally on rocks and cobbles in upper Otter Creek, also were not found.

Megaloptera (Fishfly and Alderfly) Larvae: Larvae of *Nigronia serricornis*, which take about four years to complete development, were unusually scarce in 1994, probably because many were swept away by the flood. *Sialis* spp. larvae, which mostly inhabit pools, were collected only from upper Otter Creek.

Coleoptera (Riffle) Beetles and Larvae: Only three *Optioservus fastiditus* larvae were collected in 1994, compared to 86 adults and larvae in 1984 and 65 in 1985. Although most riffle beetles and their larvae burrow into sandy substrate when flooding occurs, the depth to which sand and gravel were removed by the flood suggests most were washed downstream. Adults and larvae of *Dubiraphia minima* Hilsenhoff and *D. quadrinotata* (Say), which inhabit vegetation and decaying wood, and those of *Macronychus glabratus* Say, which also inhabit decaying wood, were not found, probably due to a lack of habitat.

Adults and larvae of three species of Dytiscidae that previously were found in debris or sand were not collected; they were *Agabus semivittatus* LeConte, *A. seriatus* (Say), and *Sanfilippodytes pseudovilis* (Young). Also not found were several previously collected species of Hydrophilidae, including *Anacaena lutescens* (Stephens), *Cymbiodyta chamberlaini* Smetana, *C. vindicata* Fall, *Enochrus ochraceus* (Melsheimer), *Helophorus lacustris* LeConte, *H. linearis* LeConte, *H. lineatus* Say, *H. marginicollis* Smetana, *H. orientalis* Motschulsky, *Hydrobius fuscipes* (Linnaeus), and *H. melaenus* (Germar). All these species live under banks or on stream-side vegetation; they may have been eliminated by the flood along with their habitat.

Diptera (Midge and Fly) Larvae: Numbers of midge larvae (Chironomidae) apparently were reduced by the flood because most finer sediments and debris that they inhabit were removed. Larvae in 12 genera found previously in riffle samples were not collected in 1994 (Table 1); also *Diplocladius* spp. larvae, which had occurred previously, were not found. Some other Diptera may have disappeared as a result of the flood, namely larvae of crane flies *Antocha* spp. and some less common crane flies (*Limonia* spp., *Pedicia* spp., *Pilaria* spp., and *Pseudolimnophila* spp.), and moth flies *Pericoma* spp. Numbers of *Prosimulium* spp. black fly larvae were essentially unchanged. In 1994, larvae of three *Simulium* black fly species (*aureum*, *jenningsi*-group, *venustum*) were collected for the first time, and numbers of *Simulium tuberosum* larvae increased. *Tipula* spp. larvae were also more numerous, perhaps because of more favorable habitat.

Heteroptera Adults (Aquatic Bugs): Because they breathe air at the water's surface, Heteroptera adults and nymphs are not used in biotic index evaluations. Adults of *Aquarius remigis* (Say) and *Microvelia americana* (Uhler), two water striders that inhabit streams, were still present. Adults of *Limnoporus dissortis* (Drake & Harris), *Microvelia pulchella* Westwood, and *Trepobates pictus* (Herrich-Schaffer) occurred previously among vegetation along margins of pools but were not found in 1994. The latter species overwinters as an egg, and adults occur only in late summer and autumn, while the flood destroyed the habitat of *L. dissortis* and *M. pulchella.*

Biotic Index Evaluations

Although evaluation of water quality was not the intent of this study, it was noted that mean biotic index values (Hilsenhoff 1987) in 1994 were lower (ANOVA highly significant) than in 1984 and 1985, indicating a cleaner stream with higher levels of dissolved oxygen. This probably resulted from removal of excess organic debris and vegetation by the flood. Decomposition of organic matter and plant respiration at night lower dissolved oxygen levels, so a decrease in organic matter and living plants favors species of insects with high dissolved oxygen requirements.

Conclusions

The flood obviously altered species composition in the high gradient portion of the stream, increasing numbers of some, reducing numbers of others, and probably eliminating several species. Qualitative samples suggested lower gradient areas upstream were less affected. As allochthonous debris enters the stream along with silt and sand after each spring snow-melt and storm event, the composition of the substrate and insect fauna may gradually change to approach preflood conditions. Insects eliminated by the flood can return if suitable habitat exists, because adults of almost all species fly long distances. However, alteration of the high gradient portion was so great that it is unlikely the fauna will revert entirely to its preflood composition. A follow-up study after several years would provide insight into long-term effects of this catastrophic flood.

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Richard A. Lillie

A quantitative survey of the floating-leafed and submersed macrophytes of Fish Lake, Dane County, Wisconsin

Abstract *Quantitative surveys of the submersed and floating-leafed macrophytes inhabiting the littoral zone of Fish Lake, Dane County, were conducted annually from 1991 to 1994. These surveys were conducted in conjunction with a Wisconsin Department of Natural Resources cooperative management-research effort that was intended to manipulate the lake's dense weed bed as a means to improve the largemouth bass-bluegill fishery. Biomass (dry weights) and frequency of occurrence data were obtained from 21 transects spaced 200 m apart. Samples were collected via SCUBA at 5 m intervals along each transect from shore to a water depth of 6 m during late July - early August each year.*

Eurasian watermilfoil, Myriophyllum spicatum *L., was dominant, representing approximately 90% of the total plant biomass, occurring in almost 95% of all samples, and covering about 100 acres or nearly 40% of the total lake bottom. Coontail,* Ceratophyllum demersum *L., ranked a distant second, with frequencies of occurrence ranging from 20 to 40% and relative biomass ranging from 3 to 11% of the total. The distribution of seven other plant species was limited primarily to shallow nearshore areas. Milfoil biomass was extremely high, averaging 420 g* m^{-2} *for the four years. Highest densities of milfoil were restricted to a nearly continuous bed at a water depth of 1.5 to 4.0 m that ringed the entire perimeter of the lake. Although distribution (as measured by frequencies of occurrence) of milfoil was highly stable among years, milfoil biomass and relative dominance declined substantially during 1994. Evidence suggests that the milfoil population may be in the process of crashing in Fish Lake. An aquatic weevil,* Eurhychiopsis lecontei *(Dietz), is believed to be responsible for the decline in milfoil.*

Fish Lake, a 251 acre (100 ha) seepage lake located 4 miles east of Prairie du Sac and 25 miles northwest of Madison in the northwest corner of Dane County, Wisconsin (T9N, R7E, Sec. 3; lat 43 17' 14", long. 89 39' 08"), is the site of a cooperative Wisconsin Department of Natural Resources (WDNR), research-management project designed to improve the lake's largemouth bass-bluegill fishery through selective harvesting of channels in a dense macrophyte bed (Pellett 1995). The creation of deep channels in dense macrophyte beds is expected to increase edge habitat available to fish and fish food items, thus improving the habitat for both predator and prey populations (Smith 1993*a* and 1993*b*; Storlie et al. 1995). Fish Lake was selected as the study site for this project because it contained a large population of stunted panfish and a slow-growing bass population, both of which were suspected to be attributable, in part, to the dense beds of Eurasian watermilfoil (*Myriophyllum spicatum* L.) distributed throughout the littoral zone of the lake. Eurasian watermilfoil, first recognized in Wisconsin in 1967 (Nichols and Mori 1971), has become widely naturalized in the eastern half of the United States in recent decades and now occurs in more than 70 Wisconsin lakes (Nichols 1994). Nichols (1984) reported having found both *M. sibiricum* Komarov (then called *M. exalbescens* Fern.) and *M. spicatum* in Fish Lake in 1982, and a few specimens of the former still exist.

The 1991–1994 period during which the data reported herein were collected represented the premanipulation phase of the whole lake demonstration project. Quantitative surveys of the macrophyte community were conducted once each year at the peak of the growing season (late July to early August) in order to characterize the structure and population dynamics of the macrophyte community prior to manipulation of the macrophyte bed. This paper summarizes the findings resulting from the annual surveys of the macrophyte community of Fish Lake.

Methods

Surveys of the floating-leafed and submersed macrophytes of Fish Lake were conducted 30 July–2 August, 1991; 23–29 July, 1992; 21–27 July, 1993; and 21–26 July, 1994. Macrophyte surveys were conducted using SCUBA along 21 transects (19 transects in 1991) positioned perpendicular to shore and spaced 200 m apart around the shoreline (Figure 1a). Presence/absence data for all macrophyte species were recorded within circular quadrats (0.8 m^2) spaced at 5 m intervals (linear distance) along each transect from shore to a water depth of 6 m. Water depth was recorded at each quadrat location. The number of sample quadrats totaled 644, 732, 706, and 735 for 1991, 1992, 1993, and 1994, respectively. These data were used to compute frequencies of occurrence for each species. Divers also visually assessed and classified total plant standing crop at each site as: rare = only a few sprigs of plant present, sparse = less than 50% of the space or water volume occupied by plants, or dense = more than 50% of the space occupied by plant material (combined plant species). Samples for biomass determinations were collected from a representative number of sites within each subjective biomass class (i.e., rare, sparse, or dense) by harvesting all plant shoots and stems within 0.1 m^2 quadrats (defined by a three-sided aluminum frame) at the sediment-water interface. Biomass samples were collected from the first and, thereafter, every third rare or sparse quadrat encountered and at 10 m intervals within the interior of uniformly dense mil-

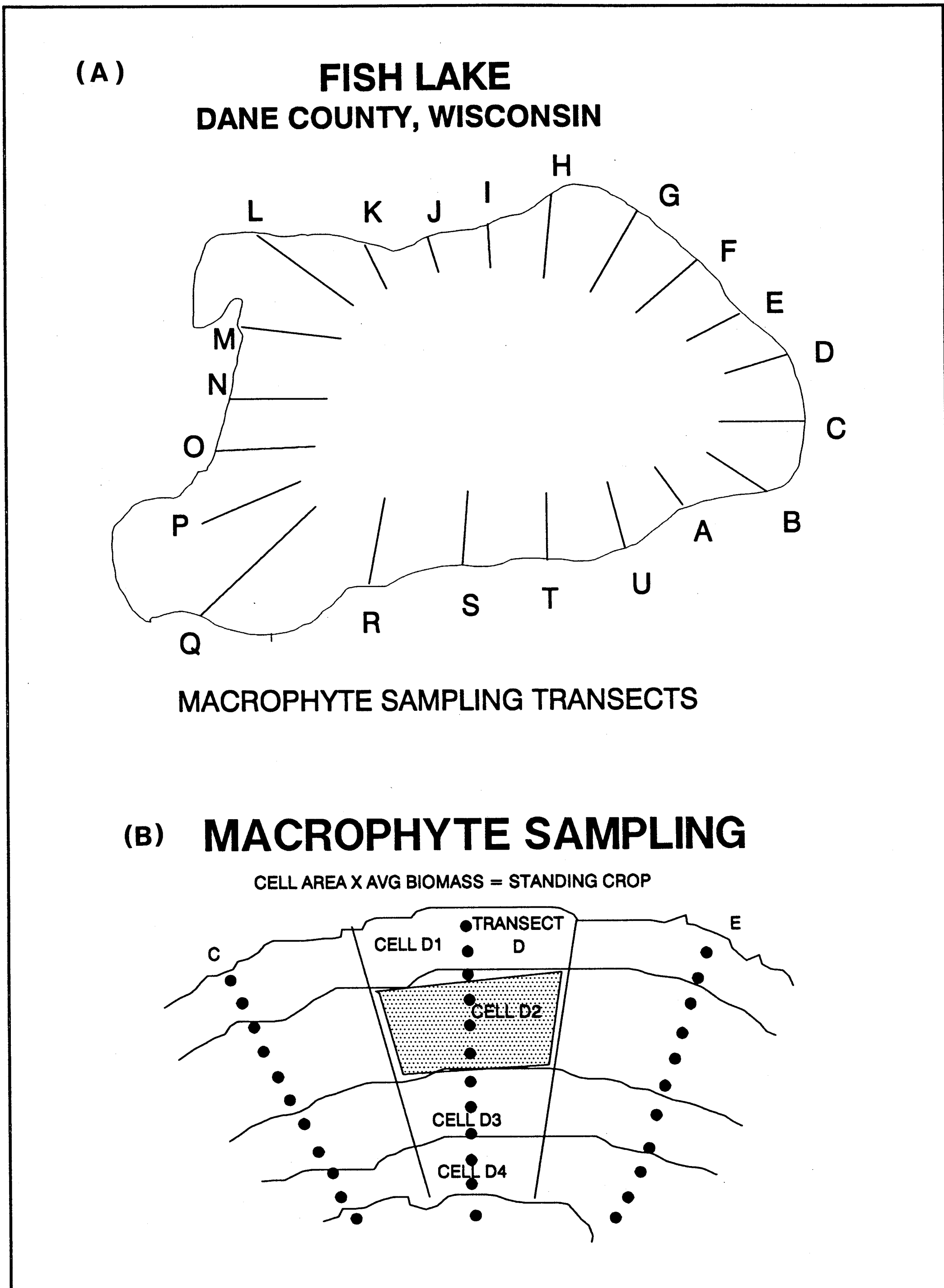

Figure 1. (a) Distribution of macrophyte survey transects in Fish Lake, and (b) areal cells defined by depth contours and boundaries between adjacent transects.

foil stands. All samples were bagged and labeled accordingly as to transect, quad, and depth, and transported in a cooler to the laboratory where samples were sorted by species and oven-dried for a minimum of 48 hrs at 106°C. Epiphytic growths and carbonate deposits on the surfaces of macrophytes in Fish Lake were generally very limited, and therefore no effort was taken to remove epiphytic deposits prior to analysis. Roots were removed and excluded from the samples during the sorting process. Dry weight determinations were made to the nearest 0.1 g using a top-loading balance. Weights were corrected for tared weight of bags, and data were transcribed onto the original field sheets for entry into the computer. Taxonomy follows Gleason and Cronquist (1991). Voucher specimens were prepared, and their identities were verified by S. Nichols of the Wisconsin Geological and Natural History Survey, Madison. Three specimens of *M. spicatum* and one of *M. sibiricum* taken in 1990 and deposited in the University of Wisconsin-Madison Herbarium were rechecked to assure accuracy by R. Couch and E. Nelson of Oral Roberts University, specialists in this difficult genus. Genetic DNA analysis (Furnier et al. 1995) of four specimens of milfoil collected in 1994 from Fish Lake and two specimens from adjacent Mud Lake revealed all specimens were *M. spicatum*.

Absolute frequencies of occurrence represent the percentage of quadrats in which a species was present. Relative frequencies of occurrence represent a taxon's absolute frequency of occurrence divided by the sum of absolute frequencies of occurrence of all taxa present. Biomass data were reported as g m^{-2}. For those rare or sparse quads where biomass samples were not collected, we applied a standard biomass value derived from the mean of actual biomass measurements for each class (the mean was computed after eliminating the lowest and highest 10% extreme values for each subjective class). These standard values ranged from 15 to 30 g m^{-2} for rare quadrats and 30 to 60 g m^{-2} for sparse quadrats, varying among years and teams of divers. For dense quads within the interior of the milfoil bed, we interpolated values for intervening 5 m quadrats from adjacent 10 m quadrat data. Detailed analysis of the macrophyte biomass data, both including or excluding the interpolated data, demonstrated that the interpolated data did not change the outcome of our statistical comparisons.

In order to obtain an estimate of the total standing crop of each species in the lake, the lake bottom was separated into cells outlined by depth contours and common boundaries equidistant between adjacent transects (see Figure 1b). Within each cell, the average biomass of all quads located therein was calculated (by species), and the resulting values were subsequently multiplied by the area of the cell to derive an estimate of the total biomass of each species on an areal basis. These estimates (i.e., individual cells) were then summed by depth zone (e.g., 1.5–3.0 m zone) or further compiled to derive an estimate of total standing crop for each species for each depth zone or for the entire lake for a given year. Statistical comparisons among means were conducted using ANOVA (SAS Institute 1989). Data analysis and statistical comparisons were made using both the simple sample means (untransformed and unweighted) and areally weighted means. Statistical significance is reported at the $p < 0.05$ level.

Results and Discussion

Twenty-one species of submersed and floating-leafed plants were recorded during the

Table 1. Taxonomic list of floating leafed and submersed macrophytes collected during the period 1991–1994 in Fish Lake, Dane County, Wisconsin.

Scientific Name	*Common Name*
Bidens beckii Torr.	Water Marigold
Brasenia schreberi Gmel.	Water Shield
Ceratophyllum demersum L.	Coontail
Chara spp.	Stonewort or Muskgrass
Eleocharis acicularis (L.) R. & S.	Spike Rush
Elodea canadensis Michx.	Waterweed
Lemna minor L.	Lesser Duckweed
Myriophyllum sibiricum Komarov	Northern Watermilfoil
Myriophyllum spicatum L.	Eurasian Watermilfoil
Najas flexilis (Willd.) Rostk. & Schmidt	Bushy Pondweed
Nuphar variegata Durand	Yellow Water Lily
Nymphaea odorata Ait.	White Water Lily
Polygonum natans Eat.	Smartweed
Potamogeton amplifolius Tuckerm.	Large-leaf Pondweed
Potamogeton crispus L.	Curly-leaf Pondweed
Potamogeton gramineus L.	Variable-leaf Pondweed
Potamogeton natans L.	Floating-leaf Pondweed
Potamogeton pectinatus L.	Sago Pondweed
Potamogeton richardsonii (Benn.) Rydb.	Clasping-leaf pondweed
Potamogeton zosteriformis Fern.	Flat-stemmed Pondweed
Utricularia vulgaris L.	Bladderwort

current study, 1991–1994 (Table 1). With the exception of a few scattered stems of cattail (*Typha* sp.) and some grasses and sedges, emergents were not routinely collected and identified as part of this study of Fish Lake. Among the floating-leafed plants, duckweeds were routinely overlooked and, therefore, were underrepresented in this survey. Eight species of pondweed were identified during the study, but it is likely that other narrow-leafed forms were also present among several specimens of unidentified pondweeds collected. Ten additional taxa, including the stonewort, *Chara* sp., were also collected. Northern watermilfoil *(M. sibiricum*, formerly *M. exalbescens)* has virtually disappeared concomitant with the invasion of Eurasian watermilfoil *(M. spicatum)*, but a few specimens were located. Some of these specimens may represent a hybrid, and representative specimens have been collected and shipped to the University of Minnesota for isozyme analysis. Coincidentally, Nichols (1994) reports that the first confirmed specimen of *M. spicatum* in Wisconsin was collected from Fish Lake in 1967. *Bidens (=Megalodonta) beckii* Torr. was observed in bloom in 1990 at 2–3 m depths (pers. obser.) along the south shore but was not present in the biomass surveys of 1991–1994.

Milfoil

Milfoil dominated the plant community of Fish Lake during 1991–1994, both in terms of relative frequency of occurrence and biomass (Table 2). The absolute frequency of occurrence of milfoil in the 0–6 m littoral zone of Fish Lake remained relatively constant (Table 3); however, the overall frequency of occurrence of sites with dense milfoil (> 60 g m^{-2}) declined from 80% to 72%, and sites with very dense milfoil growth

Table 2. Relative importance of dominant macrophytes in Fish Lake based on relative frequency of occurrence and relative dry weight biomass.

	Relative Frequency of Occurrence				*Relative Biomass*			
Year:	91	92	93	94	91	92	93	94
Plant Taxa:								
Milfoil	63	65	74	65	93	92	95	86
Coontail	26	24	15	24	5	6	3	11
Bushy Pondweed	5	4	5	3	tr.	tr.	tr.	tr.
Water Shield	3	2	3	2	1	tr.	1	1
White Water Lily	2	3	2	3	tr.	tr.	tr.	tr.
Waterweed	1	1	1	3	tr.	tr.	tr.	tr.
All others	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.

tr. = trace

Table 3. Absolute frequencies of occurrence of milfoil by stand density (limited to 0–6 m zone).

Sites Included	*1991*	*1992*	*1993*	*1994*
All sites (incl. unvegetated)	90%	90%	92%	89%
All vegetated sites	94	93	96	95
Milfoil > 60 g m^{-2}	80	80	78	72
Milfoil > 300 g m^{-2}	68	63	62	34

(> 300 g m^{-2}) declined by half from 68% to 34% (Figure 2). The frequency of occurrence of dense milfoil sites declined at shallow-water stations and increased at deeper stations during the same period (Table 4). This may have been an artifact of a rise in the water level during 1992–1993. The frequency of occurrence of unvegetated sites did not change substantially during the study (4%, 4%, 3%, and 5%, 1991–1994, respectively).

Total milfoil biomass in Fish Lake was very high, averaging 420 g m^{-2} in vegetated portions of the littoral zone (445 g m^{-2} within milfoil stands). Large fluctuations in biomass occurred among years (Table 5). Milfoil biomass decreased significantly in 1992, recovered in 1993, and declined dramatically in 1994. The decrease in milfoil biomass from 1991 to 1994 (Table 5) accounted for the significant decline in relative biomass of milfoil (Table 2). Irrespective of the biomass measurement (i.e., all vegetated sites or milfoil sites only), average milfoil biomass declined by 50%, 49%, and 45% from 1991 to 1994 using vegetated, milfoil, or areally weighted estimates, respectively. Milfoil-stand biomass (sites where milfoil was present) declined from 555 g m^{-2} in 1991 to 283 g m^{-2} in 1994. This reduction corresponded to a decline from 532 g m^{-2} to 268 g m^{-2} during the same time period including all vegetated sites. The contribution of milfoil biomass to total standing crop declined from 93% to 77% (Table 6). Despite these substantial declines, milfoil remained dominant in terms of relative biomass throughout the pretreatment period (Table 2).

Milfoil formed a dense, primarily monotypic bed at water depths from 1.5 m to 4 m in Fish Lake. Maximum biomass occurred at the 1.5 to 3 m depth interval (Figure 3), with slightly reduced levels at the 3 to 4.5 m depth interval. Inasmuch as the 1.5 to 3 m depth interval represented 58% of the lake's littoral zone, relatively small changes in biomass occurring in this zone could have large impacts on total standing crop. Only a few sprigs of milfoil grow beyond 4.5 m in Fish Lake. Large declines in milfoil bio-

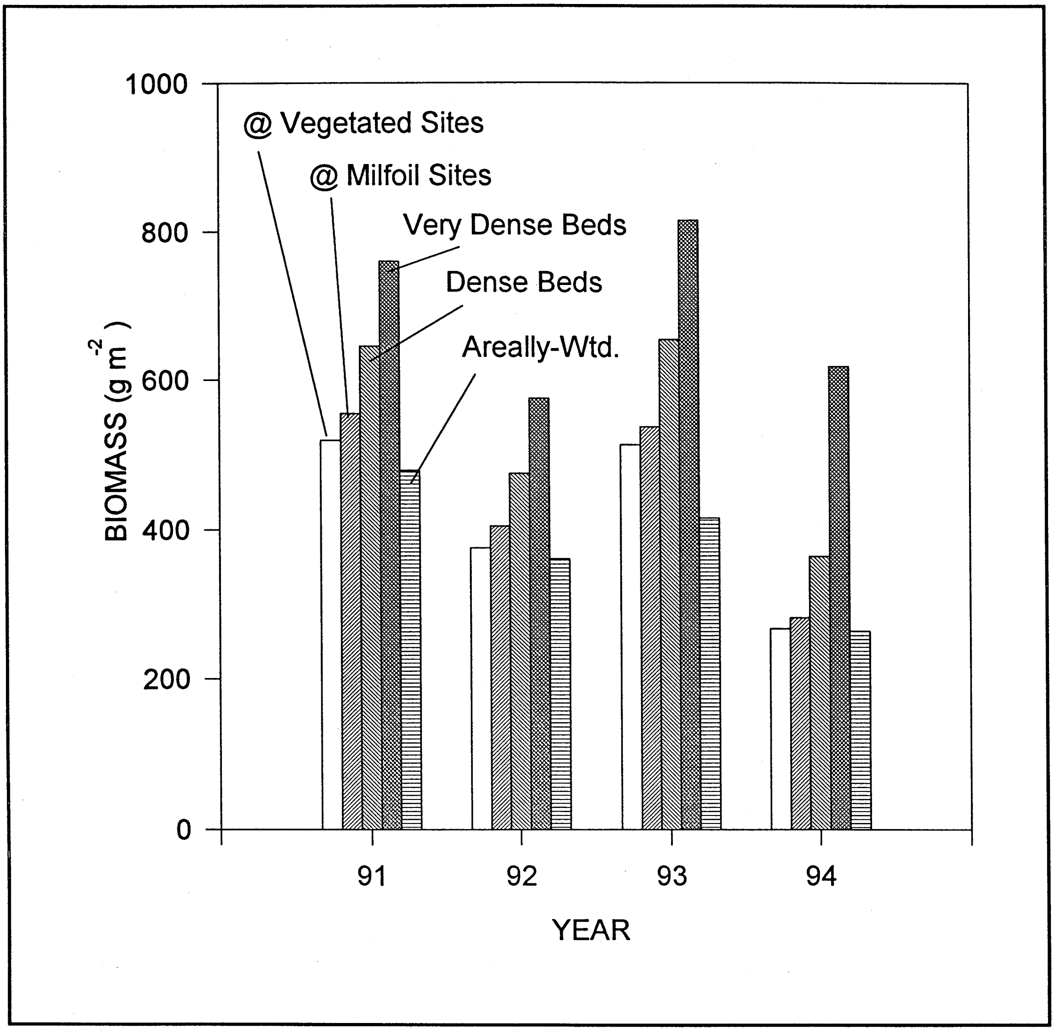

Figure 2. Mean dry weight biomass of milfoil across all vegetated sites, all sites with milfoil present, sites with dense milfoil (> 60 g m^{-2}), sites with very dense milfoil (> 300 g m^{-2}), and areally weighted estimates for the entire littoral zone (0–6 m) by year.

mass occurred during 1992 and 1994 in both the 1.5 to 3 m and the 3 to 4.5 m zones.

Milfoil biomass was evenly distributed among shoreline regions during the first year of the study (Figure 4 and Table 7). Fluctuations in milfoil biomass during subsequent years were not consistent across all locations in Fish Lake. Milfoil biomass in the South Shore bed declined in 1992 and remained low through 1994 (87% decline). Average milfoil biomass actually increased slightly during the cool summer of 1992 in the SW Bay bed (and remained quite high during 1994). Milfoil biomass declined by 73% in the North Shore bed from 1991 to 1994 (560 g m^{-2} to 153 g m^{-2}). Declines in the other beds from 1991 to 1994 were 60% in the NE Beach, 43% in the West Shore, and 36% in the SE Shore.

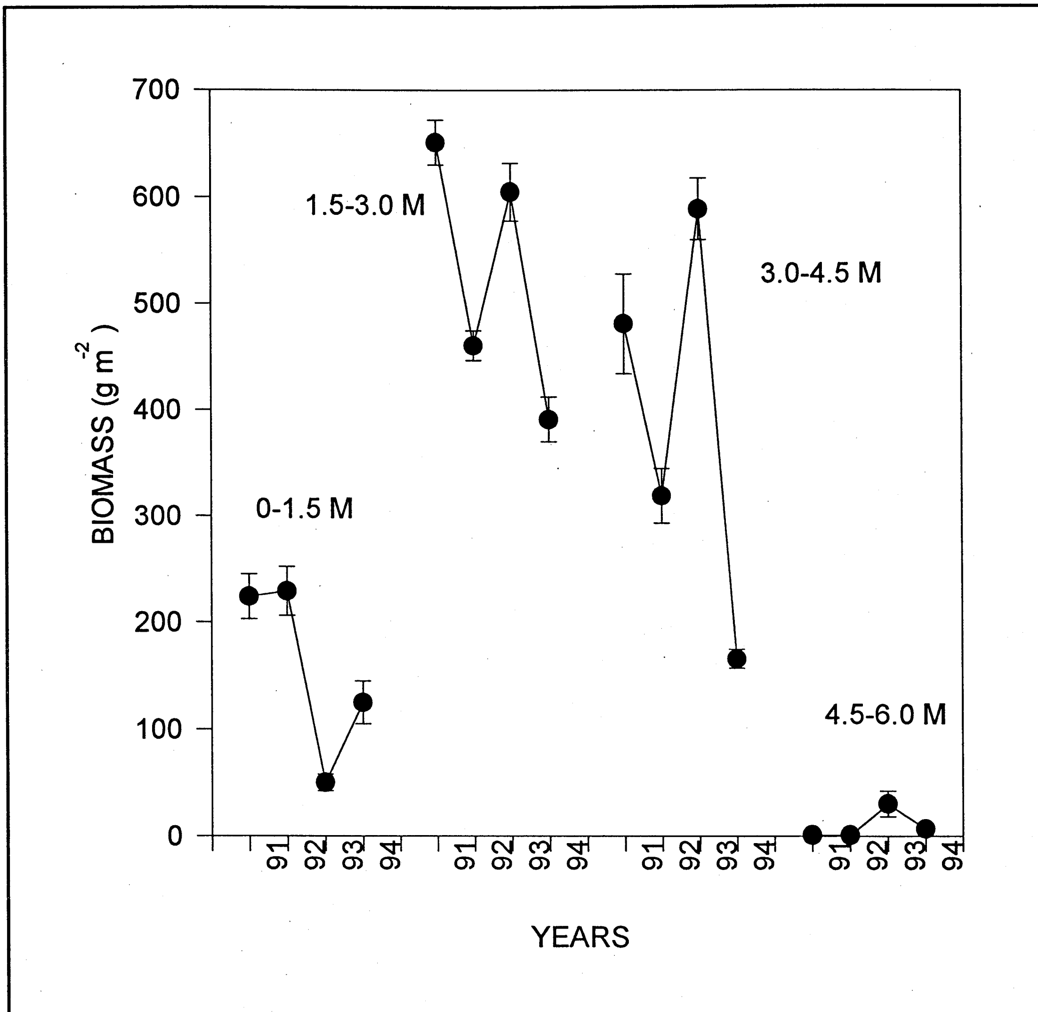

Figure 3. Milfoil biomass (mean ± 1 SE) by depth zone and year.

Overall, the total standing crop of all macrophytes in Fish Lake declined by 32% from 1991 to 1994 (Table 6). While the absolute frequency of occurrence of milfoil remained relatively stable during this time, average milfoil biomass declined dramatically. The lowered biomass observed in 1992 may have been related to the cool and cloudy weather experienced in the area that summer (mean monthly temperatures were 3.4°F below normal, and only 44% sunshine was available for July – NOAA 1992). Milfoil biomass recovered in all areas except along the South Shore in 1993, thus supporting the climatic effect hypothesis. However, in 1994 all areas of the milfoil bed suffered severe losses. In general, the milfoil bed appears to have undergone a thinning (i.e., decreased stem densities) rather than experiencing either a reduction in stature (i.e., plant height and individual mass) or reduction in areal distribution. The latter is supported by the fact that, although the frequency of occurrence of dense and very dense milfoil stands de-

Table 4. Distribution of sites with dense (> 60 g m^{-2}) milfoil biomass by depth zone (percent of sites containing dense milfoil). Data restricted to 0–4.5 m zone; only very small amounts of milfoil grow beyond 4.5 m.

Depth Zone in Meters	*1991*	*1992*	*1993*	*1994*
(% littoral area)				
0–1.5 (27%)	12%	13%	3%	5%
1.5–3 (58%)	55	54	40	39
3–4.5 (15%)	13	11	35	28

Table 5. Milfoil biomass (g m^{-2}) within different densities of stands. Data represent mean ± 1 SE of all samples within each area or zone except for areally derived estimates (see methods).

Area or zone	*1991*	*1992*	*1993*	*1994*
All vegetated sites	532 ± 17	379 ± 12	515 ± 18	268 ± 12
Milfoil sites only	555 ± 17	406 ± 12	538 ± 19	283 ± 13
Milfoil > 60 g m^{-2}	645 ± 17	476 ± 12	655 ± 20	365 ± 15
Milfoil > 300 g m^{-2}	760 ± 17	576 ± 12	815 ± 21	618 ± 23
0-20 ft (areally weighted)[a]	480	362	417	265

[a]No estimate of variance is possible.

Table 6. Estimated total standing crop of macrophytes within the littoral zone (0–6 m) of Fish Lake during 1991–1994. Data represent dry weight biomass X 10^3 kg.

Plant Taxa	*1991*	*1992*	*1993*	*1994*
Total plants (all species)	309	241	279	209
Milfoil only	288	216	251	160

Table 7. Distribution of milfoil biomass in Fish Lake by shoreline region. Data represent dry weight means ± 1 SE in g m^{-2} (includes unvegetated sites).

Shoreline region (transects)[a]	*1991 [b]*	*1992*	*1993*	*1994*
NE Beach (F, G, H)	531 ± 56	310 ± 24	539 ± 50	210 ± 17
SE Shore (C, D, E)	476 ± 55	452 ± 40	543 ± 73	304 ± 23
North Shore (I, J, K)	560 ± 63	332 ± 26	671 ± 73	153 ± 24
South Shore (A, B, S, T, U)	539 ± 37	164 ± 18	180 ± 17	69 ± 7
West Shore (L, M, N, O)	571 ± 39	390 ± 18	599 ± 30	324 ± 22
SW Bay (P, Q, R)	496 ± 24	528 ± 28	654 ± 39	451 ± 40

[a]Transects correspond to Figure 1a.
[b]Transects F and N missing for 1991.

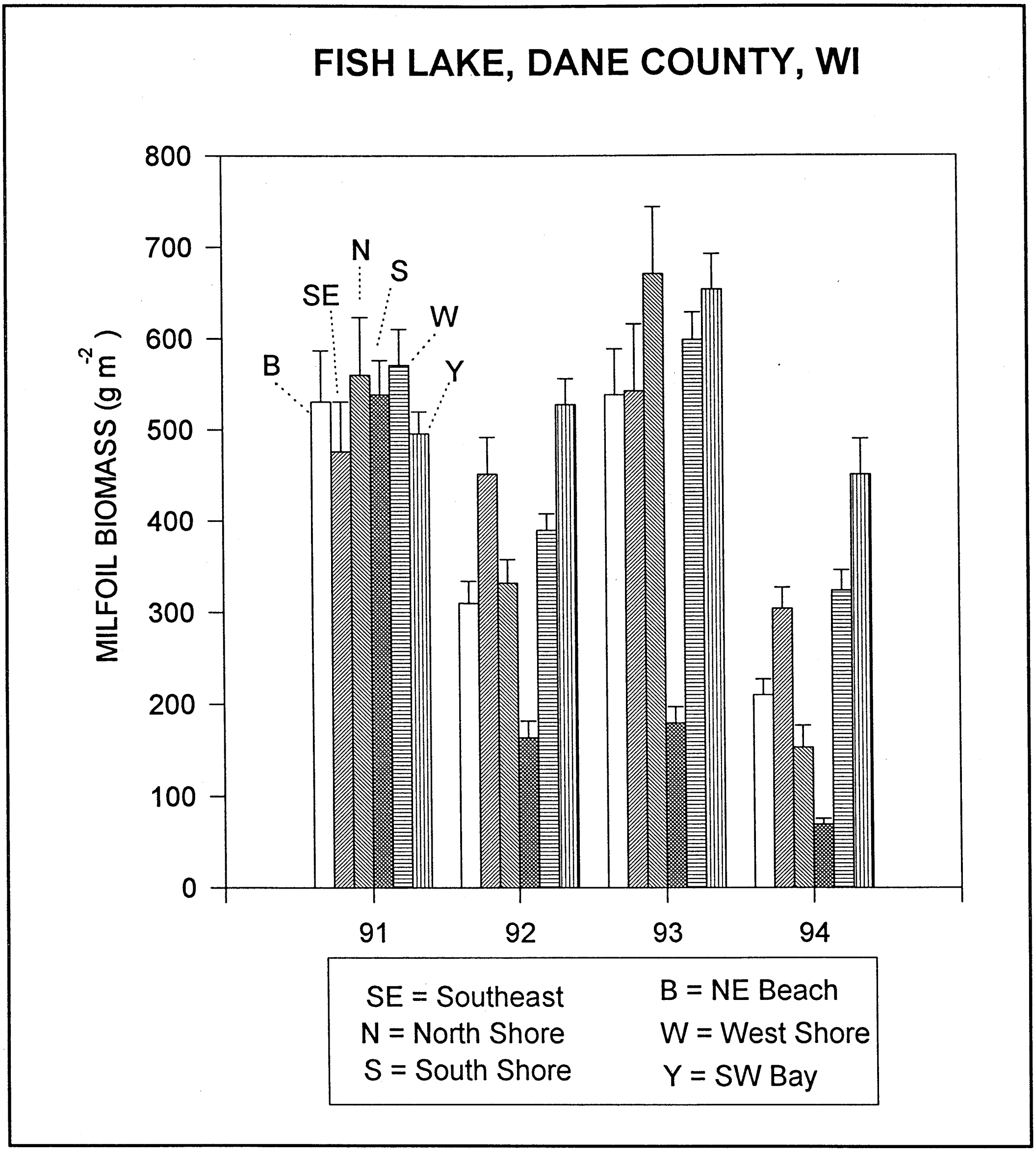

Figure 4. Distribution of milfoil biomass (mean ± 1 SE) by shoreline region and year.

clined, the overall frequency of occurrence of sites with at least some milfoil present remained unchanged during 1991–1994. While we can not dismiss altogether the possibility that changes in the robustness of milfoil plants on an individual basis may have occurred, visual observations by divers and others suggest that the height, degree of branching, and general morphometry of surviving plants were not substantially different during 1994 than during preceding years. The major observation made by divers was simply that fewer plants were present. This observation is further supported by analysis

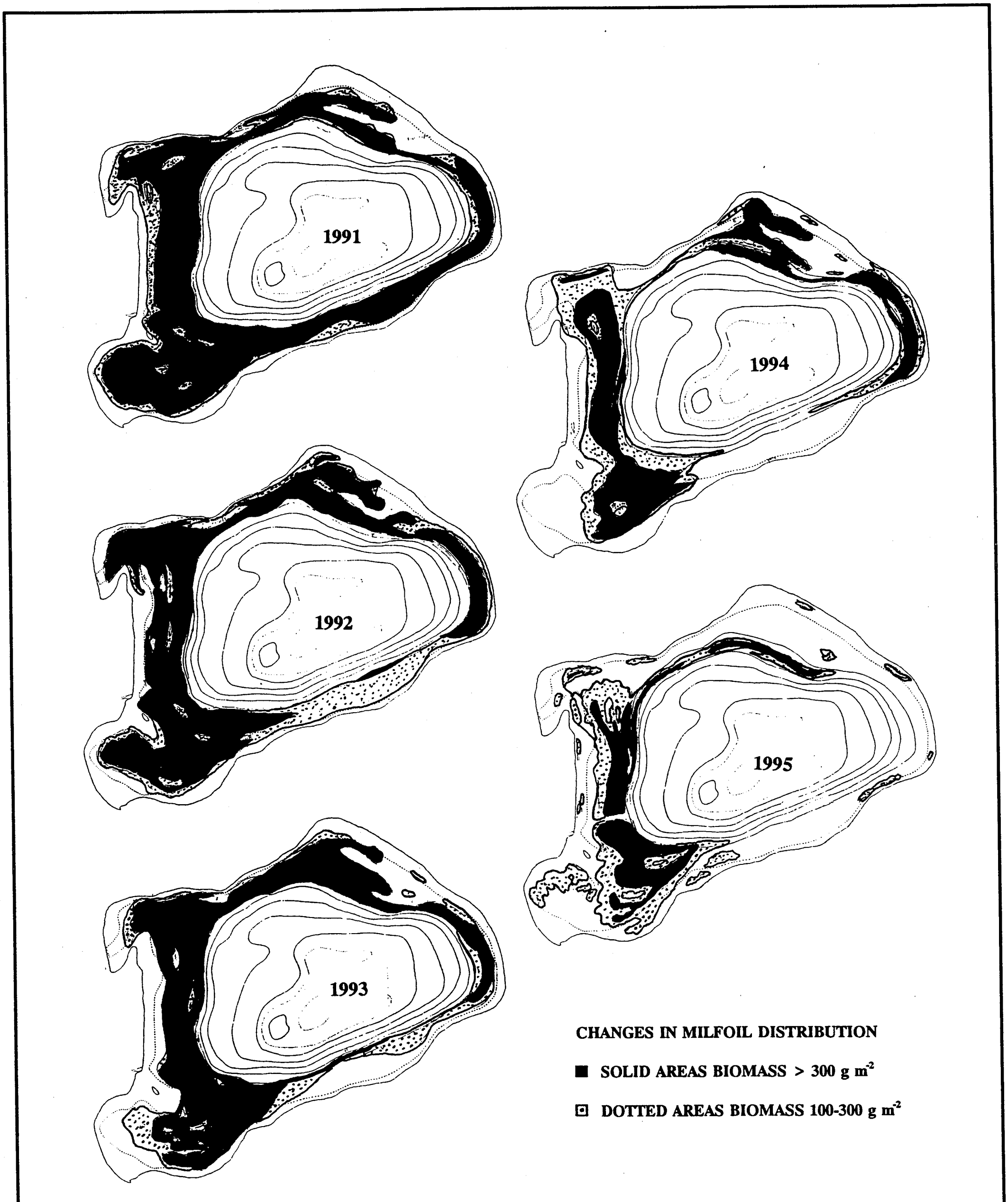

Figure 5. Changes in the distribution of milfoil beds in Fish Lake from 1991 to 1995 based on a combination of aerial photography and biomass transect data. Depth contour lines are shown as solid lines for 10 ft intervals (dashed lines represent 5 ft and 55 ft intervals).

of aerial photographs taken each summer. Estimated coverage of milfoil based on aerial images (Figure 5) decreased from 75% of the littoral zone (100 acres) in 1991 to approximately 58% (78 acres) in 1994. This trend continued in 1995. These reductions correspond quite closely with observed reductions in frequency of occurrence at some intermediate level of milfoil (see Table 3) between 60 and 300 g m^{-2}.

Native taxa

Coontail (*Ceratoophyllum demersum* L.) ranked a distant second to milfoil in respect to relative importance (Table 2). Absolute frequency of occurrence ranged from 20 to 39% (Table 8), with a rather substantial dip occurring in 1993, which was due primarily to a decrease in the distribution of coontail. Where coontail occurred, its biomass remained stable or actually increased slightly in 1994 (n.s., $p > 0.05$), particularly in co-occurrence with milfoil (Table 8—increase was significant within stands of dense milfoil, $p < 0.05$). In general, coontail biomass was inversely related to milfoil biomass. Coontail was most commonly found at, and just beyond, the deep water edge of the milfoil bed, where it became the dominant plant.

White water lily (*Nymphaea odorata* Aiton) and water shield (*Brasenia schreberi* J. F. Gmelin) were locally abundant and important contributors to total plant biomass (Table 9). Both species were dominant remnants of the native plant community, with absolute frequencies of occurrence ranging between 2.6 and 4.4% per year. Water shield produced greater levels of biomass than white water lily, reaching a maximum (within stand average) of 129 g m^{-2} in 1994. Both species were confined predominantly to the western end of the lake.

Although bushy pondweed (*Najas flexilis* (Willd.) Rostk. & Schmidt) occurred more frequently than either white water lily or water shield, it never comprised more than 1% of total plant biomass due to its small stature. Other than waterweed (*Elodea canadensis* Michx.) (1–3% frequency of occurrence), no other native taxa achieved any degree of relative importance. Total native taxa occurrences ranged from 4.4% to 6.7% (Table 9).

Conclusions

The dominant macrophyte in the lake, Eurasian watermilfoil, appears to be in the process of crashing. Similar population crashes have occurred in other nearby lakes (Nichols 1994, Nichols and Lathrop 1994, Trebitz, et al. 1993), but exact causes for these population crashes were not identified. Several factors have been implicated in milfoil declines elsewhere, including nutrient depletion or toxin accumulations in sediments; attacks by pathogens, parasites, or herbivores; interspecific competition with other plants; and climatic variations, to name a few (see Carpenter 1980, Nichols 1994, Smith and Barko 1990). Declines generally occur within 10 to 15 years after reaching the heavy infestation stage or dominance (Smith and Barko 1990). Because milfoil has been a nuisance in Fish Lake since the mid-1970s (pers. obser.), a population crash appears overdue. The current data suggest that a crash is in progress. In the case of Fish Lake, we have documented a fairly large population of an aquatic weevil, *Euhrychiopsis lecontei* (Dietz), which has been associated with milfoil crashes elsewhere (Creed and Sheldon 1993, 1994, 1995; Sheldon and Creed 1995; Spenser 1995). Observations in 1995 suggest that the milfoil bed in Fish Lake has continued to decline. It is not clear

Table 8. Absolute frequency of occurrence and biomass of coontail during 1991–1994. Data represent percentages for frequencies of occurrence and means ± 1 SE for biomass (given in g m^{-2}) within 0–6 m.

Parameter and sites	*1991*	*1992*	*1993*	*1994*
Frequency of occurrence:				
All vegetated sites	39%	34%	20%	35%
Coontail > 60 g m^{-2}	12%	12%	7%	10%
Sample biomass:				
All vegetated sites	29 ± 4	26 ± 3	15 ± 2	34 ± 5
All coontail sites	73 ± 10	76 ± 8	77 ± 11	98 ± 14
Coontail present & milfoil absent	126 ± 60	111 ± 27	113 ± 37	64 ± 24
Coontail present & milfoil present	66 ± 8	70 ± 7	69 ± 11	104 ± 16
Coontail present & milfoil > 60 g m^{-2}	22 ± 3	18 ± 3	9 ± 2	35 ± 6
Coontail > 60 g m^{-2}	211 ± 26	200 ± 15	191 ± 24	299 ± 37

Table 9. Frequency of occurrence and dry weight biomass of water shield and white water lily during 1991–1994. Frequencies of occurrence represent percent of vegetated sites containing each taxa. Biomass means ± 1 SE in g m^{-2} represent within stand data (i.e., average at sites where species was present).

Parameter & taxa	*1991*	*1992*	*1993*	*1994*
Frequency of occurrence:				
White water lily	3.2%	4.4%	2.6%	4.3%
Water shield	4.4%	3.3%	4.0%	3.3%
(All native taxa)	5.8%	6.7%	4.4%	5.3%
Sample Biomass:				
White water lily	22 ± 10	37 ± 13	67 ± 42	28 ± 13
Water shield	114 ± 18	49 ± 12	96 ± 16	129 ± 35

just what impact this decline will have on the ongoing manipulation project. Thinning of extensive areas of the formerly dense milfoil bed may be expected to decrease habitat cover for macroinvertebrate prey and protective cover for small bluegills. The anticipated recovery of native flora may compensate for the loss in milfoil habitat. Postmanipulation studies will continue to monitor changes in the macrophyte community during the next several years, including measuring the response of the native flora (and fishery) to the channel harvesting (or to the natural decline in the milfoil).

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Richard A. Lillie and Rebecca S. Isenring

Comparisons among aquatic insect communities of streams draining the Baraboo Range

Abstract *Aquatic insects were inventoried in the spring of 1992 as a means of classifying 24 streams draining the Baraboo Hills. A combination of standard kick sampling in riffles with a D-frame net and additional searches of pools produced a diverse assemblage of aquatic organisms, from which we identified 18 mayfly, 12 stonefly, and 25 caddisfly genera or species, in addition to numerous other macroinvertebrates. Estimates of water quality based on the arthropods (and their individual tolerance to organic pollution) found in each stream ranged from excellent (eight streams), very good (five streams), good (eight streams), to fair (three streams). Biological richness of insect fauna as estimated by the total number of distinct taxa present in each stream (mixture of taxonomic levels) ranged from extremely high (59 in Otter Creek) to low (14 in Hoot Owl Creek). Based on the distribution and numerical abundance of mayflies, stoneflies, and caddisflies, streams were classified into one of four clusters or complexes. These clusters were clearly dependent upon geographic location within the Baraboo Hills, and chiefly divided according to glaciated and unglaciated cover.*

Only 2 of 11 aquatic insects listed as rare, endangered, threatened, or of special concern that have been previously collected from the Baraboo Hills region were collected during the study. The stonefly, Zealeuctra narfi, *was found in Otter Creek, Pine Hollow Creek, and Leopold Pines Creek. Six specimens of* Wormaldia moestus, *a caddisfly, were discovered in Pine Glen Creek.*

Inasmuch as aquatic insect communities are affected by water chemistry and stream water chemistry is largely influenced by watershed land use or geology, examination of aquatic insect communities can be a useful means to detect differences among watersheds or to monitor changes occurring within watersheds. The relatively distinct differences as noted in this study emphasize the importance of protecting watersheds with different geological characteristics within the Baraboo Range.

The Baraboo Range, identified as the wooded, hilly region of Columbia and Sauk counties, is created by the Baraboo syncline (Brown 1986). The Precambrian bedrock of the syncline consists of very resistant quartzite. The eastern portions of the Baraboo Range are covered by a mantle of glacial till, marking the western edge of the Green Bay lobe of recent glaciation (Attig and Clayton 1990). The Baraboo Range, or "Baraboo Hills," contains the single largest remaining contiguous stand of southern upland forest in the state (The Nature Conservancy, fact sheet, undated). The Baraboo Hills serves as a refugium for many species of birds, mammals, reptiles, and amphibians that are found only infrequently elsewhere in the state.

Streams draining the Baraboo Range harbor a number of aquatic insects that are rarely found in other collections. The aquatic insect community of Otter Creek has been extensively studied over the past several decades by Dr. W. Hilsenhoff, UW-Madison Department of Entomology, and his students (Flowers and Hilsenhoff 1978, Hilsenhoff, this issue, Narf and Hilsenhoff 1974, Steven and Hilsenhoff 1984, and W. Hilsenhoff, pers. comm.). Indeed, it is probably true that Otter Creek is the most extensively studied stream in Wisconsin in regard to aquatic insects. The caddisflies (Trichoptera) of Parfrey's Glen Creek also have been thoroughly examined (Karl and Hilsenhoff 1979), and Dr. W. Hilsenhoff evaluated three streams located on the Badger Ordinance property in 1987, including Pine Hollow (=Pine Glen Creek in this study) (Hilsenhoff, unpubl. manuscript). Aside from these extensive efforts, relatively little is known concerning the aquatic communities of other streams draining the Baraboo Hills. The objective of this study was to inventory and compare the insect communities of 24 streams draining the Baraboo Range with respect to the streams' position in the landscape, specifically drainage aspect (i.e., north-south drainage exposure) and location relative to glaciated-unglaciated (i.e., east-west) gradients.

Methods

Macroinvertebrate samples were collected from 24 streams draining the Baraboo Range (Figure 1, Table 1) during the period 18–25 April 1992. All streams north of the drainage divide of the South Range drain to the Baraboo River, which flows to the east and enters the Wisconsin River south of Portage. All streams south of the divide drain to the Wisconsin River either directly or through Otter Creek or Honey Creek drainage systems. Two distinct sets of samples were collected at each site. Samples for biotic index (BI) calculations were collected from riffles or snags with a kick-net by methods established by Hilsenhoff (1987). A second set of samples was collected from riffles and pools with a kick-net or by hand-picking of various microhabitats (e.g., seeps, wood, sand, and silt). Organisms captured in this latter set of samples were not used in BI calculations, but rather were used to supplement the taxa listings for each stream. Sampling effort was approximately the same in all streams. All macroinvertebrate samples were preserved in 95% ethanol. Stream width and maximum depth were estimated at each sampling location, and field measurements of pH and conductivity were made with electronic meters. Stream length (aggregate of main and tributary segments) was estimated from digitized maps using SigmaScan/Image image analysis software (Jandel Scientific 1993). Biotic index samples were processed at the University of Wisconsin-Stevens Point under a contract with The

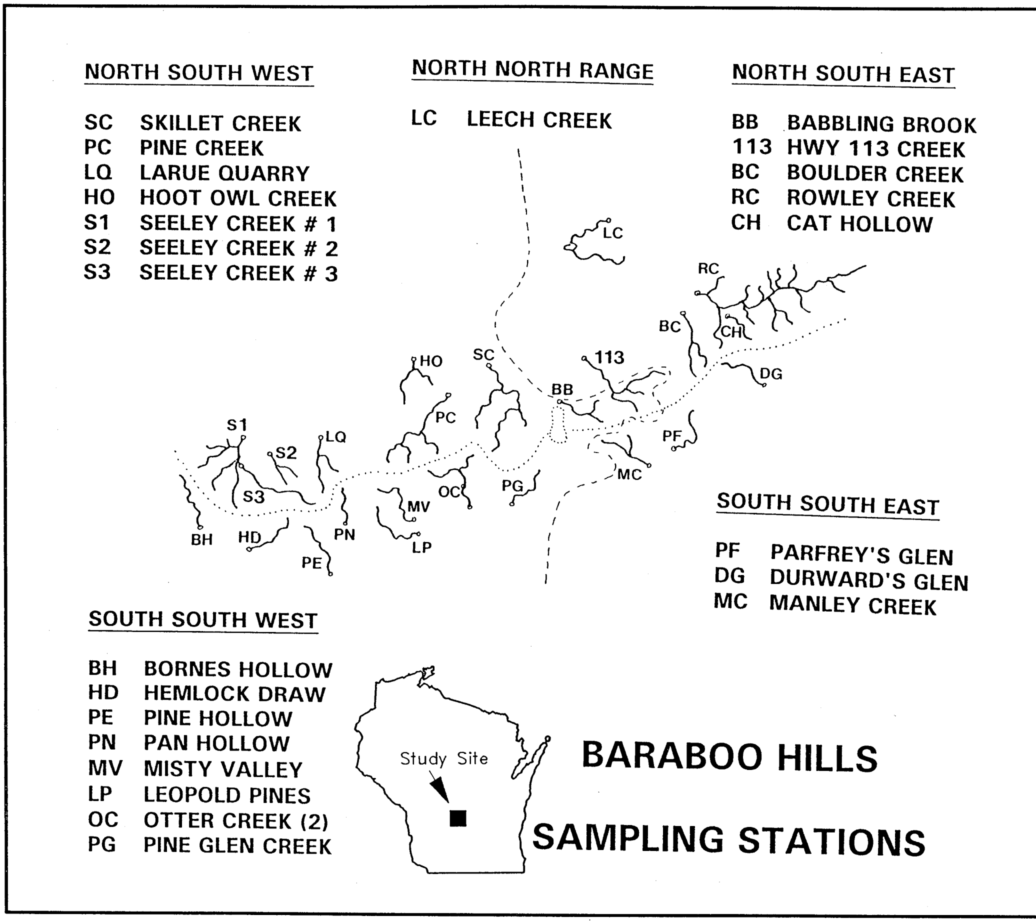

Figure 1. Location of 24 Baraboo Hills streams (Sauk and Columbia counties—see inset) relative to north-south drainage aspect as denoted by the dotted line (running from left to right) and the western advance of the glacial terminal moraine of the Green Bay lobe (after Attig and Clayton 1990) as denoted by the dashed line (running from top to bottom). Devil's Lake is shown adjacent to Babbling Brook Creek (BB) for purposes of orientation.

Nature Conservancy (TNC) in accordance with standard methods established by Hilsenhoff (1987). Under this procedure, only the first 100+ organisms (a minimum of 100 is required) encountered during a random selection from among all organisms present in the sample are actually counted, identified, and used in computing the biotic index score. Consequently, some of the rarer insects may be missed. In an attempt to provide a more complete taxa listing for the Baraboo Hills streams, we supplemented the taxa list derived from the BI samples with additional insects from pools and other microhabitats. This set of samples was processed completely by the senior author for mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera). Identifications in these three orders were made to the lowest taxonomic level permitted by

Table 1. Location description of aquatic insect sampling sites on 24 Baraboo Hills streams. Stream codes correspond with Figure 1. Streams are grouped by aspect and location. Regions are coded as follows: **SSE:** south slope of south ridge, east of Hwy 113, direct drainage to Wisconsin River, **NSE:** north slope of south ridge, northeast of Devil's Lake, direct drainage to Baraboo River, **NNE:** north slope of north ridge, northeast of Baraboo, drainage to Baraboo River, **NSW:** north slope of south ridge, southwest of Baraboo, drainage to Baraboo River, **SSW:** south slope of south ridge, southwest of Devil's Lake, drainage to Wisconsin River via Honey and Otter Creeks.

Region	*Code*	*Stream Name*	*Location description (Town-Range-Sec.-Corner)*	*Directional Information*
SSE	DG	Durward's Glen Creek	T11N R8E S08 NE/NW	25 m above bridge at entrance to church property
SSE	PF	Parfrey's Glen Creek	T11N R7E S23 SW/SW	100 m above Hwy DL
SSE	MC	Manley Creek	T11N R7E S28 SE/SW	10 m below Hwy 113
NSE	CH	Cat Hollow Creek	T12N R8E S32 SW/NW	North side of Luebke Road
NSE	RC	Rowley Creek	T12N R7E S35 NE/NW	25 m above Hwy W
NSE	BC	Boulder Creek	T11N R7E S02 NW/NW	25 m above end of Potter Road (UW property)
NSE	113	Unnamed Creek	T11N R7E S07 NE/NW	1st 25 m below Hwy 113
NSE	BB	Babbling Brook Creek	T11N R6E S13 NW/SE	25 m above park road, Devil's Lake State Park
NNE	LC	Leech Creek	T12N R7E S17 SW/NE	200 m above Paschen Road (walk-in)
NSW	SC	Skillet Creek	T11N R6E S04 SE/SW	50 m below Hwy W
NSW	PC	Pine Creek	T11N R6E S17 NE/NW	East of Happy Hill road (walk-in)
NSW	HO	Hoot Owl Creek	T11N R6E S07 NE/NW	50 m above Hoot Owl Road
NSW	LQ	LaRue Quarry Creek	T11N R5E S22 SW/NW	500 m above Quarry Road (walk-in)
NSW	S1	Seeley Creek # 1	T11N R5E S19 NW/SE	Below junction Hwy W & Maple Hill Road
NSW	S2	Seeley Creek # 2	T11N R5E S29 SW/NE	Wilson Road, on tributary to Seeley, confluence below S1
NSW	S3	Seeley Creek # 3	T11N R5E S32 NW/NW	Below Hwy PF, tributary to Seeley, above S1
SSW	HD	Hemlock Draw Creek	T10N R5E S07 NW/NW	Above end of Reich Drive, TNC access
SSW	PE	Pine Hollow Creek	T10N R5E S04 NE/SW	West of Pine Hollow Road (walk-in)
SSW	PN	Pan Hollow Creek	T10N R5E S03 NW/NE	East of Denzer Road (walk-in)
SSW	LP	Leopold Pines Creek	T11N R5E S02 SW/NE	Northeast of Freedom and Hill Top Roads (walk-in)
SSW	MV	Misty Valley Creek	T11N R5E S01 NE/NE	Half mile north Tuckaway Road (walk-in)
SSW	OC	Otter Creek (upstream)	T11N R6E S33 NW/SW	Below 2nd bridge crossing Stones Pocket road
SSW	OC	Otter Creek (downstream)	T11N R6E S33 NW/NW	Above 1st bridge (near parking area), Stones Pocket Road
SSW	PG	Pine Glen Creek	T11N R6E S35 NW/NE	West Burma Road, Devil's Lake State Park (walk-in)
SSW	BH	Bornes Hollow Creek	T10N R4E S11 NW/SE	25 m above Sky View Road

available keys (as listed by Hilsenhoff 1995). Identifications of specimens representing other insect orders generally ceased at the family or genus level. Clams, snails, amphipods, and isopods were also collected and identified, but are not included in this report. The taxa lists for the 24 streams represent a compilation of both the BI samples and the supplementary samples. EPT taxa richness refers to the total number of different taxa (combination of taxonomic levels) represented by the orders Ephemeroptera, Plecoptera, and Trichoptera. These three orders are generally considered sensitive water-quality indicators, where higher values generally suggest better water quality (Plafkin et al. 1989). Total taxa richness refers to the total number of different taxa represented by all aquatic orders present. It should be noted that low EPT and low total taxa ratings may naturally occur in small, pristine headwater streams (Plafkin et al. 1989).

In order to examine spatial relationships among streams according to east-west orientation (i.e., glaciated versus unglaciated) and north-south aspect of drainages, streams were assigned to one of four groups (Figure 1). Leech Creek, which was the only stream representative of the north range, was not grouped with the other streams. Similarities of insect communities among streams were evaluated on the basis of the relative abundance of mayflies, stoneflies, and caddisflies using the Index of Biotic Similarity (Pinkham and Pearson 1976, Pearson and Pinkham 1992) and BIOSIM1 software (Gonzales et al. 1993). Data size limitations with computer software precluded analysis of the entire community. Consequently we chose to base our comparisons using the most sensitive groups (EPT taxa) for which we had the most detailed data. Similarity comparisons were made using a combination of abundances of EPT taxa found in BI and supplemental samples. Similarities were tested both including and excluding rare taxa (i.e., </> five specimens).

Results and Discussion

Streams included in the survey ranged from small, first-order streams, 2–3 ft wide and less than 1 ft deep, to third order streams, over 10 ft wide and up to 2 ft deep (Table 2). Rowley Creek had the most extensive drainage system, consisting of over 8 miles of contributing stream lengths. Excluding Leech Creek, mean width and depth of streams did not differ substantially among the four regions. Conductivity, which ranged from 30 to 340 μmhos cm^{-1}, and pH, which varied from 6.4 to 8.6 units, differed substantially among streams. Conductivities and pH were much reduced in streams draining the unglaciated NSW and SSW regions (Figure 2). Drainage aspect did not have a significant influence on either pH or conductivity within the Baraboo Hills.

This study was limited intentionally to represent the fauna present during a very short time period in the spring of one year. A more exhaustive survey, conducted at different times of the year, naturally would have produced a greater taxa listing. For example, Steven and Hilsenhoff (1984) reported "a minimum of 56 species of caddisflies live in Otter Creek" with 10–14 more species listed as possibly developing in the stream. This value compares with only 12 caddisfly taxa found in Otter Creek in this study. Much of this disparity is likely due to the fact that the former study represented a year long summary that included collected and reared adults. Adult taxonomy is more complete than larval taxonomy; keys to larvae have not been developed for many aquatic species. Consequently, because we

Table 2. Physical and chemical characteristics (with biotic index scores) of 24 Baraboo Hills streams.

Region	Code	Stream Name	Width	Depth (ft.)	Length (miles)	Order (miles)	pH (Units)	Conductivity (µmhos cm^{-1})	Substrates (Codes[a] by %)	Biotic Index Score[b]
SSE	DG	Durward's Glen Creek	8.0	1.0	0.71	1st	8.0	250	R50%-S25%-G25%	3.45
SSE	PF	Parfrey's Glen Creek	6.0	1.0	0.99	1st	8.6	340	R50%-S25%-G25%	4.17
SSE	MC	Manley Creek	9.0	1.5	1.19	2nd	7.6	210	N. D.	4.07
NSE	CH	Cat Hollow Creek	3.0	1.0	0.51	1st	8.0	120	R50%-S25%-T25%	4.61
NSE	RC	Rowley Creek	10.0	1.5	8.11	3rd	7.8	260	S50%-T50%	2.44
NSE	BC	Boulder Creek	7.0	1.0	1.58	2nd	8.0	260	R50%-G50%	2.97
NSE	113	Unnamed Creek (113)	9.0	1.0	2.47	2nd	8.0	270	N. D.	3.12
NSE	BB	Babbling Brook Creek	10.0	1.0	0.99	2nd	7.0	75	B50%-R25%-G25%	3.87
NNE	LC	Leech Creek	2.0	1.0	1.62	1st	8.0	310	G50%-S25%-T25%	5.27
NSW	SC	Skillet Creek	N. D.	N. D.	3.01	2nd	6.6	50	R50%-G25%-S25%	5.36
NSW	PC	Pine Creek	10.0	1.0	2.26	2nd	6.6	35	B50%-R50%	5.04
NSW	HO	Hoot Owl Creek	5.0	1.5	1.11	1st	6.8	75	R25%-T75%	5.19
NSW	LQ	LaRue Quarry Creek	8.0	1.5	1.56	2nd	6.6	40	B50%-R25%-G25%	5.95
NSW	S1	Seeley Creek # 1	8.0	1.5	4.54	3rd	7.2	175	G50%-S25%-T25%	6.20
NSW	S2	Seeley Creek # 2	7.0	1.0	0.82	2nd	6.6	75	R50%-G50%	4.18
NSW	S3	Seeley Creek # 3	5.0	1.0	1.23	1st	6.6	50	RGST-25%	4.57
SSW	HD	Hemlock Draw Creek	8.0	0.5	0.85	1st	6.8	35	R50%-G25%-S25%	5.91
SSW	PE	Pine Hollow Creek	5.0	0.5	0.58	1st	6.6	30	R50%-G25%-S25%	2.67
SSW	PN	Pan Hollow Creek	5.0	1.0	0.51	1st	6.8	30	R75%-G25%	2.74
SSW	LP	Leopold Pines Creek	8.0	1.0	0.66	1st	6.6	60	R50%-G25%-S25%	4.56
SSW	MV	Misty Valley Creek	7.0	1.0	0.67	1st	6.4	50	G50%-S25%-T25%	2.50
SSW	OC	Otter Creek (upstream)	12.0	2.0	1.35	2nd	6.6	50	R50%-G25%-S25%	3.85
SSW	OC	Otter Creek (downstream)	12.0	2.0	1.66	2nd	6.6	50	R50%-G25%-S25%	2.57
SSW	PG	Pine Glen Creek	7.0	1.0	0.59	1st	6.4	32	K50%-B50%	3.95
SSW	BH	Bornes Hollow Creek	9.0	0.5	1.06	1st	7.6	160	R50%-G50%	4.81

[a]Substrate Codes: K = bedrock, R = rubble, B = boulders, G = gravel, S = sand, T = silt, N.D. = no data.

[b]After Hilsenhoff (1987): water quality ratings "excellent" = < 3.50, "very good" = 3.50–4.50, "good" = 4.50–5.50, "fair" = 5.50–6.50.

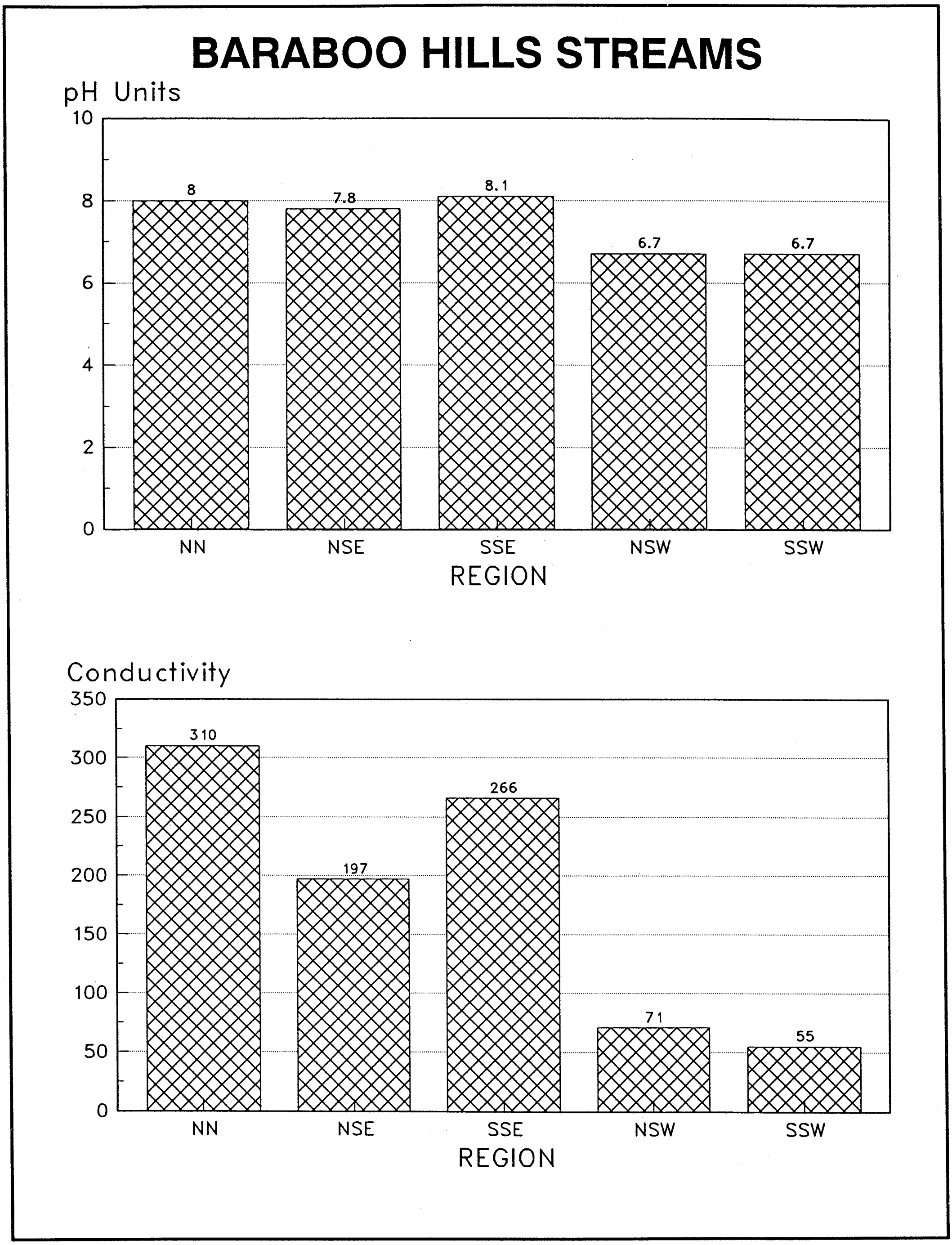

Figure 2. Mean pH (in pH units) and conductivities (in µmhos cm^{-1}) of streams within different regions of the Baraboo Hills.

had only larvae to work with, our taxa lists likely were incomplete. Although our measure of taxa richness (representing the April community) is not comparable to more extensive examinations of stream fauna, relative comparisons of taxa richness among the 24 streams are informative. Total taxa richness ranged from as few as 14 in Hoot Owl Creek to as many as 59 in Otter Creek (Figure 3). EPT richness ranged from a minimum of 2 in Hoot Owl Creek to a maximum of 32 in Otter Creek. The average Baraboo Hills stream, excluding Otter Creek, contained 22 total taxa and 9 EPT taxa. Neither EPT nor total taxa richness appeared to be related to the spatial position of the streams in the Baraboo range. The eastern, glaciated streams (SSE and NSE) generally tended to support more taxa than the western, unglaciated streams, but the differences were not significant. The SSE streams had more caddisflies (mean 7.7 taxa) than other streams, and the SSW streams had a greater number of stonefly taxa (mean 3.9 taxa) than the remaining stream groups. The latter difference was due, in part, to the influence of Otter Creek (without Otter Creek the SSW streams had a mean of 3.0 stonefly taxa). Leech Creek contained only caddisflies (among EPT taxa) with no mayflies or stoneflies present, and Manley Creek contained only one mayfly taxon and eight caddisfly taxa (Table 3). Not coincidentally perhaps, the four streams containing the fewest EPT taxa were located in the NSW region. No obvious patterns were evident in the relationships between taxa richness (either EPT or total) and stream physical characteristics, including stream order, width, depth, and aggregated stream length.

Water quality of the Baraboo Hills streams, based on BI values, ranged from excellent to only fair (Table 2). In the Hilsenhoff Biotic Index system (Hilsenhoff 1987), the lower the BI value, the better the water quality is. More than half of the streams received a rating of very good or excellent. Rowley Creek (BI = 2.44) ranked best among the 24 streams, while Seeley Creek # 1 (BI = 6.20) had the worst ranking. Water quality (BIs) was not influenced substantially by stream position (Figure 4). However, the three streams with the lowest ratings (fair) were located in the unglaciated western end of the Baraboo Hills, where agricultural land use was high and nutrient inputs would be assumed to be higher than predominantly forested watersheds (Panuska and Lillie 1995). As a group, the Baraboo Hills streams have a much better rating than the majority of southern Wisconsin streams.

The EPT fauna in the 24 Baraboo Hills streams were quite diverse (Table 3). Combining the data for all streams, 18 mayfly, 12 stonefly, and 25 caddisfly taxa were present during the sampling period of late April 1992. EPT fauna generally exhibited a high degree of similarity among streams (Figure 5). Four distinct complexes were evident based on the cluster analysis (Figure 6). The first complex was composed of three adjacent glaciated streams located at the far eastern edge of the Baraboo Hills. These included Rowley Creek, Boulder Creek, and Durward's Glen Creek. These streams were more similar to one another in their EPT fauna than to all other Baraboo Hills streams. These streams had excellent water quality ratings and were characterized by *Baetis tricaudatus* Dodds, *Ephemerella subvaria* McDunnough, *Isoperla signata* Banks, *Ceratopsyche slossonae* (Banks), and *Neophylax* spp. The second complex consisted of another set of nearby eastern glaciated streams, namely Parfrey's Glen Creek, Manley Creek, Leech Creek, and the unnamed creek that crosses Hwy 113 south of Baraboo. These streams drained glaciated

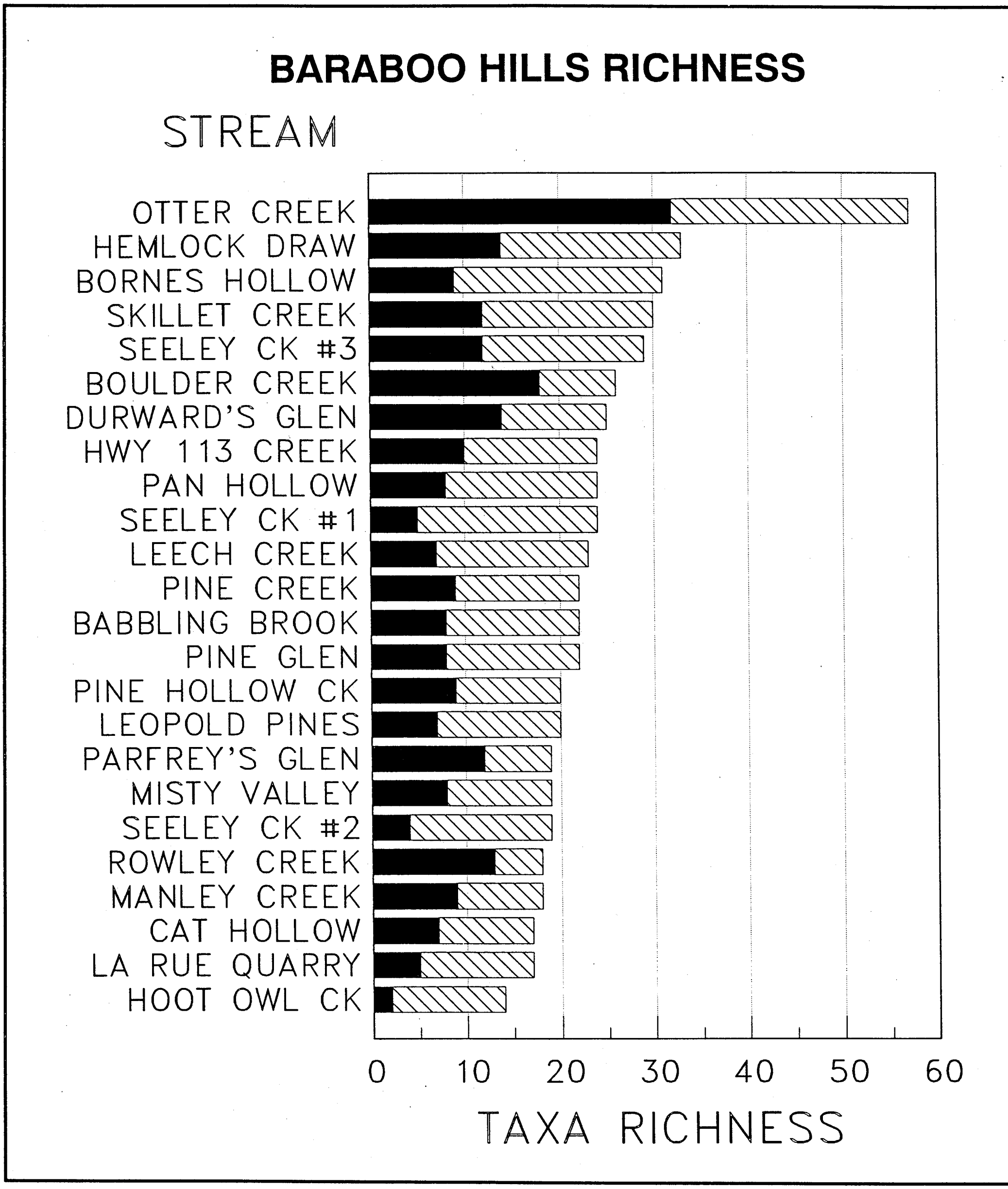

Figure 3. Total taxa richness and EPT taxa richness (dark bars) in 24 Baraboo Hills streams during April 1992. Streams are ranked from highest to lowest richness.

portions of the Baraboo Hills and were characterized by lower numbers of *Ceratopsyche slossonae* and *Cheumatopsyche* spp., with relatively little else in common. These streams exhibited a wide range in BIs and exhibited only a moderate taxa richness, and yet they were more similar to one another than to other Baraboo Hills streams. Skillet Creek, Bornes Hollow Creek (a Honey Creek tributary), and Seeley Creek # 3 formed a third

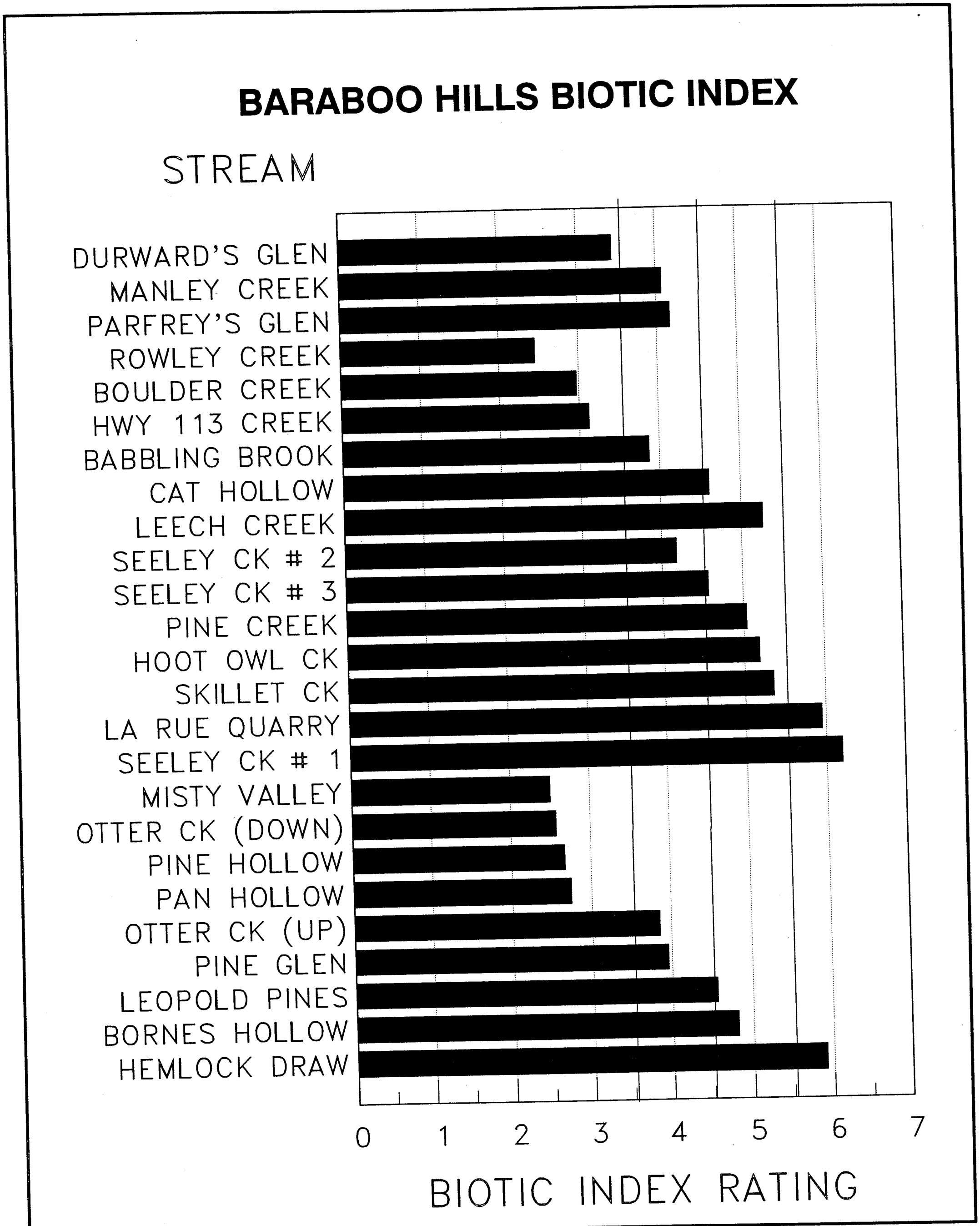

Figure 4. Biotic index values for 24 Baraboo Hills streams arranged by order within regions (SSE, NSE, NN, NSW, and SSW), based on April 1992 data (note: Otter Creek upstream and downstream data are reported separately).

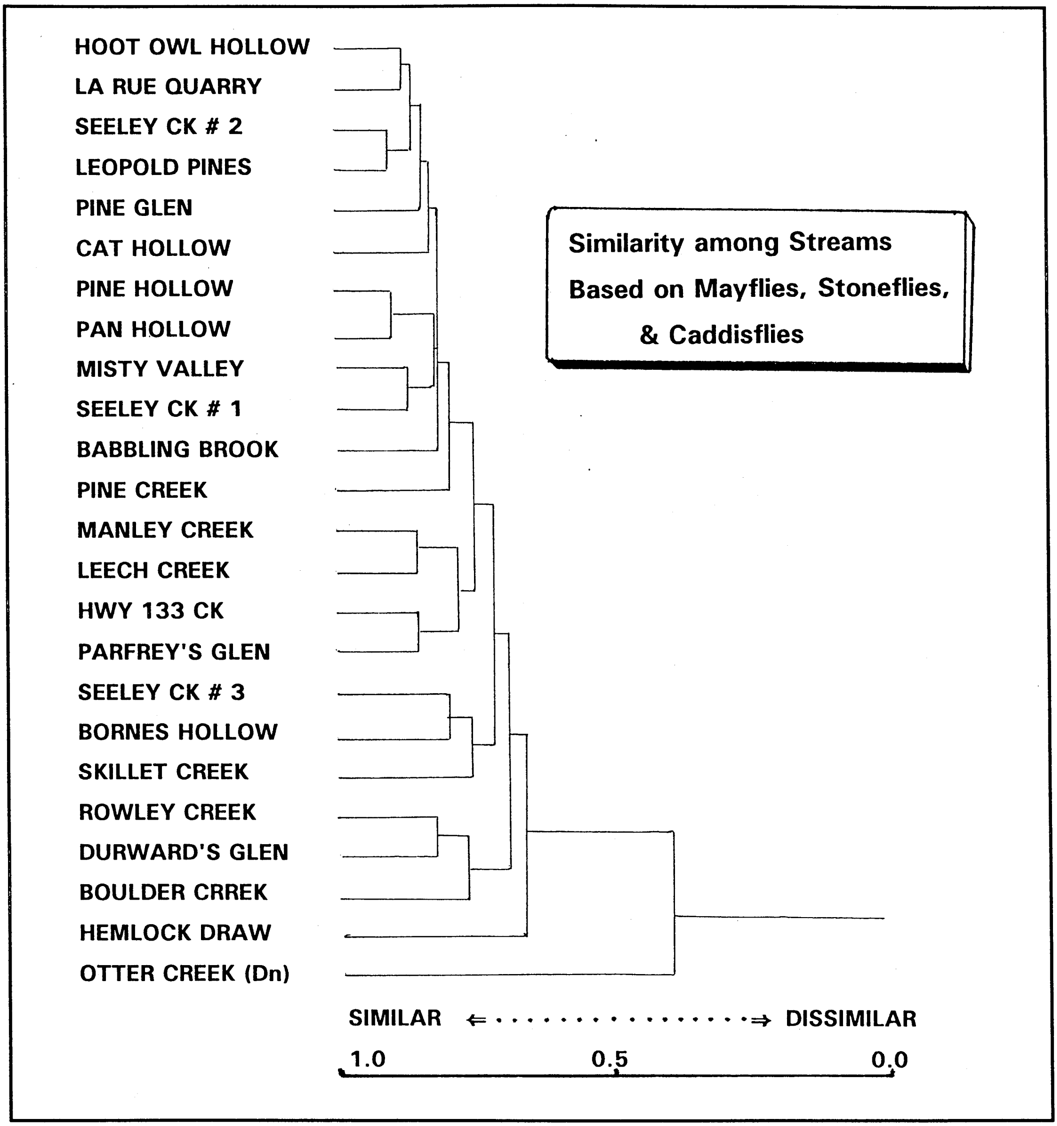

Figure 5. Cluster dendogram created by BIOSIM1 (Gonzales et al. 1993) showing degree of similarity among 24 Baraboo Hills streams based on the relative abundances of mayflies, stoneflies, and caddisflies in each stream.

complex of streams that may be best characterized as having good water quality, but containing a slightly greater amount of sand-silt substrate than is typical for the Baraboo Hills. The insect community in this group of streams was characterized by the presence of *Caenis* spp. (a mayfly genus that is often associated with silts and sands), along with *Stenonema vicarium* (Walker), leptophlebiid mayflies, and *Chimarra aterrima* Hagen. A large group of 12 streams, among which existed many strong subassociations, formed a fourth complex (Figure 6). These streams exhibited a wide gradient in water quality

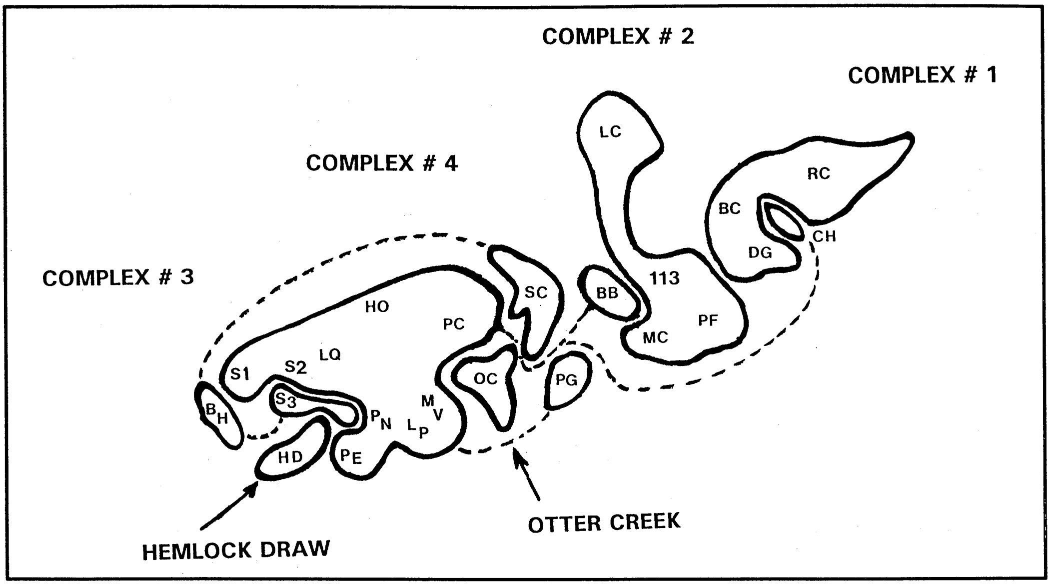

Figure 6. Complexes of streams in the Baraboo Hills based on similarities in springtime EPT fauna as determined by analysis of BIOSIM1 results shown in Figure 5.

and were predominantly positioned in western unglaciated watersheds. One eastern stream, Cat Hollow Creek, a tributary to Rowley Creek, appeared to be an anomaly. The sampling site on Cat Hollow Creek was just downstream from a heavily grazed pasture. Organic loadings from the pasture may have contributed to its higher than average BI for the region and partially explain its dissimilar (to the adjacent streams) EPT fauna. Quite interestingly, this large cluster of streams also included Babbling Brook Creek and Pine Glen Creek which, although draining watersheds adjacent to streams from complex # 2, are also unglaciated. Therefore, the EPT fauna clearly differentiate between the glaciated-unglaciated divide. This finding is consistent with other studies that indicate the productive capacity of streams may be a direct function of water chemistry, which is largely controlled by a combination of geology and land use (Koetsier et al. 1996). Conversely, north-south drainage aspect of watersheds did not appear to have influenced EPT faunal compositions of the Baraboo Hills streams.

Two streams, Hemlock Draw Creek and Otter Creek, were quite dissimilar to the remaining 22 streams (Figure 6). Although Hemlock Draw had a relatively high BI, it supported a relatively high taxa richness. The extremely high number of *Baetis flavistriga* McDunnough (=*Labiobaetis flavistriga* per McCafferty and Waltz 1995) in the sample may have unduly influenced the similarity assessment. Although no obvious source of organic inputs to the stream was visible at the time of sampling, manure spread on the fields adjacent to the stream at other times of the year may have contributed to the observed high BI value. Therefore, further examination of the fauna of Hemlock Draw Creek at other times of the year is desirable. Otter Creek contained a rich, diverse assortment of aquatic insects, with large numbers of the mayflies *Ephemerella subvaria* and

Paraleptophlebia spp., the caddisfly *Neophylax* spp., and representatives of ten stonefly taxa, in addition to numerous other taxa. Otter Creek is a unique resource habitat in southern Wisconsin in that it represents the largest, exclusively forested watershed stream in the southern half of the state. As such, this stream serves as an excellent benchmark or reference (i.e., least impacted) stream for comparing conditions in other streams of the Baraboo Hills.

Of the dozen or so aquatic insect species listed as rare, threatened, endangered, or of special concern that have been recorded previously from the Baraboo Hills (WDNR, Bureau of Endangered Resources, Natural Heritage Inventory files, Madison), we collected only two listed species during our short investigation. Six specimens of the caddisfly *Wormaldia moestus* (Banks) were recovered from Pine Glen Creek, and single specimens of what are believed to be the stonefly *Zealeuctra narfi* Ricker & Ross were found in Otter Creek, Pine Hollow Creek, and Leopold Pines Creek. Previously, *Z. narfi* (as adults) had been collected in Wisconsin only from the shores of Otter Creek (Narf and Hilsenhoff 1974). Dr. W. Hilsenhoff has collected *W. moestus* from Pine Glen Creek (=Pine Hollow on some maps) on Badger Ordinance property downstream from our collection site, and reports additional collections from Florence, Forest, Marinette, and Price counties (W. Hilsenhoff, pers. comm.).

Conclusions

Much effort has been expended in protecting portions of the Baraboo Hills over the last 100 years, including the creation of Devil's Lake State Park and Baxter's Hollow Nature Conservancy Preserve, along with 18 other protected areas. However, increased demands for rural property, mining interests, and highway expansion threaten the biological diversity of the Baraboo Hills region or threaten to further fragment existing habitat and inflate land prices. Consequently, future efforts to preserve habitat within the Baraboo Hills (whether by direct purchase or lease agreements) should be carefully directed and prioritized to maximize the benefits to the public for the least cost. Inasmuch as aquatic insects serve as excellent indicators of water quality and the water quality of a stream reflects the combined influences of geology, soils, vegetation, and land use within its respective watershed, examination of aquatic insect communities provides a means to rapidly assess the biological integrity and "uniqueness" of a particular watershed relative to adjacent watersheds. Based on this limited study of the aquatic insect communities of 24 streams, the following recommendations are offered. Every effort should be made to prevent further watershed degradation because streams in the Baraboo Hills generally contain better than average water quality and harbor several rare taxa. Future preservation efforts should include the glaciated eastern watersheds that represent habitats different from those currently receiving protection in the unglaciated western watersheds of the Baraboo Range. Further investigations are warranted in the case of Hemlock Draw Creek, although it is quite possible that the relatively high BI value observed in this survey may have been an anomaly.

This study has documented the potential application of using stream water quality indicators in prioritizing future conservation efforts in the Baraboo Hills and elsewhere. More specifically, we have presented evidence that the degree of dissimilarity among stream insect communities is related to differences in landscape features.

Table 3. Total insects collected from 24 Baraboo Hills streams during April 1992. Numbers represent the sum of insects collected in the biotic index samples and supplementary samples (note: in most cases, Diptera were not identified below family level in the latter sets of samples. Therefore, numbers of Diptera are underrepresented relative to EPT taxa in this table).

	REGION and STREAM[a]																							
	SSE			NSE					NNE	NSW							SSW							
TAXA	DG	PF	MC	CH	RC	BC	113	BB	LC	HO	LQ	SC	PC	S1	S2	S3	HD	PE	PN	LP	MV	OC	PG	BH
EPHEMEROPTERA (Mayflies)																								
AMELETIDAE																								
Ameletus lineatus Traver	0	0	0	0	0	0	0	16	0	0	4	0	0	0	1	0	0	22	43	104	51	0	13	0
BAETIDAE																								
Acerpenna macdunnoughi (Ide)	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1
Baetis brunneicolor McDunnough	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Baetis flavistriga[b] McDunnough	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	157	0	0	0	0	7	0	0
Baetis tricaudatus Dodds	29	42	0	14	24	169	112	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Centroptilum alamance (Traver)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
CAENIDAE																								
Caenis spp.	0	0	0	0	0	0	0	0	0	0	0	12	0	1	0	2	0	0	0	0	0	0	0	5
EPHEMERELLIDAE																								
Ephemerella invaria (Walker)	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemerella needhami McDunnough	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Ephemerella subvaria McDunnough	46	0	0	0	45	73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62	0	0
Eurylophella temporalis (McDunnough)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
HEPTAGENIIDAE																								
Leucrocuta hebe (McDunnough)	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0
Stenacron interpunctatum (Say)	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	5	0	0	0	0	0	4	0	0
Stenonema femoratum (Say)	0	0	0	1	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0
Stenonema vicarium (Walker)	2	0	13	0	30	6	16	0	0	0	0	17	0	0	0	20	5	0	0	0	0	9	0	15
LEPTOPHLEBIIDAE																								
(unidentified)	0	0	0	0	0	3	0	0	0	0	1	8	5	1	0	20	0	0	0	0	0	35	0	7
Leptophlebia spp.	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0
Paraleptophlebia spp.	1	1	0	0	0	19	0	0	0	0	0	5	0	0	0	0	14	0	0	0	0	59	1	0
SIPHLONURIDAE																								
Siphlonurus spp.	0	0	0	0	0	0	0	0	0	0	64	0	0	0	5	0	0	4	5	119	0	0	0	0

[a]Please refer to Figure 1 and Table 1 for codes and locations.
[b]Now placed in genus *Labiobaetis* per McCafferty and Waltz (1995).

TAXA	SSE			NSE					NNE	NSW							SSW							
	DG	PF	MC	CH	RC	BC	113	BB	LC	HO	LQ	SC	PC	S1	S2	S3	HD	PE	PN	LP	MV	OC	PG	BH
PLECOPTERA (Stoneflies)																								
CAPNIIDAE																								
Allocapnia spp.	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
Paracapnia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0
LEUCTRIDAE																								
Leuctra spp.	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	1	2	0	0	1	5	0
Zealeuctra narfi Ricker & Ross	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0
NEMOURIDAE																								
Amphinemura delosa (Ricker)	0	56	0	2	0	30	30	18	0	0	2	0	30	0	53	7	60	16	18	36	10	2	39	0
Nemoura trispinosa Claassen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0
Prostoia similis (Hagen)	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	2	2	0	2	0	8	5	0	0
PERLIDAE																								
Acroneuria lycorias (Newman)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0
Paragnetina media (Walker)	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
PERLODIDAE																								
Clioperla clio (Newman)	2	4	0	0	0	1	0	2	0	0	0	0	0	1	0	1	7	3	3	0	10	1	0	0
Isoperla cotta Ricker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Isoperla dicala Frison	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0
Isoperla signata (Banks)	4	0	0	0	14	5	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
TAENIOPTERYGIDAE																								
Taeniopteryx sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0
TRICHOPTERA (Caddisflies)																								
BRACHYCENTRIDAE																								
Brachycentrus occidentalis Banks	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micrasema gelidum MacLachlan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Micrasema rusticum (Hagen)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
GLOSSOSOMATIDAE																								
Glossosoma spp.	23	4	0	0	14	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0
HELICOPSYCHIDAE																								
Helicopsyche borealis (Hagen)	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0

*Represents taxa that are known to occur in the stream based on collections by the authors on other sampling dates.

Table 3, continued.

	REGION and STREAM[a]																							
	SSE			NSE					NNE	NSW							SSW							
TAXA	DG	PF	MC	CH	RC	BC	113	BB	LC	HO	LQ	SC	PC	S1	S2	S3	HD	PE	PN	LP	MV	OC	PG	BH
TRICHOPTERA (Caddisflies), cont.																								
HYDROPSYCHIDAE																								
Ceratopsyche alhedra/sparna (Ross)	0	0	0	0	5	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
Ceratopsyche slossonae (Banks)	74	2	1	0	20	35	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	12	0	7
Cheumatopsyche spp.	24	1	4	0	12	5	2	0	2	0	0	2	0	2	0	1	0	0	0	0	0	0	0	5
Diplectrona modesta Banks	3	9	0	2	0	1	0	0	0	0	0	0	0	0	0	0	1	10	0	0	0	1	0	0
Hydropsyche betteni Ross	3	0	5	0	2	0	2	0	11	0	0	0	0	0	0	1	4	0	0	0	0	0	0	1
LEPIDOSTOMATIDAE																								
Lepidostoma spp.	0	2	0	0	0	8	0	0	2	4	0	0	0	0	0	0	1	0	0	0	0	17	25	0
LEPTOCERIDAE																								
Nectopsyche sp. (small)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oecetus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
LIMNEPHILIDAE																								
Anabolia spp.	0	0	0	0	0	0	0	0	0	2	6	0	2	0	0	0	0	0	0	0	3	0	0	0
Frenesia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0	0	0	0	0	0
Hesperophylax designatus (Walker)	0	0	0	0	0	0	0	1	0	0	0	0	1	0	3	0	2	10	0	6	0	0	0	0
Ironoquia spp.	0	0	0	0	0	0	0	2	0	0	9	0	1	0	0	0	1	0	4	12	0	0	5	0
Pseudostenophylax uniformis (Betten)	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	5	0	0
Pycnopsyche spp.	10	1	2	0	1	1	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	12	0	0
PHILOPOTAMIDAE																								
Chimarra aterrima Hagen	0	0	4	0	2	0	0	0	0	0	0	6	0	0	0	2	3	0	0	0	0	5	0	2
Dolophilodes distinctus (Walker)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wormaldia moestus (Banks)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0
POLYCENTROPODIDAE																								
Paranyctiophylax sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
PSYCHOMYIIDAE																								
Psychomyia flavida Hagen	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RHYACOPHILIDAE																								
Rhyacophila vibox Milne	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UENOIDAE																								
Neophylax spp.	4	6	14	4	21	13	1	0	0	0	0	2	7	1	0	2	0	18	3	0	3	25	24	0

TAXA	SSE			NSE					NNE	NSW							SSW							
	DG	PF	MC	CH	RC	BC	113	BB	LC	HO	LQ	SC	PC	S1	S2	S3	HD	PE	PN	LP	MV	OC	PG	BH
COLEOPTERA (Beetles)																								
DYTISCIDAE																								
(unidentified)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Agabus sp. (larva)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
DRYOPIDAE																								
Helichus striatus LeConte	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1
ELMIDAE																								
Dubiraphia spp. (larvae)	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Dubiraphia minima Hilsenhoff	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Optioservus spp. (larvae)	16	11	15	2	15	7	12	1	4	0	0	8	0	0	0	1	6	1	0	0	1	2	4	1
Optioservus fastiditus LeConte	2	5	8	0	7	*	5	0	0	0	0	4	0	0	0	1	*	0	0	0	1	1	1	0
Stenelmis spp. (larvae)	1	0	1	0	0	0	0	1	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
Stenelmis crenata (Say)	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
PSEPHENIDAE																								
Ectopria nervosa (Melsheimer)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
ODONATA (Dragonflies)																								
AESHNIDAE																								
Boyeria vinosa (Say)	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0
CORDULEGASTERIDAE																								
Cordulegaster spp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*	0	0
MEGALOPTERA (Fishflies & Alderflies)																								
CORYDALIDAE																								
Nigronia serricornis (Say)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0
SIALIDAE																								
Sialis spp.	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	*	0	0	0	0	*	0	0
DIPTERA (Flies & Midges)																								
ATHERICIDAE																								
Atherix variegata Walker	0	0	0	0	2	5	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0
CERATOPOGONIDAE																								
Ceratopogon culicoidithorax	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0
Bezzia/*Palpomyia* spp.	0	0	0	0	0	0	0	0	1	0	2	0	0	1	0	0	6	0	0	0	1	0	1	3
Probezzia spp.	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	2	0	0	0	1	1	0	0

*Represents taxa that are known to occur in the stream based on collections by the authors on other sampling dates.

Table 3, continued.

TAXA	REGION and STREAM[a]																							
	SSE			NSE					NNE	NSW							SSW							
	DG	PF	MC	CH	RC	BC	113	BB	LC	HO	LQ	SC	PC	S1	S2	S3	HD	PE	PN	LP	MV	OC	PG	BH
DIPTERA (Flies & Midges), cont.																								
CHIRONOMIDAE (Midges)																								
Chaetocladius sp. A	0	15	2	3	0	3	36	0	20	20	4	7	10	6	1	3	25	2	2	0	1	7	0	8
Chaetocladius sp. C	0	0	0	2	0	0	0	6	0	1	6	17	1	0	0	0	0	0	0	1	0	0	0	0
Cladotanytarsus sp. B	0	0	0	0	0	0	0	0	139	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conchapelopia spp.	0	0	0	1	0	0	0	0	1	0	0	0	0	3	0	2	0	0	0	9	0	0	1	4
Corynoneura sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Cricotopus spp. undetermined	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Cricotopus sp. A	0	0	0	0	0	0	0	0	0	1	0	1	2	5	0	2	1	0	0	0	0	0	0	0
Cricotopus sp. C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Cricotopus sp. D	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2
Cricotopus nr. *bicinctus* (Meigen)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Cricotopus nr. *intersectus*	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diamesa spp.	17	4	3	26	0	7	1	0	14	0	2	1	3	1	0	14	18	7	6	1	5	16	1	4
Dicrotendipes spp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Diplocladius spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	4	0
Eukiefferiella sp. A	0	0	0	0	0	0	0	6	0	0	1	6	16	1	10	7	12	2	8	5	3	3	20	3
Eukiefferiella sp. B	0	0	0	0	3	7	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Hydrobaenus spp.	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Limnophyes spp.	1	5	3	0	0	0	3	1	0	0	0	0	0	8	1	0	5	0	0	1	0	3	2	2
Micropsectra spp.	1	0	0	0	0	0	1	4	0	1	1	4	0	29	0	2	17	4	17	1	0	9	33	4
Microtendipes spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	1
Natarsia spp.	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Orthocladinae undetermined	0	1	0	2	0	3	0	7	0	1	1	5	8	1	2	2	22	1	0	2	3	4	5	0
Orthocladius sp. B	0	0	0	5	0	1	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	7
Orthocladius sp. C	0	0	0	0	0	0	0	23	0	0	1	2	0	0	18	0	1	1	1	6	1	0	8	0
Orthocladius sp. D	0	31	0	57	0	4	1	7	3	6	0	8	1	17	1	14	0	0	0	0	0	22	0	1
Orthocladius sp. E	0	0	0	0	0	0	0	0	0	16	0	5	8	0	0	0	35	0	0	0	6	2	0	2
Paracladopelma sp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paratendipes spp.	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0

TAXA	SSE			NSE					NNE	NSW							SSW							
	DG	PF	MC	CH	RC	BC	113	BB	LC	HO	LQ	SC	PC	S1	S2	S3	HD	PE	PN	LP	MV	OC	PG	BH
Polypedilum nr. *convictum* (Walker)	0	0	5	1	0	0	0	0	23	2	0	0	0	0	0	0	0	0	0	0	0	7	0	1
P. nr. *fallax* (Johannsen)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. nr. *halteralis* (Coquillett)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
P. nr. *scalaenum* (Schrank)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Prodiamesa spp.	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rheocricotopus spp.	0	0	0	0	0	0	0	2	0	5	0	0	0	0	0	2	15	0	1	1	0	0	9	2
Rheotanytarsus spp.	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0
Synorthocladius sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Tanytarsus spp.	0	0	0	2	0	0	0	1	1	0	1	0	1	0	0	0	11	1	1	0	3	1	1	0
Thienemanniella spp.	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0
Thienemannimyia complex	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tvetenia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
DIXIDAE																								
Dixa sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
DOLICHOPODIDAE (undetermined)	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EMPIDIDAE																								
Chelifera spp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
Hemerodromia spp.	0	0	0	0	0	0	0	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SIMULIIDAE (Black flies)																								
(undetermined)	1	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Greniera denaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Prosimulium decemarticulatum (Twinn)	0	0	0	0	0	0	0	0	0	0	1	0	0	2	1	0	0	0	0	0	0	0	1	0
P. fuscum Syme & Davies	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P. gibsoni (Twinn)	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	1	0	0	0	0	0	0	0	0
P. magnum Dyar & Shannon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0
P. mixtum Syme & Davies	0	0	0	0	0	0	1	27	0	0	1	0	10	0	19	0	9	6	1	3	0	0	27	0
P. multidentatum (Twinn)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	1	0	0	0
P. mysticum Peterson	0	0	0	0	0	0	1	1	0	0	0	1	4	0	3	3	1	2	38	1	2	10	2	0
Simulium fibrinflatum Twinn	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S. longistylatum Shewell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
S. verecundum Stone & Jannback	0	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
S. vittatum Zetterstedt	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Stegopterna mutata Malloch	0	0	0	0	0	0	0	1	0	0	3	0	1	2	32	0	0	0	0	0	0	0	0	0

Table 3, continued.

TAXA	SSE			NSE				NNE	NSW						SSW							
REGION and STREAM[a]	*DG*	*PF*	*MC*	*CH*	*RC*	*BC*	*113*	*BB*	*LC*	*HO*	*LQ*	*SC*	*PC*	*S1*	*S2*	*S3*	*HD*	*PE*	*PN*	*LP*	*MV*	*OC*	*PG*	*BH*
DIPTERA (Flies & Midges), cont.																								
TIPULIDAE																								
Antocha spp.	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
Dicranota spp.	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	*	0	1	0	0	0	0	0
Helius sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Hexatoma spp.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Limnophila spp.	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	2	0	0
Pedicia spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	*	0	0
Pilaria spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	6	0	3
Pseudolimnophila spp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Tipula spp.	1	5	1	0	3	12	1	0	0	0	0	0	1	0	0	1	7	0	0	0	2	4	0	1
STRATIOMYIDAE																								
Oxycera sp.	0	0	0	0	0	*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TABANIDAE																								
Chrysops spp.	2	1	0	3	0	*	1	0	0	0	0	1	0	1	0	1	*	0	0	0	0	1	0	1
Tabanus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

*Represents taxa that are known to occur in the stream based on collections by the authors on other sampling dates.

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Susan Talbot-Stanaway

When you can't see the forest for the folks: Late 19th/Early 20th century Wisconsin photographs of outdoor leisure activities

Picnics, camping, recreational fishing and hunting, boating, swimming, bicycling, and backroads motoring became extremely popular leisure pastimes for Wisconsin residents by the second decade of the 20th century. Annual vacations, free time on weekends, and increased discretionary income made these rough-and-ready pleasures accessible to the middle class as well as to the wealthy. Better roads, reliable bicycles and motorcars, and ready-made outdoors gear, like tents and campstoves, made long ventures to woods and shore possible with reasonable comfort. Fishing expeditions, such as the one some Green Bay businessmen made to the Thunder River in 1889 (Figure 1), were especially popular.

Social historians tell us that nature was seen as a tonic and remedy for the stresses and anxieties of modern life. The commercialized, industrialized city and town were where one lived, where one went to school and work, where one's ambitions, babies, and bank accounts flourished, but the woods and streams were sustenance for the spirit. Henry David Thoreau, and nearly everyone since, had told Americans to simplify their lives, to be free, within the restorative bosom of nature. And, we are told, by the early 20th century, bits and pieces of surviving American wilderness were universally perceived to be the wellsprings of the nation's unique history and pride (Braden, 315–17; Miller, 113–14, 118).

On Sunday afternoons in May in the late 1880s, much of the population of boisterous, thriving Green Bay could be

Figure 1. Fishing camp on the Thunder River, 1889, unknown photographer. Collection of the Neville Public Museum.

found picnicking near the Bay shore or along Baird Creek with the family; in the August heat, many of these same families camped and feasted with friends at the edge of a cool northern forest (Figure 2). Family albums record the process of packing the carriage or wagon to bursting with necessities and people, roadside stops and misadventures, and the campout or picnic achieved and enjoyed. We must suppose that everyone went home sunburned, perhaps dyspeptic, but soothed. Men's fraternal societies, in particular. seemed to gather with bottles, kegs, photographer, and booyah kettles near the beach to hold their summer meetings[1] (Figure 3).

[1]Booyah is a stew of Belgian ethnic origin, still popular in Brown and Door Counties, prepared in a large kettle, preferably over an open fire. Early photographs are labeled "making bouillon."

The following study explores the composition and meaning of such photographs of outdoor recreation in northeastern Wisconsin dating between about 1890 and 1920. Neville Public Museum photographic collections include almost 200 images from this time and in this theme and served as the venue for study. The images were gleaned from family albums and personal collections donated to the museum; the identity of the photographer, in almost every case, is unknown. Popular photographs, such as these, offer many opportunities for study and interpretation that are not present in professional, commercial work.

A professional or serious amateur photographer might have documented ceremonial occasions such as hunting camps or family picnics, but simplified cameras and roll film, available at the conclusion of the 1880s, al-

Figure 2. "Camping Party Down the Bay, 1889," unknown photographer. Collection of the Neville Public Museum.

lowed almost everyone to record their fresh-air fun, and they did. By the fall of 1889, the year George Eastman of Rochester, New York, had introduced the No. 2 Kodak camera, 5,000 cameras had been sold, and the company's photoprocessing-by-mail service was already printing 6,000 to 7,000 negatives daily. Eastman declared, "You Press the Button, We Do the Rest" (Ford, 62). Within the decade, Americans embraced the most popular of popular arts—snapshot photography.

Photography had begun sixty years earlier as a chemical-mechanical process for making likenesses of people, places, and momentous events. Photographs were perceived as mirrors which gave permanence and portability to transient appearances. As portraits they could capture the charms of a sweetheart, the pride of a father with offspring grouped around him, or the ravages of responsibility, as in Alexander Gardner's image of Lincoln made four days before his assassination. For all the centuries of human history, portraits had been available only to the wealthy, who could commission them from artists. This new technological marvel was incredibly compelling.

However, in addition to skill and talent, making daguerreotypes (1830s–1850s) and wet processes on glass plates (1850s–1870s) required expensive, time-consuming, sometimes hazardous procedures, which were quite mysterious to the average person. Cameras were large and clumsy, and a variety of equipment was also needed—so was a studio or at least a sizeable wagon. Lengthy exposure times required the subject to hold very, very still. Indeed, the transcription of reality through early photography was a se-

Figure 3. Men's fraternal society outing, Green Bay vicinity, about 1890, unknown photographer. Collection of the Neville Public Museum.

rious, impersonal business which lent itself to solemn likenesses, Civil War battlefields, Western scenic wonders, and European architectural masterpieces. The interposition of the photographer's aesthetic and social attitudes and beliefs was largely unrecognized and would remain so until the pictorialists, like Stieglitz and Weston, rejuvenated the artistic, expressive elements of photography during the first two decades of the present century.

For most people, however, George Eastman's cheap, sturdy, hand-held cameras and roll films instigated a visual revolution. Photography became accessible, personal, less formal, often autobiographical, though the amateur camera enthusiast was largely unaware of the subjectivity of selection, focus, and framing.

Now it is easy to look at old photographs, particularly vintage snapshots, and dismiss them as mildly amusing records of appearances only, of the mere look of people, places, and things. We are struck by the differences and then reassured by the sameness of human behavior. But reading a photograph is like reading a letter or a diary in which the descriptions are particularly vivid. Like letters and diaries, photographs are singular social and cultural documents, whose texts contain an amazing variety of information. Popular photographs are important because they are expressions of popular beliefs and attitudes and hence can be read to discern these beliefs. As one photographic historian wrote recently, "Unconcerned with posterity or the public, the amateurs' only frame of reference was themselves. When they recorded people or things they did so in a manner that emphasized their personal, not public meaning" (Greenough, 131). Thus when we read these photographs of Wisconsin people surrounded by the tall trees and limpid waters of bountiful Wisconsin nature, we can inventory objects and gestures and interpolate how average people used nature and even how they felt about it. Even more important, popular photographs were shared and treasured, often displayed within the home, and handed down to subsequent generations. In an era when images were still seen as special and meaningful, they served as sources of values and models for private and public behavior, as well as photographic decorum and strategies.

Within this group of popular photographs, especially the images made before 1900, it seems that nature has been occupied as a temporary locus for civilized pleasures; the natural environment of woods and lakeshore appears merely as a cluttered stage or fuzzy backdrop for social rituals or a narrow enframing border for a group portrait. Almost all of the photographs are people pictures, in which the appearance and activities of the subjects are clear, but the setting or locale is only acknowledged by segments of tree trunks, indications of the leafy canopy, or a perimeter section of meadow or beach and sky. Photographs of individuals or even couples in a natural setting are rare; rather, clusters of people occupy the central two-thirds to three-quarters of images. These groups of people are placed well in front of manifestations of nature, and, in most cases, they are placed with a tent, lake cabin, or some other important article of domestic comfort between them and nature. Clearly, as if a line had been drawn, the people are here, and the uncivilized landscape is out there, safely along the periphery of the occasion.

Indeed, the people are not just here having their photo taken; first they have structured the beach or clearing and set up housekeeping. A spotless cloth or blanket has been laid upon the grass; baskets, bottles, and bowls are laid out and around. Other implements hang from tree branches. In Figure 3, the men's hats, coats, ties, and spotless and carefully buttoned shirts seem more appropriate for an urban lodge hall than a clearing in the woods. Occasionally, photographs like Figure 4, a holiday group at Baird's Creek, near Green Bay, in 1889, can be found that show people looking at nature, together, as a group, sharing a picturesque prospect and, we expect, the mosquitoes. But these photographs are still really about the people (who were dutifully trying to look like they were communing with nature) and not *about* nature itself or about human relationships with nature.

The kind of photographs we love to take—unsullied views in which we scramble to eliminate the presence of pesky fellow nature-lovers, road signs, litter, telephone poles, and other evidence of infringing modern blight, or at least show the wonders of nature big and the people smaller—are almost entirely absent. We seem to need to affirm that we saw unspoiled nature in secrecy or in company restricted to selected nuclear family members. Certainly some Wisconsin people of a few generations ago collected trophy views of scenic wonders, but mostly they preferred to revel in nature *en masse,* with lots of civilized stuff along, and if they saw nature as a source of beauty or inspiration, they didn't find it necessary to snap a picture of their inspiration to take home to Aunt Wilma and Uncle Fred and paste in the family album next to the one of Cousin Louis hanging upside down from the tree branch. Family albums are full of photographs of silly Cousin Louis; images of pure scenery are few and far between amongst the black paper pages.

Figure 4. Outing at Baird's Creek, Green Bay, 1889, unknown photographer. Collection of the Neville Public Museum.

These photographs, just like ours, were carefully deliberate. Since the viewfinder on early hand-held cameras was not very useful and the cameras had to be held at waist height, the resulting viewpoint is a bit strange. But in any case, the camera's attention was focused on people—their facial expressions, their activities, body language and gestures, costume, outdoors paraphernalia and vehicles (sometimes just paraphernalia and vehicle). Many people smiled for the camera, and the camera could catch a smile, now that film and shutter speeds were faster. Often, those photographed seemed to be busy talking to each other. These are not quiet photographs; no one was listening to the birds singing. In fact, one suspects that some of these images of hearty male drinking societies and booyah cookouts captured occasions that were a teeny bit boisterous. Almost certainly the robust gentlemen in Figure 3 didn't pick up their bottles and recycle them!

When popular photography developed in the 1880s, average people were used to owning images of family and friends acquired from local professional photographers, and most people had themselves posed in the uncomfortable chair before the painted backdrop in the local studio. Most backdrops depicted elaborate interiors or formal gardens, but some examples portraying pristine rural landscapes, and even lakes and beaches, can be found. Several of the latter were in use in northeastern Wisconsin studios. These were the accepted examples of how the human figure should be portrayed by the camera.

Similarly, almost everyone was familiar with popular images of nature. Stereograph pictures of Yellowstone, the Grand Canyon, Yosemite, as well as Eastern tourist meccas had been cheaply and widely available since the 1850s. It is also significant that the Currier & Ives prints and gaudy chromolithographed advertising pictures and reproductions of famous paintings that hung in every family parlor had introduced the conventions of the picturesque landscape practiced by fashionable artists. Everyone, too, partook of the mania for sending and collecting picture postcards, which drew on and reinforced high art, popular art, and stereograph conventions. Indeed, much of 19th century American painting and illustration was moralizing, narrative, or journalistic in character. Advertising images themselves, especially the advertising for cameras and photographic products, may have been very influential in establishing conventions for images.

Thus, the average person was used to seeing people in claustrophobic portraits, people and scenes which taught important lessons, and nature as "views" composed under the conventions of the fine and popular art. However, the new light-weight cameras and celluloid film should have opened grand new vistas: "To any American with twenty-five dollars, however ignorant of chemistry or photography, the Kodak system promised the power to become an artist" (Schlereth, 198).

But few, if any, northeastern Wisconsin citizens went out, camera in hand, and became artists of the landscape. It is true that several natural features near Green Bay, such as the falls in DePere, were photographed for stereo views, but these were poor efforts by studio portrait photographers. At the end of the 19th century, northeastern Wisconsin had no reknowned professional picture-makers like H. H. Bennett. Bennett, in Wisconsin Dells, had recorded (and commercialized) the bluffs, caves, and riverboats of the Dells at roughly this time. Bennett, as if he were a Hudson River School painter like Thomas Cole, introduced the human figure only to give scale and introduce properly contemplative attitudes.

Bennett was a purposeful artist whose medium was photography. His approach was similar to that of Andrew L. Dahl, who worked in Dane County from about 1870–1880. Dahl photographed people in the out-of-doors, but his images often display farmers with their implements and animals before a barn, or meticulously-posed families in formal finery, ensconced in their best parlor chairs and having tea upon the parlor table, within the context of their front yards. Dahl's photographs are remarkable for their narrative quality and complex compositional schemes, though in his own time his intentions were more unusual than his product.

But unlike Bennett or Dahl, the anonymous photographers in this study wanted to record the appearance of their own lives—at least the parts of their lives they judged memorable. They were not interested in the lives or appearance of strangers or the intricacies of natural history or geological formations. They did share with Dahl the clear intention to achieve true likenesses of people and their possessions. Having one's picture made in a studio had been a public event, rather like Dahl's tableaux; the family camera could capture what was seen, known, and cherished in private. As a tool for personal expression, it could depict the interests and experiences of a single family member, or it could memorialize important occasions, like holiday outings. In all respects, the family camera was closer to the subject, who, if family or friend, could influence many particulars of the image.

It seems reasonable that the introduction

Figure 5. "Picnic Party Down the Bay, 1889," unknown photographer. Collection of the Neville Public Museum.

of the family camera would have occasioned innovations in composition and style. But precedent seems to have been irresistible. Well-furnished outdoor leisure was a new and highly cherished aspect of middle class life in the 1890s; hence, it had to be memorialized with a sufficient sense of the proprieties. Early images of adults are portrait-studio solemn. Younger people, however, might grin and clown for the camera, since such behavior was perfectly acceptable now the photographer was their father or dear friend. Nevertheless, for every image with purely casual gestures or provocative style, there are fifty like Figure 5 that are meticulously choreographed. Certainly, the composition and style of these photographs seem to derive directly from the safely familiar conventions of studio portraiture and commercial stereograph photographs.

First, the composition is symmetrically articulated, with a shallow horizontal band of human subjects placed parallel to the picture plane. Second, nearly everyone is carefully placed and strikes a purposefully graceful or theatrical pose. The poses are livelier versions of studio prototypes. Third, gender roles are almost as clearly defined as they were in studio portraits: women sew, read, or arrange food and eating implements; men display stylish sporting apparel or elaborate fishing gear. Fourth, in the earliest images, the photographer pays very close attention to clothing and to the display of important belongings: the ubiquitous picnic basket, bottles, hampers, musical instruments, sporting equipment, food, or dead game. Clothing and tasteful or expensive appurtenances signified the importance of the sitter in a studio portrait; it fulfilled the same purpose for

Figure 6. The whole family camping out, unknown location in northern Wisconsin, about 1910, unknown photographer. Author's collection.

snapshots. In stereographs, something had to be placed in the foreground of the image in order to make a successfully three-dimensional view. The popular photographer followed precedent. Finally, nature remained behind like a painted backdrop in the professional photographer's studio in downtown Green Bay.

Evidently, these conventions became more elastic after the century's turn. In Figure 6, an image made about 1910, faces and body positions are more relaxed and genuine, and the photographer allows the grassy, well-wooded setting to occupy almost half the background of the picture. Yet, the smiles of the children and the woman's affectionate petting of her dog are the most memorable aspects of the image.

Of course, popular photographs have always been about the growth of children, happy times, and significant family occasions. Some of the types of occasions we see in these photographs required certain behaviors, as established by tradition. The history of popular American leisure pastimes, like the history of American popular photography, has really only been studied and published in the past decade. Already, however, several scholars have studied the development of picnic practices in the 19th century. They tell us that well-to-do Americans were familiar with picnics; the upper classes of American society had adopted this European activity in the 1850s. Winslow Homer, the great 19th century painter and illustrator, had drawn humorous images of picnickers, like "Picnicking in the Woods," published in the September 14, 1858 issue of *Harper's*. One could even read about picnics in books of etiquette. For example, *Decorum, A Prac-*

tical Treatise on Etiquette and Dress of the Best American Society, published in 1879, instructs the reader thusly: "Let us treat of the picnic, in which a lot of people join together for the purpose of a day's ruralizing....In giving a picnic, the great thing to remember is to be sure and have enough to eat and drink. Always provide for the largest possible number of guests that may by any chance come....Great latitude in dress is allowed on these occasions. The ladies all come in morning dresses and hats; the gentlemen in light coats, wide-awake hats, caps, or straw hats." The book specified each aspect of proper picnic planning, transportation, and games, and the writer further declares, "Each gentleman should endeavor to do his utmost to be amusing on these occasions" (154–55).

Indeed, in an article about picnicking in New England in the 19th century, Mary Ellen Hern writes, "A striking aspect of the American Victorian picnic ritual was its sensuousness. In addition to singing, dancing, and other frolicking, the picnic offered a feast...The picnic ritualized and made acceptable frivolous and marginally inappropriate behaviors such as overeating and flirting with the opposite sex" (146–47). A great deal of courting and some surreptitious necking was sanctioned at New England picnics, and so, too, it must have been in Wisconsin. This may explain a good deal of what appears in our photographs. To illustrate, in Figure 4, three of the couples stand or sit distanced from each other, like comfortably married folks tend to do. One couple, however, who appear nearest the top of the image, seem to converse in a flirtatious manner. Their faces are very close, and, unlike the other young men, he has removed his hat in polite deference. One concludes they are courting. Finally, the number of wine and beer bottles and kegs we see in the images certainly confirms the popularity of alcoholic beverages at Wisconsin picnics.

The picnic, and the relationships with nature it encouraged, or discouraged, served as the model for newer types of outdoor leisure, like camping. As picnics moved out of city parks, public cemeteries, and local farmer's fields, and into the newly accessible wilderness, picnickers' lighthearted traditions moved with them. Wilderness nature received the same treatment and began to function for the active enjoyment of city folks bent on refreshing outdoors activities.

Popular photography is and was both an expressive and a documentary medium. Reading popular photographs of picnics, camping, and other such alfresco adventures tells us what average people did, how they did it, and what they valued. On one level, we can examine popular varieties of picnic baskets; on another, we can also surmise people's attitudes and beliefs. Evidently, as their amateur photographs reveal, the people of northeastern Wisconsin during the late 19th and early 20th century found the natural outdoors a great place for personal, family, and peer group recreation. Reading these photographs also tells us that average Wisconsin citizens at the turn of the century were strongly influenced by the conventions of studio portrait and commercial landscape photography. By 1920, probably most Wisconsin families had collected hundreds of conventionalized outdoors images, many of which were pasted in monumental leather-bound scrapbooks. This was the norm in the northeastern quarter of the State, and it seems unlikely that customs differed greatly in Superior, Chippewa Falls, or Milwaukee. Almost certainly, the children and grandchildren of these early photographers learned a great deal about nature and how to behave in the great outdoors through looking at individual photographs and albums of photographs such as these.

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Paul Wozniak

They thought we were dreamers: Early anti-pollution efforts on the lower Fox and East Rivers of northeast Wisconsin, 1927–1949

Abstract *A major environmental debate took place in Wisconsin from the 1920s through the 1950s on river and stream water quality. Conservation activists, local governments, and industries struggled in political and regulatory debates to control pollution. This article describes regulatory and social debates in northeast Wisconsin's lower Fox River Valley in the period 1927–1949. As a political issue in this area, the controversy was instigated by citizen conservationists who worked as elected officials or as citizen activists to promote change. The strategy of the conservationists was to establish or expand regulatory control of industrial and household waste discharges to rivers and streams. Green Bay attorneys Meyer Cohen, Frederick Kaftan, Arthur Kaftan, Michael Kresky, Jr., Virgil Muench, and Donald Soquet were most visible as conservation advocates. In the latter years of this period the Izaak Walton League was a key organization in advancing the anti-pollution agenda, helped by the efforts of advertising executive Harry Tubbs. Many government and business organizations responded, including the Green Bay Metropolitan Sewerage District, the Sulphite Pulp Manufacturers Research League, and the paper industry firms of Kimberly-Clark, Northern Paper Company, and the Hoberg Paper Company.*

They thought we were dreamers, and we were," said Harry Tubbs. Nearly 50 years before, when the post-World War II baby boom was just beginning, Tubbs had been a political activist for the environment. An advertising executive for a grocery store chain, Tubbs served as communications adviser for advocates of water pollution control in the lower Fox River

Valley. He helped promote an agenda for water quality improvement that was quixotic for its time.[1] It was a dream of the restoration of heavily polluted, stinking rivers, a dream of clear waters with abundant gamefish and of laughing children splashing at the local beach. In reality, the rivers at that time carried visible industrial pollution and significant discharges of disease-carrying sewer effluent.

Advocacy for water quality in the 1940s is noteworthy for the significant improvements that were eventually made in terms of fisheries and swimming safety and for its lasting presence as a political and social issue in communities along the lower Fox River. Today water quality remains an issue with an active local constituency.[2]

On a national and even international level, Wisconsinites have played a major and highly visible role in the development of environmental protection, including a key role in forming the national organizations of the Sierra Club and the Wilderness Society and in organizing the first Earth Day, an event with some international influence.[3] However, local efforts to deal with local pollution problems are rarely recounted in Wisconsin environmental history.[4] The events described are important because they involved Wisconsinites who furthered cultural acceptance of natural resource protection as a social responsibility at the local and state levels.

Geographical Setting

Much of the political debate described in this account focused on water quality in the lower Fox River Valley and in the southern reaches of Green Bay, Lake Michigan, near the mouth of the river. The 38-mile (61 km) lower Fox River is the channel through which the combined waters of the upper Fox River and Wolf River flow to Green Bay. From a broader perspective, the combined Fox River-Wolf River watershed drains a 6,400-square mile (1.7 million ha) area. The Fox River originates in south-central Wisconsin near the central Wisconsin city of Portage. With only a moderate change in elevation of 35 ft (11 m), the Fox River flows from the area near Portage northeast into Lake Butte des Morts (Winnebago County) At this point, the waters of the Wolf River combine with the Fox River to flow east to Lake Winnebago, which serves as a broad, shallow holding pond. The waters exit Lake Winnebago as the lower Fox River, continuing about 35 miles (56 km) northeast down a drop of more than 175 ft (53 m) into the Green Bay of Lake Michigan. The significant drop in elevation provides for the significant hydropower resources that first attracted the large energy users, including the pulp and paper industry that developed in the late 1800s. Along its journey to the Great Lakes, the river collects water from tributaries, including the East River that joins the Fox River in the industrial area of the city of Green Bay (Figure 1).

The East River is directly related to the pollution controversies reported here. The East River is a much smaller river of 27 miles (43 km) in length, draining 206 square miles (0.05 million ha). It flows parallel to the Fox River in Brown County. Water quality problems in the East River are amplified by an unusually long residence time for water due to the seiche effect that forces waters from Green Bay, Lake Michigan, to flow upriver for short periods of time. During extreme conditions involving a seiche, water flow in the East River reverses its direction. The East River's central role in the public debate was due in part to its location in the residential and business districts of Green Bay's east side.

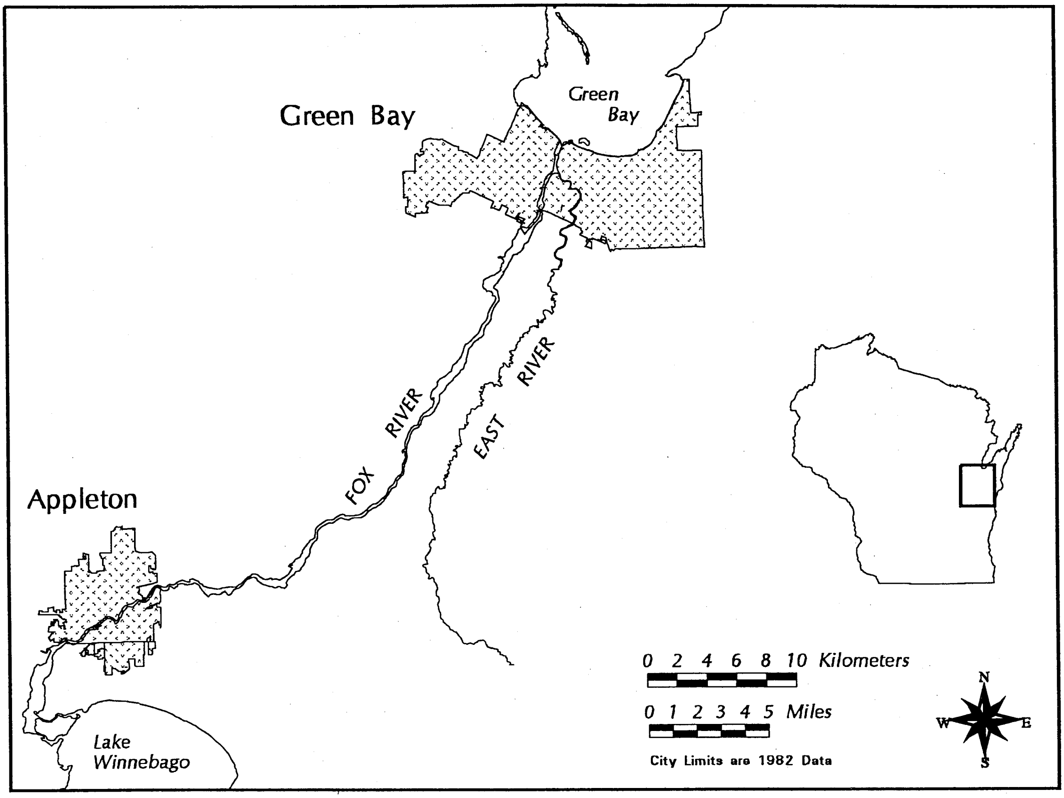


Figure 1. The lower Fox River and the East River flow from southwest to northeast. They join just before entering Green Bay, Lake Michigan. Social controversy about water pollution on these rivers has occurred through most of the twentieth century.

East River Stench

One of the earliest records of public dispute about water quality in the lower Fox River Valley is a 1920s report by a committee that included business people of the East River neighborhoods.[5] The most frequent complaint in the commentary was the river's smell, described as "terrible." In 1933 the smell was reported as being bad enough to require the city's East High to regularly hold classes with windows closed.[6]

Green Bay was a city of 37,000 in 1930, and at this time, the neighborhoods on Green Bay's east side along the East River were a mix of lower-income housing, retail shops, and small factories. Green Bay's economy was rooted in natural resources, with the largest employment and greatest economic value in the pulp and paper industry. Industries along the East River converted logs into pulp, milk into cheese products, cows into cuts of meat, and malt and barley into beer. Other businesses cooked and packed vegetables in metal cans for the grocer's shelves. Fish packing plants trimmed and cleaned the fish caught on Green Bay. These and many other activities produced wastes, which, as in other parts of Wisconsin at this time, were discharged with little or no treatment into the nearest stream or river.

In addition to industrial waste, there was the problem of individual, non-business behavior, including the dumping into the East River of engine oils, household garbage, appliances, and worn-out boats and cars.[7] Clearly, the city of Green Bay did not have an adequate system of solid waste collection and disposal. A description of local conditions by a reporter for the Green Bay *Press-Gazette* also reflects local understanding of environmental pollution:

> Food waste is trucked to a farm on the outskirts and fed to hogs. For this reason, the food remnants must be kept separate from inedible rubbish and harmful ingredients. No housewife would expect hog-feeding to dispose of broken glass, decrepit furniture, unused lye or surplus rat poison. On the other hand, the glass and the furniture and even the poison could be dumped into a swamp without danger to health, but the food waste could not.[8]

The Fox River differed from the East River by the larger size of its flow, not by the type of wastes dumped into it. Sordid conditions were reported on the lower Fox River from Lake Winnebago to the bay of Green Bay. Although the degree of the stench and concentration of the pollution in most of the Fox was reported to be less severe than in the East River, pollution was a recognized problem:

> Every summer the city and village officials received numerous complaints of offensive odors given off by the [Fox] river. The colored, turbid waters of the Fox River were filled with fibrous materials, sludge deposits and unstable organic wastes. The sight and odor of dead fish along the banks added to the nuisance.[9]

Human Sewage

Industrial and chemical wastes were a problem, but many people, including some authorities, thought they did not cause human health problems. Human waste, however, was recognized as a threat in spreading disease. At this time, many homes and businesses had pipes flushing raw wastes into the river. Also, many homes had outhouses, including at least one on the East River that was built on extensions over the river so as to deposit waste without need for an outhouse pit.[10] Despite these widely known conditions, children swam in these waters, including many parts of the lower Fox and East rivers at what were likely the filthiest stretches.[11]

If there were health warnings against such exposure, they are not well remembered or recorded, with the exception of Bay Beach. Bay Beach was a city swimming beach on the shores of Green Bay near the mouth of the Fox River. Its use by bathers appears to have been much greater than all other surface water swimming areas in the Green Bay-De Pere area. After the beach was re-opened in 1937 after six years of closure by the State Board of Health, one warm day brought an estimated 1,500–2,000 bathers to the beach.[12] The beach was opened and closed in the following years as monitoring provided evidence of problems,[13] with final closing occurring in 1943, according to the Green Bay Health Department.

Social Response

In 1927, the State of Wisconsin sponsored the first modern scientific survey of Wisconsin rivers and streams. The survey was initiated as a result of a 1925 incident in northwest Wisconsin in which a pulp mill discharge killed 25 to 30 tons of fish, but the survey evolved to cover a much larger geographic area. The resulting 327-page report, *Stream Pollution in Wisconsin,* documented the role of dissolved oxygen in the

Fox and other rivers.[14] The report noted that fish could not survive in many parts of the lower Fox River for periods of the year because of the lack of dissolved oxygen in the water. This was especially true in the approximately six-mile stretch from the De Pere dam to the mouth of the river in the city of Green Bay. This 1927 report was a factor in the state's authorization that same year of regional sewerage systems with taxing powers and the creation of the state-level Committee on Water pollution (COWP).[15]

The legislation creating the COWP assigned the new committee duties for scientific experimentation and research on "economical and practicable" solutions to industrial discharges. Some solutions had been suggested in the 1927 study, which reported that sulphite liquors could be converted to numerous products including alcohol, fuel, and fertilizer.[16] The report also summarized a Park Falls experiment that showed dramatic reductions in the oxygen-demanding impact of mill wastes through temporary holding and aeration. It would be almost 50 years after this experiment that adoption of aeration technology (supplemented by microorganism cultures) would be made at Wisconsin pulp and paper mills.

In local politics in 1927, a Green Bay City Council committee joined members of the North Side Advancement Association for a September boat ride down the lower stretches of the East River. A report filed in the City Council proceedings painted a sordid picture.

> Pleasant Street bridge is not so pleasant...Elm Street sewer water or river here is terrible. In fact it can no longer be called a river, but more in the line of an open sewer...The only movement of water was from the boat or eruptions of gases in the bottom of the river, which would shoot to the top solids of sewerage matter. [17]

The report went on to state that when the group reached the mouth of the East River where it enters the Fox River, they found that "...the Public Service Co. pumps oil and gas into the river. It is so bad that we touched a match to it and it ignited and threw a flame two feet high."[18]

With public attention heightened, a campaign was organized with the help of attorney Meyer "Mike" Cohen. Cohen served as councilman for an East Green Bay ward in the early 1930s. From this post, he organized public support and local governmental funding for the area's first sewer system and treatment plant. A citizen petition campaign was conducted and more than 1,000 signatures collected to support formation of the Green Bay Metropolitan Sewerage District (GBMSD). The GBMSD soon built the city's first sewer treatment plant with federal funds from the Depression-era Federal Emergency Administration of Public Works.[19] The new plant had the effect of raising public hopes for an end to the stench of the East River. When the undersized and ill-equipped plant failed to make any perceptible impact on the odor problem, some members of the public were upset and angered, calling for continued action.[20] Part of the problem was the combination of storm and sanitary sewers, mixing large volumes of runoff and ground waters into sewage and overloading the small plant.

Cohen's law partner, Michael Kresky, Jr., supported the call for ongoing action. In 1936 Kresky ran as a Progressive Party candidate for the two-county second senatorial district that included Green Bay. After his election, Kresky played a public role in a late 1930s controversy that developed over the health of the fisheries in lower Green Bay. Commercial fishing businesses were closing, reportedly because of the loss of river and bay fisheries due to pollution. Other wild-

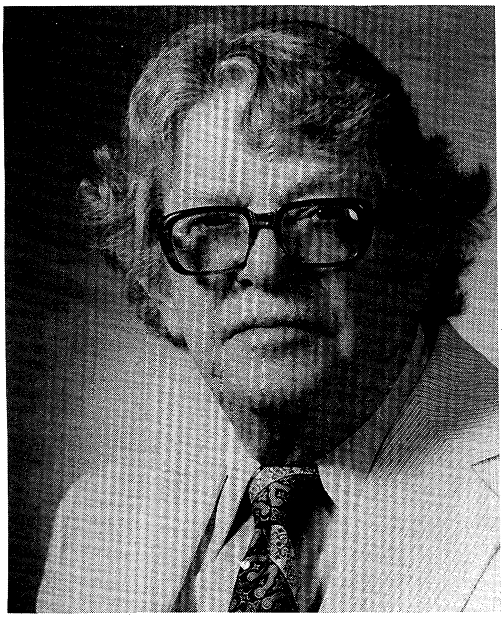


Figure 2. Attorney Meyer Cohen is recognized as the prime mover behind the creation of the first municipal sewerage works in Green Bay. Photo courtesy of the Neville Public Museum, Green Bay.

life problems were occurring, including massive die-offs of waterfowl at the Fox River mouth.[21] When commercial fishermen complained to the Wisconsin Conservation Commission that dead fish were found in nets set in lower Green Bay in the winter of 1937–38,[22] a state investigation was begun with support from Progressive Party Governor Phil LaFollette and State Senator Kresky. A study began in September 1938 as a cooperative effort of the COWP, the State Board of Health, and the GBMSD. President-elect for the State Board of Health, Green Bay physician Dr. W. W. Kelly, was also a visible participant in the discussion. For nine months, employees loaned from agencies in other states studied the claims of commercial fishermen.[23] The fishermen had reported that the fish were discolored and appeared almost white and bleached. Lab experiments exposed fish to high concentrations of a major pulp mill effluent called sulphite liquor, and the fish did not become bleached. The study therefore absolved the pulp mills of allegations that fish were bleached and tainted from mill discharges.[24]

However, the study did report that fish kills were due to low oxygen levels in the waters, caused primarily by the sulphite liquor of the pulp mills; the numerous paper mills on the river were identified as much smaller contributors to dissolved-oxygen problems. According to the study, about 80 percent of the dissolved-oxygen problem was due to pulp mill discharges, with the remaining 20 percent due to other business and household discharges. The concept that low levels of dissolved oxygen harmed fish was not new, but a quantified assessment of sources was new.

The focus of public attention spurred industry discussion of its previous efforts and plans to deal with the problem. In July 1939 newspapers reported success by the Marathon Paper Company at its Wisconsin River facility at Rothschild in capturing and using wastes normally discharged to water. The waste was used to produce the food flavoring vanillin and the "cheapest plastic material yet."[25] In the fall of 1939 the paper industry announced formation of a major research effort. The Sulphite Pulp Manufacturers Research League (SPMRL) was created and funded by major pulp companies on the Fox and Wisconsin rivers. Its major research goal was to identify ways to recover and reuse the waste materials being discharged to the waterways.[26] Pulp and paper industry executives had long been aware of the seriousness of the waste discharge issue. They had played a role in the politics of 1927 that formed the COWP and introduced a major expansion of government involvement in surface water quality issues.[27]

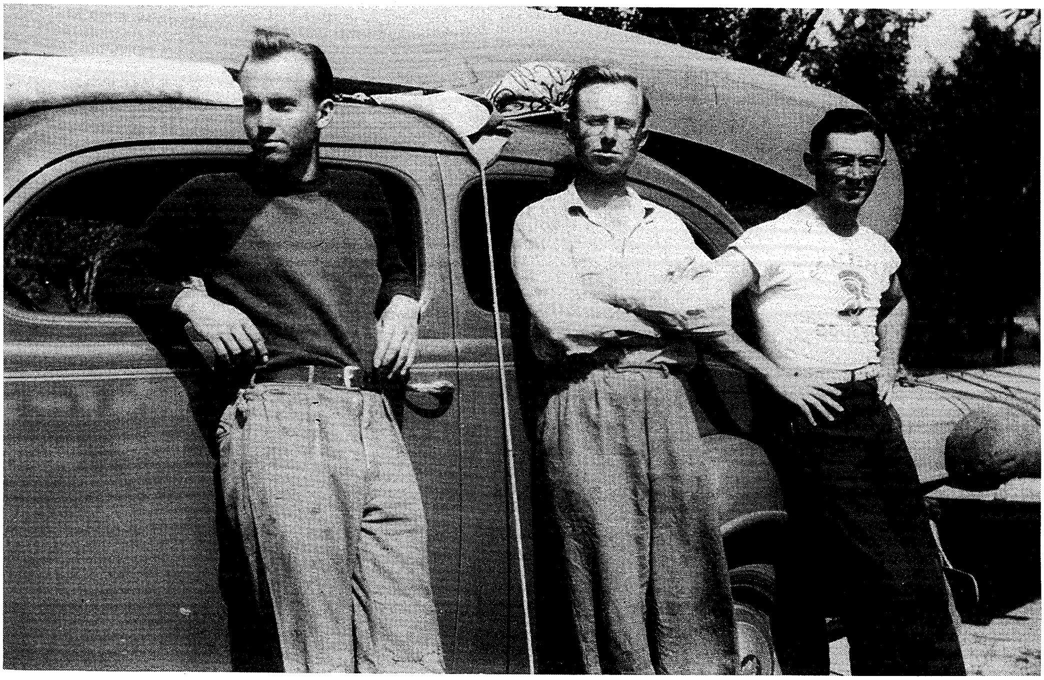


Figure 3. Recreational canoeing played a role in the post-World War II debate to clean up state rivers. Left to right are Fred Kaftan, Art Kaftan, and Don Soquet, who as college students canoed Wisconsin rivers together. Soquet initiated the anti-pollution crusade after he canoed the polluted Fox River and was angered by the degraded conditions. (1939 photo from the collection of Arthur Kaftan)

World War II dampened efforts at wastewater control. The debate was refueled by returning war veterans , such as attorney Donald Soquet, who worked to regain a sense of place and home. Soquet recalls that as a boy in the 1920s he caught perch, bluegill, and bass from the Fox River,[28] often from a pier in downtown Green Bay on his way to school. At that time, desirable game fish could not survive the summer months in the lower Fox due to lack of dissolved oxygen.[29] During his college years in the late 1930s, Soquet and some high school friends canoed Wisconsin rivers (Figure 3) and were in fact camped on the banks of northwest Wisconsin's Flambeau River when the radio reported the Nazi invasion of Poland.[30] In a few years, several of the crew would find themselves in military service. In the postwar years, the vets returned to their previous careers and found themselves unexpectedly assuming leadership roles in water protection efforts. The event that sparked Soquet's involvement in water politics was a postwar canoe ride on the Fox River. The serious pollution he observed led him to write a letter-to-the-editor published in the Green Bay *Press-Gazette.* He recalls that in the letter "I spoke of what I had seen and how disturbed I was, and the change in this beautiful body of water and marsh and everything into this cesspool."[31]

That week, he received a call from a stranger who had read his letter. Orrin Wilson was a handicapped paper mill worker from a mill upriver of Green Bay. Wilson

Figure 4. Virgil Muench, Green Bay attorney and son of a commerical fisherman, was a blunt-spoken advocate for strict regulation of water pollution. Muench was a leader of the Brown County chapter as well as the state chapter of the Izaak Walton League. (Photo from collection of Jane Muench Burke)

drove to Soquet's Green Bay apartment one evening to persuade the lawyer to help form a local chapter of a national conservation advocacy group called the Izaak Walton League (IWL).[32] Soquet spoke to Virgil Muench (Figure 4), a 44-year-old attorney who happened to have an office in the same building as Soquet in downtown Green Bay. Blunt in speech with others, Muench had recently been active as a proponent for small businesses struggling with chain-store competitors.[33] With a few others, Soquet and Muench became the core of the Brown County chapter of the IWL. Attorney A. D. Sutherland of Fond du Lac, by then a long-time veteran in the IWL, wrote to encourage the chapter to take action on local water pollution, which the group did.[34]

A change in state pollution regulation was deemed critical in the mind of the attorneys who led the new IWL chapter. Fred Kaftan was recruited by his elder brother Art and others to run for the state senate on the Republican Party ticket (Figure 5).[35] The second senatorial district seat was the same held in the late 1930s by Cohen's partner and water-quality advocate Kresky.[36] To generate voter support, the IWL recruited Harry Tubbs, a Green Bay native who served as Kaftan's campaign manager and later as communications adviser for the IWL. Muench had been circulating a petition he drafted, calling for government action on water pollution.[37] At an IWL meeting in the fall of 1948, Tubbs was seated at the back of the room in the downtown Green Bay YMCA when he was asked by the presiding chair what he thought should be done. Tubbs suggested the signed petitions be delivered to Republican Governor Oscar Rennebohm who was on a campaign tour and lodged across the street at the Northland Hotel. [38] As a result of the meeting, the Governor arranged hearings of the Committee on Water Pollution for December 1948 at the Brown County Courthouse in Green Bay (Figure 6). The hearings went on for several days and were postponed for the Christmas holidays, being resumed in January 1949. Extensive newspaper coverage described the debate over the technical and economic feasibility of controlling discharges from pulp and paper mills as well as municipal sewage treatment plants. IWL attorneys Virgil Muench, Arthur Kaftan, and Donald Soquet led the call for immediate anti-pollution action and challenged the pulp mill and municipal government representatives on the witness stand. Charges of economic blackmail were made when a paper mill executive suggested that his plant might need

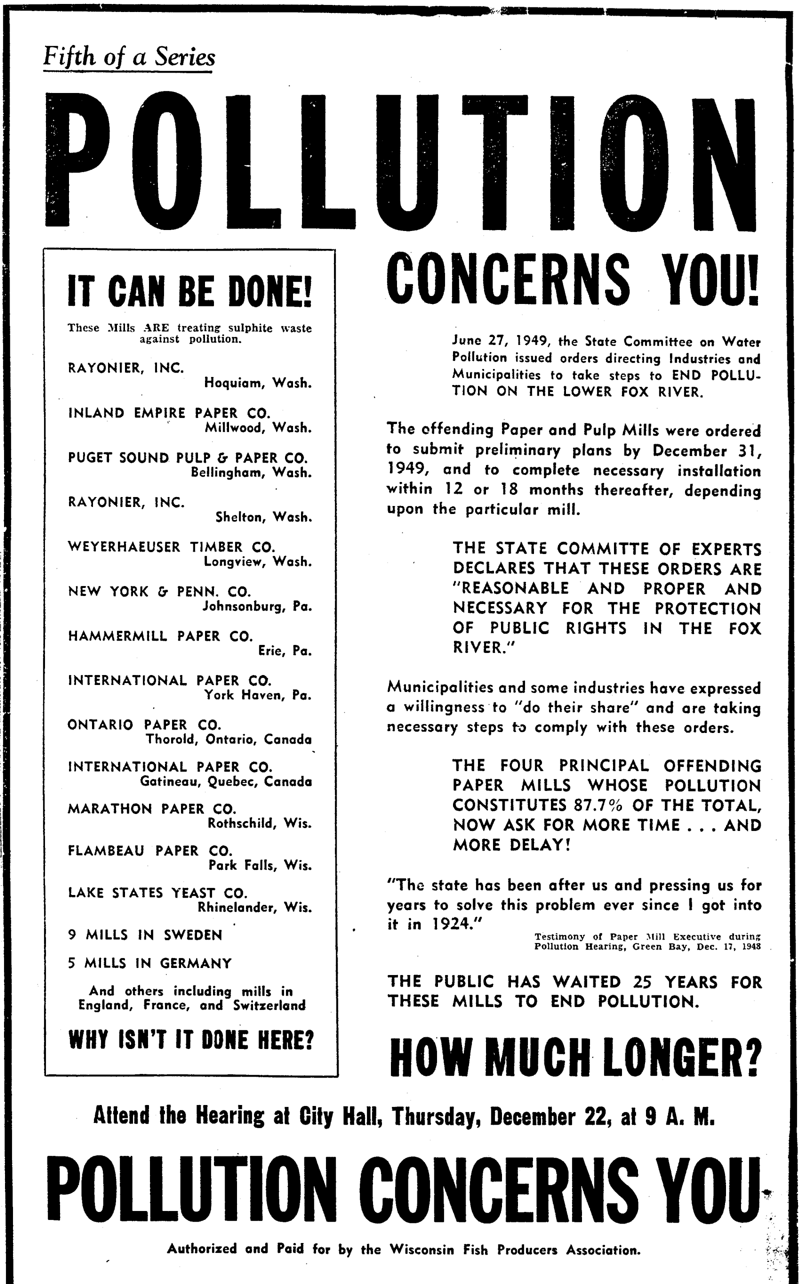
Figure 5. Water quality advocates recruited and helped elect Fred Kaftan to the Wisconsin State Senate in 1948. This was a single-issue campaign focused on improving regulation of industrial and sewage treatment plant pollution. Kaftan drew the news media's attention in part because it is unusual for a politician to criticize the major industry of his district. (Campaign poster from collection of Fred Kaftan.)

to leave town. The pulp and paper mills were the economic mainstay of the community, and union representatives were recruited by the mills to attend and testify against pollution control.

Among the surprises was testimony by the Democratic State Senator recently defeated by Republican Fred Kaftan. Former State Senator Harold Lytie, a 51-year-old barber, told the hearing that paper mill executive J. M. Conway had promised Lytie in 1939 that the water pollution problem would be solved in two years. Lytie said this promise was made to get Lytie to withdraw support for stricter state regulations being discussed in 1939 when Lytie was an assemblyman, although Conway denied the promise was made.[39]

The hearings extended longer than planned, possibly in part because of the public attention drawn to them by the conservationists. A Green Bay *Press-Gazette* ad campaign had been organized by Tubbs, and a sympathetic WHBY radio announcer, Mike Griffon, gave regular coverage.[40] Daily crowds of 150 or more were reported to have daily attended the hearings, and the emotional level of the discussions was high.[41] Economic loyalties were called upon, with mill workers and others urged to oppose water quality regulations. Soquet lost some clients from his law firm, as did Kaftan. However, the losses were not financially significant to their law practice. Muench had been living in large part from funds not related to his law practice, and he gave up his conventional case practice to devote his efforts more fully to conservation advocacy. What is believed to be a small sample of Muench's speeches and correspondence with conservationists across the nation is preserved in state archives.[42]

In November 1948, the month before the hearings, Fred Kaftan had been elected State Senator. The campaign had emphasized a personal hand-shaking campaign in small towns based on a single issue: water pollution control. Joining the Senate in 1949 with the Green Bay hearings just completed, Kaftan began raising the water pollution issue by authoring several legislative proposals, one of which called for steep daily fines on parties discharging pollutants.[43] As a freshman senator, Kaftan worked with only a few allies in the senate, one of whom was the freshman Democrat Senator Gaylord Nelson of Dane County.[44] Kaftan was noted by the



Fifth of a Series

POLLUTION

CONCERNS YOU!

June 27, 1949, the State Committee on Water Pollution issued orders directing Industries and Municipalities to take steps to END POLLUTION ON THE LOWER FOX RIVER.

The offending Paper and Pulp Mills were ordered to submit preliminary plans by December 31, 1949, and to complete necessary installation within 12 or 18 months thereafter, depending upon the particular mill.

THE STATE COMMITTE OF EXPERTS DECLARES THAT THESE ORDERS ARE "REASONABLE AND PROPER AND NECESSARY FOR THE PROTECTION OF PUBLIC RIGHTS IN THE FOX RIVER."

Municipalities and some industries have expressed a willingness to "do their share" and are taking necessary steps to comply with these orders.

THE FOUR PRINCIPAL OFFENDING PAPER MILLS WHOSE POLLUTION CONSTITUTES 87.7% OF THE TOTAL, NOW ASK FOR MORE TIME . . . AND MORE DELAY!

"The state has been after us and pressing us for years to solve this problem ever since I got into it in 1924."

Testimony of Paper Mill Executive during Pollution Hearing, Green Bay, Dec. 17, 1948

THE PUBLIC HAS WAITED 25 YEARS FOR THESE MILLS TO END POLLUTION.

HOW MUCH LONGER?

IT CAN BE DONE!

These Mills ARE treating sulphite waste against pollution.

RAYONIER, INC. Hoquiam, Wash.

INLAND EMPIRE PAPER CO. Millwood, Wash.

PUGET SOUND PULP & PAPER CO. Bellingham, Wash.

RAYONIER, INC. Shelton, Wash.

WEYERHAEUSER TIMBER CO. Longview, Wash.

NEW YORK & PENN. CO. Johnsonburg, Pa.

HAMMERMILL PAPER CO. Erie, Pa.

INTERNATIONAL PAPER CO. York Haven, Pa.

ONTARIO PAPER CO. Thorold, Ontario, Canada

INTERNATIONAL PAPER CO. Gatineau, Quebec, Canada

MARATHON PAPER CO. Rothschild, Wis.

FLAMBEAU PAPER CO. Park Falls, Wis.

LAKE STATES YEAST CO. Rhinelander, Wis.

9 MILLS IN SWEDEN

5 MILLS IN GERMANY

And others including mills in England, France, and Switzerland

WHY ISN'T IT DONE HERE?

Attend the Hearing at City Hall, Thursday, December 22, at 9 A. M.

POLLUTION CONCERNS YOU

Authorized and Paid for by the Wisconsin Fish Producers Association.

Figure 6. Advertising was one of the tactics used by the Izaak Walton League in its effort to draw public attendance to the 1948 Green Bay state hearings on Fox River pollution. Local advertising executive Harry Tubbs orchestrated an advertising and publicity campaign to elect Fred Kaftan and draw attention to his legislative agenda. (Ad from Green Bay *Press-Gazette,* December 1948)

media for the bold step of publicly chastising the major industry of his home district.[45] Kaftan's major accomplishment in the Republican-controlled state legislature was the appropriation of funding for a director and full-time staff for the COWP. Conservationists had argued that the COWP was ineffective in enforcing existing laws and that lack of staffing was part of the reason.

In July 1949, the COWP issued an order calling for the installation of wastewater treatment facilities by municipalities and paper mills on the Fox River by 1951. The conservationists considered this order a significant victory. Some industry and municipal sewage treatment plants made efforts to comply with the order, but delays occurred. The interpretation of the order was that continued good-faith progress needed to be shown to the COWP.[46] Hearings conducted in later years addressed progress by specific industrial and municipal sewage plants, and attention focused on the still-declining ecological conditions.[47]

According to paper industry executives interviewed in recent years, they had considerable sympathy with the goals of the conservationists;[48] they argue that the forces of market competition and a lack of technical knowledge and materials are what prevented a quick cleanup of pollution. A central argument at the time was that if state-mandated pollution controls were required only in Wisconsin, it would make Wisconsin papermakers uncompetitive with manufacturers in other states.[49]

The manufacturers argued that some experimentation in waste recovery had been conducted by Wisconsin pulp mills between the 1927 formation of the COWP and the debates of the late 1940s. Two examples were on the Wisconsin River. The Marathon Paper Company, led by D. C. Everest, had a pilot facility operating in 1939 to convert a portion of pulp mill residues into a raw material that could be converted to vanillin extract for food.[50] The Rhinelander paper mill, whose president was Folke Becker, had installed a pilot plant in 1948 that converted some of the waste material into yeast. The yeast was used as cattle food.[51] Neither of the experimental-scale facilities made major reductions in the waste discharge of the mills at which they were located.

In the lower Fox River Valley, the 1949 order and other actions of the COWP led to the construction of waste recovery facilities at the Northern Paper Company mill, the Hoberg Paper Company mill, the Consolidated Water Power and Paper mill, and a Kimberly-Clark mill. Sulphite liquor was used by Kimberly-Clark as an adhesive to control dust on rural gravel roads. At Green Bay's Northern pulp mill and at Appleton's Consolidated Water Power and Paper, sulphite liquors were burned in a boiler after concentration by an evaporator. The Charmin Paper Company bought the Hoberg Paper Company mill in the 1950s and used sulphite liquor to produce a yeast food at the facility. The combined efforts of these and other industries reduced oxygen-depleting discharges into the Fox (and East River in the case of the Northern mills). Yet dissolved oxygen levels were not improved to the point where sensitive fish could survive.

Work by the Fox Valley activists did not end with the 1948–49 efforts, but these events remain a defining moment in the postwar conservation/environmental movement in northeastern Wisconsin. They are also possibly the most influential actions by the Fox Valley activists in terms of statewide impact.[52] The resulting actions by dischargers and government helped establish the state's progressive reputation among water quality advocates. Although adequate levels of dissolved oxygen in the lower Fox River were not immediately restored, the controls advanced the national technical knowledge base and the national political agenda on the environment. In addition, the efforts raised local public awareness about water quality issues.

Water quality suitable for fish survival was not restored until the late 1970s, following implementation of standards derived from the 1972 Clean Water Act passed by the U.S. Congress. This national law required pulp and paper mills, as well as other industries and municipal sewage treatment plants, to meet specific minimum levels of pollution control. By 1987 more than $300 million in water pollution controls was invested by Fox River dischargers, including municipalities.[53] As a result of these investments, dissolved oxygen levels increased in the lower Fox and East rivers, and many species of fish and other aquatic organisms returned from the cleaner waters of Green Bay. With them returned recreational boaters and fishing enthusiasts and greater public and private investment in waterfront properties.

Endnotes

[1]Oral history interview with Harry Tubbs, Fox/Wolf Rivers Environmental History Project (FWREHP) collection, State Historical Society of Wisconsin (SHSW), stored at the Area Research Center (ARC), University of Wisconsin-Green Bay (UWGB). Interviews are filed alphabetically by surname.

[2]Social research conducted from the late 1970s through the early 1990s confirms that lower Fox River Valley residents rate water quality as a major, if not the major local environmental issue. Relevant reports include: UWGB, "Water: Environmental Optimism, Opinions of Water Quality," a report on a Title I Grant by the U.S. Department of Health, Education and Welfare, 1979; Ron Baba, Per Johnsen, Gerrit Knaap, and Larry Smith, "Public Perceptions and Attitudes Toward Water Quality Rehabilitation of the Lower Green Bay Watershed," Green Bay: UWGB Center for Public Affairs, 1991; Steve Bennett and Dotty Juengst, "Recommendations for Improving the East River Priority Watershed Urban Education Campaign," prepared for the Wisconsin Department of Natural Resources and the University of Wisconsin-Extension, 1993.

[3]The Sierra Club was founded by John Muir, who was raised in the Upper Fox River Valley, and whose book, *The Story of My Boyhood and Youth,* recounts the influence of Wisconsin experiences. The Wilderness Society was co-founded by Aldo Leopold, then a professor at the University of Wisconsin-Madison. Earth Day was the idea of U.S. Senator Gaylord Nelson (Democrat-Wisconsin).

[4]An excellent reference that discusses the work of Wisconsinites in the legal expansion of water protection is a 1965 *Transactions* article "Water Policy Evolution in Wisconsin-Protection of the Public Trust," Vol. 54, Part A, (pp. 143–97) by Walter E. Scott of the Wisconsin Conservation Department. However, this article does not detail activities at the community level.

[5]In 1927 an advisory committee to the Mayor of Green Bay undertook a fact-finding mission to document, albeit anecdotally, the sour condition of the river. This account was recorded in the City Council Proceedings of September 23, 1927.

[6]First Annual Report of the Green Bay Metropolitan Sewerage District, issued 1933.

[7]Green Bay *Press-Gazette,* "Garbage Dumping Must Be Ended to Keep River Clean," by Stanley Barnett, Dec. 3, 1936.

[8]Green Bay *Press-Gazette,* "Garbage Dumping Must Be Ended to Keep River Clean," Dec. 3, 1936.

[9]*American City,* "Sewage and Stream-Pollution Problems in Eastern Wisconsin," author not identified, February 1935, 3 pp.

[10]Green Bay *Press-Gazette,* "Mayor Out to Clean

River," July 16, 1937; Oral history interview with Art Decker, FWREHP/ARC/UWGB.

[11]Oral history interviews with Art Decker, Norman Ditzman, Don Soquet, Bill Verheyen. FWREHP/ARC/UWGB.

[12]Green Bay *Press-Gazette,* "Thousands Visited Beach on Sunday," July 12, 1937.

[13]Green Bay *Press-Gazette,* "Bathing Banned at Beach Park," Aug. 4, 1942.

[14]*Stream Pollution in Wisconsin,* Madison: State Board of Health, 1927, 327 pp.

[15]Laws of Wisconsin–1927, Chapter 442, pp. 633–41. The Committee on Water Pollution was created as an inter-agency committee, and it was not funded to conduct monitoring or other activities until Senator Kaftan's 1949–50 legislative efforts.

[16]*Stream Pollution in Wisconsin,* Madison, WI: State Board of Health, 1927, p. 75.

[17]City of Green Bay, Report of committee chaired by George F. Nick, Council Proceedings of Sept. 6, 1927. The Public Service Co. facility was a coal gas plant. A report in 1939 indicated that several other industries discharged oil into the East River. Published by the Wisconsin State Committee on Water Pollution and the State Board of Health in collaboration with the Green Bay Metropolitan Sewerage Commission, it was titled, "Investigation of the Pollution of the Fox and East Rivers and of Green Bay in the Vicinity of the City of Green Bay."

[18]City of Green Bay, Report of committee chaired by George F. Nick, Council Proceedings of Sept. 6, 1927.

[19]Second Annual Report of the Green Bay Metropolitan Sewerage District, published 1934.

[20]Green Bay *Press-Gazette,* "Tracing Source of East River Smell," June 13, 1936; "Green Bay's Rampaging River," editorial, July 23, 1938.

[21]Green Bay *Press-Gazette,* "Botulism Killed Ducks; But What Caused Disease?" Oct. 17, 1936; "Duck Deaths Are Blamed on Sewage," Oct. 20, 1936; "Ducks Dying in Bay Again," Sept. 8 1937; "Ailing Swans Treated at Sanctuary Here," April 18, 1939; "Fear Disease of Ducks May Visit State Again," July 25, 1940; "Game Biologist Has Ideas for Preventing Botulism in Ducks," April 16, 1942.

[22]The locations of the nets were as far north along the east shore of lower Green Bay as Dyckesville, Sand Bay and Point Sable. Fish kills were reported before and after this event. In late summer 1937, "wagon loads" of perch, musky, pike and 32 other species were collected between Appleton and Kimberly, according to a September 21 report in the Green Bay *Press-Gazette.* In a May 1950 letter to Dr. David Charlton, Portland, Oregon, Virgil Muench reported that fishermen had recently lifted tons of dead fish from nets 36 miles from the Fox River mouth. Muench reports making color movies of the dead fish, but the survival of this film through the years is not recorded. Muench collection, State Historical Society of Wisconsin.

[23]The scientific work for the study was done by Ben Williamson, a sanitary engineer for the Kansas Board of Health, and by John Greenbank, a biology doctoral student employed by the Michigan conservation department. Green Bay *Press-Gazette,* Nov. 2, 1938. The final report was issued by the Wisconsin State Committee on Water Pollution and the State Board of Health in collaboration with the Green Bay Metropolitan Sewerage Commission in 1939 as, "Investigation of the Pollution of the Fox and East Rivers and of Green Bay in the Vicinity of the City of Green Bay."

[24]Green Bay *Press-Gazette,* "Claim Pollution In Fox River Is Caused by Mills," by Stanley Barnett, October 6, 1939.

[25]Green Bay *Press-Gazette,* "Mills Will Finance Study of River Pollution Elimination," Nov. 15, 1939; "New Products Force Marathon to Expand," July 13, 1939.

[26]Green Bay *Press-Gazette,* "Mills Will Finance Study of River Pollution Elimination," Nov. 15, 1929. Oral history interview with A.J. Wiley, former technical director of the Sulphite Pulp Manufacturers Research League, FWREHP/ARC/UWGB. The sulphite chemical process was developed in 1874 to convert raw wood chips into a pulp usable

in the paper industry. The city of Green Bay had two sulphite pulp mills operating during most of the twentieth century. Each mill operated under several different company names. The last sulphite mill, operated by the James River Corp., was closed in the early 1990s and replaced with a secondary pulp mill fed by recycled office paper.

[27]*Stream Pollution in Wisconsin,* Madison, WI: State of Wisconsin, 1927, pp. 4–5. The experiment at Park Falls resulted from a Park Falls pulp mill discharge that killed 25 to 30 tons of fish in 1925; this fish kill led to the 1927 statewide study of river and stream conditions.

[28]This account by Soquet highlights the fact that game fish were able to survive in the lower Fox at certain times of the year, despite the report in the 1927 COWP study that fish survival was poor during critical summer months.

[29]*Stream Pollution in Wisconsin,* p. 136.

[30]Oral history interview with Donald Soquet, 1995. FWREHP/ARC/UWGB.

[31]Oral history interview with Soquet, 1995. FWREHP/ARC/UWGB.

[32]Oral history interview with Soquet, 1995. The role of the state Izaak Walton League is described from a longer historical perspective by Earl Finbar Murphy in *Water Purity: A Study in the Legal Control of Natural Resources,* Madison, WI: University of Wisconsin Press, 1961.

[33]Virgil Muench was executive secretary of the Green Bay Trade Independent Association in the mid-1940s. This group saw dire threats from large interstate corporations outcompeting local small businesspeople. Most pulp and paper mills in Wisconsin were locally owned at this time. Muench was the son of an Algoma lake fisherman who left that work to become a gas station operator. Some documents related to this group are found in the Muench collection in the State Historical Society of Wisconsin.

[34]Letter from A. D. Sutherland to Henry Bredael, President of the Green Bay chapter of the IWL, August 13, 1948, in the Virgil Muench collection, State Historical Society of Wisconsin, Madison.

[35]The Kaftan name was "known" in the Green Bay community. The brothers Robert, Arthur, and Fred Kaftan were attorneys whose father (once a Brown County judge), first set up law practice in Green Bay about 1905.

[36]The Second Senatorial District was later to elect a third environmental advocate. Assembly person Robert Cowles, Jr. was first elected to represent the 75th District East River neighborhoods in 1982, and he went on to assume the seat of the State Senate's redistricted Second District in 1987. In another echo of the East River debate, environmental activist Rebecca Leighton was elected in the mid-1980s to the Green Bay City Council from the same east side neighborhood as Meyer Cohen was in about 1930.

[37]Green Bay *Press-Gazette,* "Rennebohm Talk Slated Tonight," Oct. 21, 1948; "Plan Probe of Pollution Here," October 22, 1948.

[38]Oral history interviews with Art Kaftan, Harry Tubbs, FWREHP/ARC/UWGB.

[39]Green Bay *Press-Gazette,* "Sulphite Operators Testify Yeast Plant Impossible Now," Jan. 5, 1947. The hearing transcript from the 1948 hearings could not be found in state archives. While the State Historical Society of Wisconsin has records of COWP hearings on many river basins, the records from the lower Fox River were not deposited by the Wisconsin Department of Natural Resources, according to a staff librarian. Any reader knowing of an existing copy of the transcript is asked to contact the author.

[40]Harry Tubbs, "The Green Bay Story," *Outdoor America,* magazine of the Izaak Walton League of America, February 1950. The publication of five of Tubbs' ads in the *Press-Gazette* were: Dec. 11, 15 and 31, 1948; Jan. 12 & 15, 1949.

[41]Oral history interview with Tubbs, FWREHP /ARC/UWGB; also personal communication with Tubbs, October 1995.

[42]Virgil Muench collection, State Historical Society of Wisconsin, Madison.

[43] *Capital Times*, "Fox River is 'Grossly Polluted' Yet Committee Failed to Act," Jan. 22, 1949. Oral history interview with Fred Kaftan, FWREHP/ARC/UWGB.

[44] Although they did not work closely together, freshmen Senators Fred Kaftan and Gaylord Nelson were noted for their individualism and idealism. A *Capital Times* opinion column on April 9, 1949 cited them as the only two senators to vote for broadening the state's antitrust laws to cover the service industry, including the law profession in which they worked. Oral history interview with Gaylord Nelson, FWREHP/ARC/UWGB.

[45] *Capital Times*, "GOP State Sen. Kaftan Fights Fox River Valley Paper Mills on Pollution," by John Hoving, Jan. 29, 1949.

[46] Oral history interview with Len Montie (COWP Fox River basin engineer starting in 1950), FWREHP/ARC/UWGB; Green Bay Press-Gazette, "Kaftan Asks Prosecution of Non-Cooperative Papermills," Dec. 10, 1952. Arthur Kaftan is cited as reporting that 425 COWP orders were issued in the state between 1949 and 1952, with 65 completely complied with and 56 other projects or plans underway.

[47] Green Bay *Press-Gazette*, "Bay Pollution Rising Sharply," Dec. 1952, reports on a comparison of biological conditions between 1938 and 1952; "Kaftan Asks Prosecution of Non-Cooperative Papermills," Dec. 10, 1952; "Paper Mill, Sewage Plant Men Reply to Kaftan Charges," Dec. 15, 1952.

[48] Oral history interviews with Richard Billings, George Kress, Clyde Faulkender, (paper industry executives), FWREHP/ARC/UWGB.

[49] *Milwaukee Journal*, "On, Wisconsin: Industrial Pollution," April 7, 1940.

[50] Green Bay *Press-Gazette*, "New Products Force Marathon to Expand," July13,1939.

[51] Green Bay *Press-Gazette*, "Here Is the State of the Fox River-Green Bay Pollution Problem in Capsule Form," January 7, 1940. Both Everest and Becker had conservation sympathies that extended beyond water quality. They were key figures in establishing the privately funded conservation organization group today called the Trees For Tomorrow Natural Resources Education Center. Established in 1944 as Trees for Tomorrow, the organization was known for distributing free trees to landowners for the protection of trout streams and the control of soil erosion. Everest has been inducted (and Becker nominated) as a conservation hero in the Wisconsin Conservation Hall of Fame in Stevens Point.

[52] Fox Valley activism played a role in another major state natural resource issue. Virgil Muench was involved in a lawsuit that helped broaden the definition of affected parties in river management. The Namekagon case involved the Flambeau River of northwestern Wisconsin [see Muench v. Public Service Commission, 216 Wis 492 (1952)], and it expanded the doctrine of public trust to give all Wisconsin citizens a voice in river protection issues.

[53] Green Bay *Press-Gazette*, "Pollution from Mills is Key Issue in Area," Oct. 5, 1987. Investment in water quality continued after 1987, with a 1990 estimate by William Elman of the Fox Valley Water Quality Planning agency that more than $600 million would be spent by projects then underway, Appleton *Post-Crescent*, "Report Card Issued on Water Quality Efforts," Feb. 25, 1990.

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